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

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

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

D03507

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.89/23
28 October 1971

ORIGINAL: ENGLISH

Joint UNIDO, FAO, ECAFE Interregional
Seminar on the Industrial Processing
of Rice, organised in cooperation with
the Government of India

Madras, India, 11 - 16 October 1971

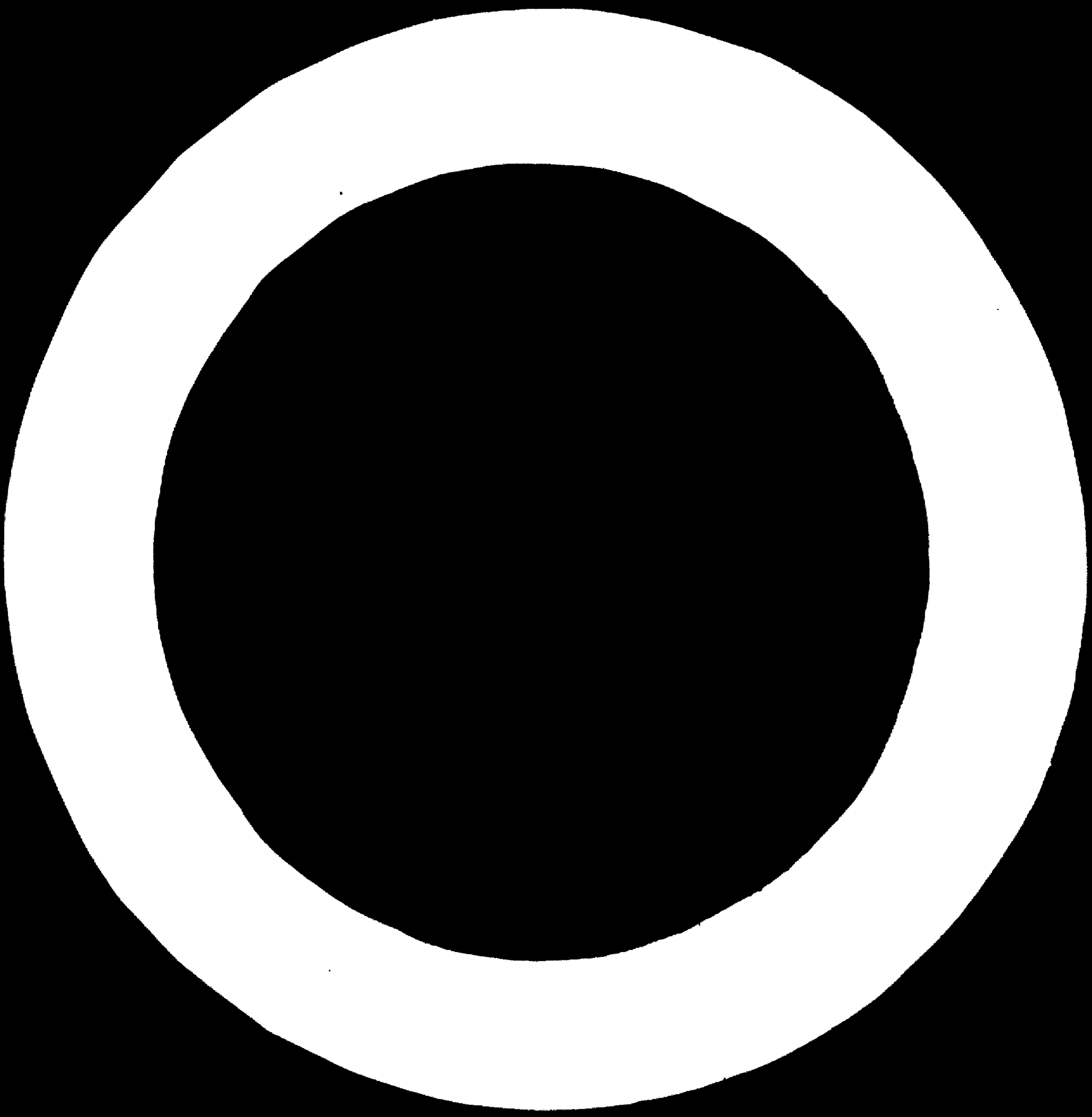
WATER RESISTANT COMPOSITE BOARD FROM RICE HUSKS [1]

by

R. C. Vasishth
Technical Services Division, Flecto Coatings Ltd.
Richmond, B.C. Canada

---

[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.



CONTENTS

I. Introduction:

1. Rice hulls, also commonly called rice husks or paddy husks, are a by-product of the rice processing industry. For every 162 lbs. of rice (one barrel) about 30 lbs. of husks (approximately 18.5%) are produced (1). They are thus available in large quantities and for this reason a great deal of research has been done into converting rice husks into a useful by-product. Lanthrop (1) in 1952 reviewed the industrial utilization of rice husks. The URS Research Company published their final report (2) on utilization of rice hulls as recently as September 1970. These reports show that despite all efforts the effective utilization of rice hulls still remains a problem. The UNIDO expert working group in its report (3) and Beagle (4) in his report to the 72nd Annual Meeting of the Rice Millers' Association came to similar conclusions.

2. During the last five months a project was undertaken to develop a panel board out of rice husks. This work shows the feasibility of producing a useful panel board from rice husks. In this report background information comparing rice husks as raw materials to wood chips and an economic comparison of the process relative to particle board manufacture is presented. The progress to date of experimental work is also given and discussed.

II. Rice Husks vs Wood Chips:

3. Since the past industrial experience in manufacturing composite boards* is largely related to wood flakes and chips, it is useful to recognise the gross structural, chemical and physical property differences between wood chips and rice husks. Thus, as opposed to wood, rice husks contain about 15 to 24% silica (1). The silica is heavily concentrated on the surfaces (5) (10).

As a consequence rice husks are relatively friable and brittle, and are abrasive in character. During the manufacture of composite boards, wood chip interfaces collapse to form more or less continuous surfaces. Such is not to be anticipated for rice husks.

*Composite boards, in this manuscript do not include the hardboards Produced by the wet fibre process.

Wood and wood chips derive their physical strength from long cellulose fibers, woven so as to form a cellular structure. The fibers in rice husks are relatively quite small, about 0.3mm (1) compared to 2 to 3 mm in soft woods. Additionally, cutting of wood to form chips or flakes can be controlled to take full advantage of grain orientation. Such is not the case for rice husks.

4. A third important difference is that rice husks are easily attacked by free alkali. All wood adhesives based upon alkali solutions of phenol-formaldehyde resins are therefore less likely to perform satisfactorily.

III. Synthetic Adhesives:

5. The four most commonly used synthetic adhesives for composite board manufacture are:

(a) Urea-formaldehyde Resins. These resins have been very popular because of their low cost, light color, fast speed of cure and excellent bonding to wood. However, they slowly depolymerize even under ambient conditions of heat and humidity and have limited water resistance. Consequently they are strictly for interior use. Since they cure under acidic conditions they could conceivably be reformulated to give a suitable adhesive for rice hulls.

(b) Melamine-formaldehyde Resins. These resins are similar to urea-formaldehyde resins except in that they have superior water resistance. However, in most parts of the world the cost of melamine is at present much higher than that of urea and this limits the use of melamine-formaldehyde resins.

(c) Phenol-formaldehyde Powder Resins. The powdered phenol-formaldehyde resins are excellent binders for wood. They have acceptable resistance to water and are classified as suitable for manufacturing materials for exterior use. They are currently used for manufacturing flakeboard, such as Aspinite, in Canada. In North America, the crushing and grinding costs associated with their production prices them about 5¢/lb. (33% approximately) above the phenolic resins sold as caustic solutions. Their use in binding rice husks was reported as early as 1951 (6). However, the boards made were of very high density.

(d) Phenol-formaldehyde Liquid Resins. Most phenol-formaldehyde resins for the wood industry are sold as caustic aqueous solutions at 35% resin solids concentration, and 6 to 10% NaOH concentration. Higher solids and lower caustic detract from resin stability. These factors, on first judgement preclude their use as suitable binders for rice husks.

IV. Economic Considerations Relative to Existing Composite Board Manufacturing Practices:

6. To come up with the exact cost of producing particle board or rice husk board in any given location requires a detailed analysis of fixed and variable costs. It was felt, however, that any panel boards made with rice husks, for any given location, would have the same fixed costs as those for a particle board plant, if the processes were essentially similar. Consequently, if the quantity and cost of resin binder used and the press times required for rice husk board manufacture were made competitive with those currently used for particle board manufacture, the process would by and large be

economically viable. A detailed cost analysis could be done for specific conditions, when needed.

7. Currently most composite boards based on wood products are manufactured with a urea-formaldehyde resin as a binder. The trend, however, is towards increased use of phenol-formaldehyde resins, to introduce prolonged shelf life of finished product and to permit exterior use (7). In North America, phenol-formaldehyde resins cost 30 to 35% more than urea-formaldehyde resins.

8. The exact amount of adhesive used for particle board manufacture varies from plant to plant. As an initial comparison point, it was decided to accept an average figure of 8% resin solids based upon the weight of the finished board. For three layer board, ½ inch (1.27 cm) or greater thickness, 10 - 12% resin is generally used on the face, keeping the resin in the centre layer, or core, at the usual 8% level, and these figures were taken for initial comparison.

9. For press time comparison, the following average figures were used:

Board Thickness		Phenolic Bonded	Urea Bonded	Press Temperature	
(inches)	(cm)	Press Times (Min)		(°F)	(°C)
1/4	0.635	5½	2½	350	176.6
		4½		410	210
5/8	1.578	8	5½	350	176.6
		7		410	210

10. For the sake of completeness it may be mentioned that in this cost comparison it is assumed that rice husks are delivered cheaper than or equal to the cost of wood chips. Moreover, since the wood chips have to be dried prior to use, while rice hulls are already at a relatively lower moisture content of approximately 8%, added savings in drying costs are to be expected. Any economic advantages, over particle board, due to these two factors, again, have to be worked out for specific cases.

Experimental:

11. The adhesive system used, the method used for coating of husks and the procedure used for making the boards are described below. The finished boards were tested for internal bond strength and modulus of rupture according to standard procedures.

(a) Adhesive Used. In keeping with industry trend it was decided to initiate the work using an exterior type or phenol-formaldehyde resin. To keep the costs under control it was also decided to use liquid phenol-formaldehyde resins.

12. As discussed earlier the currently used liquid phenol-formaldehyde resins, that are 35% solution with 6 to 10% NaOH in water, were judged to be unsuitable for binding rice hulls.

13. Taking advantage of the modern day tachnology, a special resin, based upon phenol-formaldehyde was used. This resin has some very special properties that make it particularly suitable for this application and also improve the economics of packaging and shipping. These features are summarised below:

1. The resin can be manufactured, stored and shipped at 80 - 90% resin solids. A given container can thereby contain approximately 2½ times the amount of effectively usable resin, with corresponding savings in packaging and freight costs.
2. If the resin is manufactured close to a formaldehyde plant, the age old problem of the cost of shipping 37% formaldehyde can be largely overcome.
3. The new resin is very stable at ambient temperatures encountered even in tropical countries. It is catalysed prior to use and the catalysed resin has a shelf life of over 24 hours. The catalysed resin is relatively fast curing at temperatures above 350°F.
4. The rice husks, after being coated with the polymer, can be stored for over two weeks prior to pressing in a hot press.
5. The cost of producing the resin is only 5% more than the cost of producing a conventional phenol-formaldehyde resin as a caustic

solution. It is estimated that this additional cost is more than offset by the cost savings associated with lower packaging and freight costs together with the shorter press times attained.

(b) Coating of Rice Husks with the Adhesive. A weighed quantity of rice husks was charged into a cylindered blender. The blender was equipped with baffles, was capable of rotating around its axis and had a hole in the center for the insertion of a spray nozzle. After charging the rice husks the blender was rotated and 8% by weight of the synthetic resin was sprayed on the husks using an externally air atomizing type spray gun. After spraying, the blender was opened and the coated husks discharged onto a tray.

14. The husks as charged had a moisture content of 8%. After coating, the moisture level increased to 16%. The husks were then air-dried over night, which reduced the moisture level to below 12%.

(c) Mat Forming. The dried husks were spread on an appropriate size caul plate. The amount of coated husks spread for a given board were calculated from the desired density of the finished board. Two steel stops of appropriate thickness, each 2" (5.08 cm) wide were placed on each end of this mat and a second caul plate was placed on the top of the mat.

(d) Pressing of the Board. The rice husk mat was placed into a preheated hot press and the press closed, using a definite pressure. Boards of various sizes of 1' x 1' to 4' x 8', and two thicknesses, 1/4" (0.635 cm) and 3/8" (1.578 cm), and temperatures ranging from 300°F (154°C) to 410°F (210°C) and press times ranging from 8 minutes to 20 minutes were made.

VI. Results:

15. The preliminary results that lead to the selection of a system for a test run on a full size commercial press are not reported here for the sake of brevity. It was found however, that satisfactory and reproducible boards,

5/8" (1.587 cm) could be made using press times of 7 minutes at 410°F (210°C) and 12 minutes at 350°F (176.6°C). These press times at these resin levels were considered to be acceptable and several 4' x 8' (122 x 244 cm) and 4' x 4' (122 x 122 cm) boards were made and tested.

16. The test results follow:

Thickness		Density		Internal Bond Strength	
Inches	Cms	lbs/ft^3	kgs/m^3	psi	kg./cm^2
1/4	0.635	45	720.9	90	6.328
1/4	0.635	52	833.04	180	12.656
5/8	1.578	45	720	70	4.921
5/8	1.578	52	833.04	110	7.734

Modulus of Rupture 1400 to 1600 psi

Flame spread rating (Tunnel Test) - 100

Swelling on one hour boil - 8 - 12%

All boards passed four hour boil test.

The boards can be routed and hold screws and nails on face quite well.

Edge nailing can be done 2" (5.08 cm.) away from corner.

17. Further extensive testing of the boards, with a view to establishing more specific uses of the board are underway.

VII. Discussion of Results and Conclusions:

18. From the results obtained it may be concluded that commercial size 4' x 8' (122 x 244 cm) boards of varying thicknesses can be produced from rice husks using equipment and procedures currently familiar to the particle board industry, and at resin levels and press times acceptable to present day economics of the particle board industry. The process may, therefore, be regarded as competitive with phenolic particle board of the interior and exterior type.

19. The physical properties of the boards show that it is potentially

usable for furniture, wall paneling and as floor underlayment. The specifications for exterior type composite boards as laid out for floor underlayment by FHA (8) and according to the Voluntary U.S. industry standards (9) call for an internal bond strength of 70 psi and a modulus of rupture of 1600, at board densities of 45 lbs/ft^3.

20. The modulus of rupture values obtained at present are probably too low to consider using the product without overlays for packaging. Some of these handicaps will be overcome by further research. This initial study is being followed up to further enhance the board properties by studying the role of surface veneering, overlays, additives such as water repellants and insecticides, and optimizing the adhesive and process variables.

21. The flame spread rating of the product is obviously an advantage over currently available composite boards.

VIII. BIBLIOGRAPHY

(1) Lanthrop, E.C., "THE INDUSTRIAL UTILIZATION OF RICE HULLS," Rice Annual, pp 13 (1952)

(2) Staackmann, M., et al, "RICE HULL UTILIZATION", Final Report, URS Research Company, 155 Bovet Road, San Mateo, California 94402, September (1970).

(3) UNIDO REPORT, ID/WG.83/15, February 24, 1971

(4) Beagle, Eldon, C., paper presented at the 72nd Annual Meeting of the Rice Millers' Association, Mexico City, Mexico.

(5) Koran, Z., Personal Communication, School of Forestry, University of Toronto, Ontario.

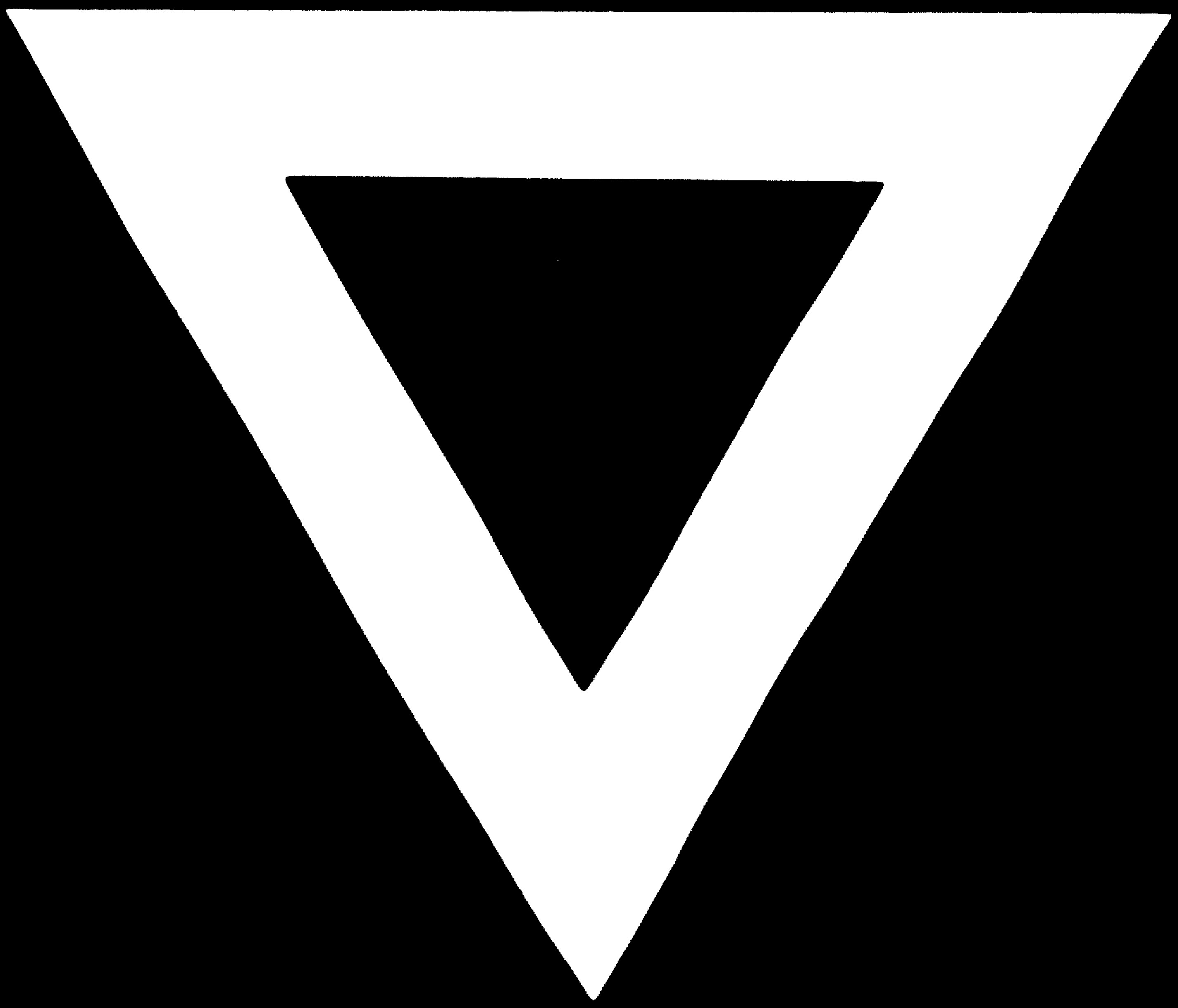
(6) Lanthrop, E.C., et al, "HARD BOARD FROM AGRICULTURAL RESIDUES", Modern Plastics, pp 126, (April 1951).

(7) Stensrud, R.K., "OVERLAYS FOR EXTERIOR PARTICLE BOARD", paper presented at the Second Particle Board Symposium, Washington State University, Spokane, Washington, (March 1968).

(8) FHA, "MAT FORMED WOOD PARTICLE BOARD FOR FLOOR UNDERLAYMENT", Bulletin UM-28a, January 26, 1967.

(9) U.S. Commercial Standard CS236-66, A Recorded Voluntary Standard of the Trade Published by the U.S. Department of Commerce.

(10) Thomas, R.S. and Jones, F.T. "MICROINCINERATION AND SCANNING ELECTRON MICROSCOPY: SILICA IN RICE HULLS" 28th Annual Proceedings EMSA.



3. 12. 73