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Danish Atomic Energy Commission

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CHEMISTRY DEPARTMENT

A PERFORMANCE TEST OF WOOD-PLASTIC PARQUET FLOORING

by

Klaus Singer and Arne Vinther

August 1972

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Abstract

Parquet flooring with a top layer of radiation-cured wood-plastic face strips of two wood species, ash or maple, impregnated with four types of plastic, poly(methylmethacrylate), poly(styrene/acrylonitril), polyester/styrene, or a special acrylic prepolymer/monomer mixture were tested in a heavily trafficked corridor.

The wear of these flooring materials was observed during three years and was compared with conventional lacquered reference flooring. Different methods of cleaning and maintenance as well as economic aspects are discussed.

Careful maintenance is necessary to keep up the original pleasant lustre of a wood-plastic parquet floor. The greater hardness prevents hollows from gravel and stiletto heels, but if the face strips are not homogeneously full-impregnated, a surface like a wash-board will appear under hard-wear conditions. A single surface treatment with a durable lacquer will last about twice as long on wood-plastic flooring as on unimpregnated wood flooring.

Parquet flooring with 2-4 mm thick plastic-impregnated face strips will cost roughly twice as much as conventional Danish face strip parquet flooring.

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ERRATUM

K. Singer and A. Vinther: A performance test of wood-plastic parquet flooring, Risø-M-1523, page 18, fig.?.

For: Untreated sample, read: Impregnated adjoining sample, and vice versa.

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CONTENTS

1. INTRODUCTION

One of the most promising applications of wood-plastic materials seems to have been parquet flooring. This field has been investigated in a number of laboratories, and in a few countries - e.g. USA, Finland, and England - industrial production has been developed (refs. 1-4).

In Denmark a collaboration was initiated in 1968 between the Chemistry Department of the Danish Atomic Energy Commission Research Establishment Risø and JUNCKERS SAVVAERK A/S in Køge. Later on RADEST A/S was involved in this development programme.

The purpose was to produce and to performance-test a number of irradiated wood-plastic combinations used as face strips in usual parquet flooring. The testing was made in the entrance part of the canteen at the Research Establishment Risø, which is daily visited by about 700 people. The study was considered as a purely practical performance test, i.e. no proper physical measurements were included. This report is solely based on visual observations during a test period of three years (fig. 1).

The investigation included two wood species, namely ash (Fraxinus excelsior) and maple (Acer pseudoplatanus), impregnated with the following types of vinyl monomer systems: methylmethacrylate (MMA), styrene/acrylonitrile (ST/AN), unsaturated polyester/styrene (PE/ST), and an acrylic prepolymer/monomer mixture. The curing was performed by cobalt-60 gamma and by electron accelerator irradiation.

2. PRODUCTION OF TEST MATERIAL

2.1. Ash

Preliminary impregnation experiments with ash sticks, 11 x 70 x 560 mm, had shown that a significant contraction of the plastic occurred during the polymerization process, resulting in a depletion of polymer from the ends of the sticks (fig. 2). These parts not rich in plastic and of a few mm's length had to be cut off, because only fully impregnated wood could be considered as relevant test material (ref. 5).

The first experiments, started in October 1968, included only ash wood. Preferably high quality, straight-grained wood without knots was used in order to achieve homogeneous full-impregnation.

2.1.1. Construction of the Test Floor

Plastic-impregnated ash strips (approximately 4 x 60 x 600 mm) were glued with an urea adhesive on a 15 mm thick support consisting of 180 mm wide, two-layer boards of pine or spruce. Four or five of these boards were connected with tongue and groove to a floor panel with a length of three metres, and they were strenghtened with four laths underneath (fig. 3a and b).

2.1.2. Impregnation Procedure

The impregnation was carried out in vacuum-pressure equipment as shown in fig. 4. After one hour's vacuum treatment at 5-10 torrs of the indoor-dry wood (moisture content approx.7%) the monomer was added under vacuum and forced into the wood under a nitrogen pressure of 6-10 atmospheres for 18-20 hours. The surplus liquid was then drained off, and the specimens were wrapped in Melinex foil prior to irradiation.

The following wood-plastic combinations were produced, using ash sticks 600 mm long and 70 mm wide and of different

thicknesses:

MMA (visc. 25 and 75 cst)*:	110 pieces	11 mm thick
	20 "	26 mm "
ST/AN, 60/40 (visc. 0.6 cst):	70 "	26 mm "
PE/ST, 50/50 (visc. 66 cst):	80 "	4 mm "
	60 "	11 mm "
	20 "	27 mm "

The unsaturated polyester was a commercial type (Alpolit 910 M from Polyplex). In the case of the high-viscosity impregnations the adherent layer of thick monomer on the surface of the wood was scraped off by hand before wrapping.

2.1.3. Gamma Irradiation

The irradiation was performed in the 10,000 curie cobalt-60 facility at Risø (fig. 5). In this plant the singly wrapped sticks, placed in a cylindrical aluminium container, were passed through a radiation field at an average dose rate of approximately 200 kilorads per hour. The radiation doses necessary for total polymerization were 3 megarads for MMA and PE/ST and 5 megarads for ST/AN.

The average plastic content obtained after irradiation was 58 grams of polymethylmethacrylate, 66 grams of poly(styrene/acrylonitrile), and 69 grams of polyester per 100 grams of wood.

2.1.4. Parquet Floor Manufacturing

After grinding and smoothing of the edges the 4 mm strips were glued directly on the pine support at JUNCKERS SAVVAERK. The 11 mm sticks were cut lengthwise into two strips, while by a similar cutting the 26 mm sticks were divided into four strips. The parquet boards were sanded with fine sandpaper, and the assembled panels were buffed to a suitable non-shining lustre.

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* The viscosity of pure MMA is less than 1 centistoke. The monomer used in these impregnations contained some polymethylmethacrylate, added in order to decrease surface evaporation during irradiation. In most wood species no impregnation difficulties were observed with viscosities below 1000 cst.

2.1.5. Appearance

In the appearance of the impregnated parquet flooring especially the colour change obtained with poly(styrene/acrylonitrile) is note-worthy. This type of plastic gives the wood a beautiful reddish-brown tint, while the two other types of plastic do not change the original light colour of the wood (fig. 6).

Right from the beginning of the testing some thin cracks in the longitudinal direction were observed in some of the face strips, especially in those containing polymethylmethacrylate (fig. 7a + b). These cracks probably occurred during the polymerization reaction. They did not increase in size or in number later on, but they became more visible because dirt gathered in them.

Insufficient glueing of the face strips was occasionally observed (fig. 8). Whether this failure could have been avoided by using another type of adhesive (e.g. a resorcinol type) is uncertain (ref. 6).

2.2. Maple

Approximately 18 months after the beginning of the testing period three panels consisting of maple impregnated with the same three types of vinyl monomer systems were prepared. The methylmethacrylate used for these impregnations contained, however, a small amount of a crosslinking monomer, butanediol-dimethacrylate (BDDMA), which improves machining properties.

The following wood-plastic combinations were irradiated by cobalt-60 gamma rays:

MMA + 0.5% BDDMA:	28	pieces	22 mm	thick,	77 g	plastic	per	100 g wood
ST/AN, 60/40:	39	"	22 mm	" ,	69 "	"	"	100 " "
PE/ST, 50/50:	108	"	4 mm	" ,	95 "	"	"	100 " "

The great plastic content in the case of PE/ST is probably due to a certain amount of plastic on the surface of the thin strips, as it was fairly difficult to remove the rather viscous monomer prior to irradiation.

2.2.1. Finishing

Before installation the maple parquet panels were ground on a belt sander with the finest sanding belt, scraped with an abrasive disc, and buffed with a mild abrasive component by means of a soft buffing wheel. After this treatment the polyester/styrene panel had achieved a pleasant silky gloss, while the PMMA- and the P(ST/AN)-panels appeared with a mirror finish (fig. 9). Hardness according to the pencil method was 8 H on all three surfaces.

Thin cracks in the longitudinal direction were observed in more than 50% of the face strips containing PE/ST, in 10-15% of those containing PMMA, and in 5-6% of those containing P(ST/AN).

2.2.2. Electron Accelerator Irradiation

Towards the end of the testing period a third type of wood-plastic composite material was included in this investigation. This combination consisted of ammonia-treated maple, impregnated with a specially developed acrylic prepolymer/MMA mixture, which could be cured by electron beam irradiation (ref. 7). The viscosity of this mixture was approximately 300 cst.

The curing was performed in the 10 MeV electron accelerator of RADEST A/S (fig. 10) with a total radiation dose of 7.5 megarads. The plastic content was 75 g per 100 g of wood.

The resulting floor panel was installed after sanding followed by light polishing which gave a semi-matt gloss.

3. INSTALLATION OF FLOORING AND COURSE OF TEST PROGRAMME

3.1. First Installation

The entrance passage of the Risø canteen was considered the most suitable testing place. More than 700 persons pass this corridor twice a day. The total available flooring area for the practical testing was 27 m^2 (fig. 11).

Before installation of the testing panels the existing linoleum flooring and the upper part of the supporting concrete was removed.

The testing area was divided into 12 fields (numbered 1-12), which were arranged in three groups each consisting of three wood-plastic panels and one unimpregnated, but lacquered, reference panel. The two reference panels in positions 4 and 12 were lacquered three times each with glossy and matt Blitza* respectively. The reference panel in position 8 was lacquered twice with a two-component urethane lacquer (Iso-Blitza). These surface treatments were done by hand before installation of the panels.

All the twelve panels mentioned (with face strips of ash) were installed in October 1968 (see fig. 12). Seven of these panels were left for continuous testing over more than three years, and out of these, three plastic-impregnated panels (one of each type of plastic: PMMA, P(ST/AN), and polyester, positions 1, 2, and 3) were without any real surface treatment during this whole period, except for a very short period with the wax sealing experiment (cf. 4.2). These positions are incidentally the most exposed ones just inside the entrance door (fig. 13). The treatment of the remaining floor panels will be discussed in section 4.7.

* Trade name of a modified urea formaldehyde lacquer from JUNCKERS SAVVAERK A/S, Køge.

3.2. Second Installation

In May 1970 the three panels of ash (positions numbers 9, 10, and 11) were removed and replaced by three impregnated panels of maple (cf. 2.2.). The urethane-lacquered panel of ash (position number 12) was simultaneously replaced by a similarly treated reference panel of maple.

Because of their greater hardness the panels removed after 18 months' wear were excellent in comparison with the lacquered reference panel. They had few scratches and almost no down-trodden gravel particles in the surface. However, the surface of all three plastic-impregnated panels had grown dull and dead.

3.3. Third Installation

In April 1971 the panel of ash with PMMA in position number 7 was removed after a testing period of 2½ years in this position, during which it had been lacquered once (cf. 4.7). It was replaced by the previously mentioned electron-irradiated panel of maple (cf. 2.2.2.).

4. CLEANING AND MAINTENANCE

4.1. Cleaning with Turpentine

During the first three months of 1969 the floor was frequently mopped with mineral turpentine either by hand or by means of a machine with a rotating medium-fine nylon felt pad (fig. 14). This is a somewhat unpleasant method of cleaning on account of the smell, but the method is effective, especially against stripes from black rubber heels. It turned out that a cloth wetted with turpentine and placed underneath the rondel of the machine was better than the nylon pad. Spraying of the floor with turpentine from a pressure container which was mounted on the machine was a doubtful advantage, particularly on account of the smell from the atomized turpentine. Nor can the fire hazard be neglected. Moreover the use of mineral turpentine causes depositing of a thin layer of oil which gradually gives rise to a greasy appearance of the floor.

4.2. Sealing with Wax

During all of 1969 and the first half of 1970 the floor was often cleaned by sweeping and light washing with mild soap water, but in the beginning of 1969 a short-lasting experiment of sealing with wax as an emulsion in water was performed on positions 1, 2, and 3. By this treatment the floor first got very slippery, and later dirty because the wax layer accumulated the dust.

4.3. Washing by Means of a Wax Emulsion

During two separate periods, each lasting for several months a daily - or almost daily - cleaning with 725 Combi Polish* was performed.

In the first period the daily washing with 1-2% of the polish in the washing water was carried out with an ordinary floor cloth, leaving a thin film of water, which after evaporation left a trace of the added wax component. Gradually a dirty wax film was built up which could only be removed by thorough mechanical treatment of the floor with strong soap water or another alkaline detergent (as for example ISS 616 Universal).

During the second period a special floor mop (fig. 15) was used, which allowed the test floor to be kept clean at an acceptable level for a longer time, although the floor at no time appeared with a gloss.

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* A wax emulsion containing metallized acryl polymer from ISS (International Sanitary System, Copenhagen).

4.4. Re-establishing of the Finish

The three plastic-impregnated panels of maple (from May 1970), which before the installation had been high-gloss polished (cf. fig. 9) lost the gloss quickly, and because of that they were taken up in October 1970, ground with the finest sandpaper and before re-installation covered (three times) with concentrated 725 Combi Polish (fig. 16a and b). Cleaning was then performed in the same way as with the other part of the floor and with the same result, namely that the floor gradually assumed a dull and grey appearance.

4.5. Cleaning by Machine

During the first three months of 1971 the daily cleaning was performed as a machine polishing with Scotch Brite Spray Cleaner* . The spray can was fixed on the machine and operated via a cable and a push-button at the handle (cf. fig. 14). This method of maintenance was extremely good, but rather expensive in materials, and not particularly quick. The product gives the floor a bright - but not slippery - surface which remains fairly clean.

4.6. Lacquering of Reference Panels

This was carried out at suitable intervals, i.e. when the old lacquer was worn through at the most exposed spots (cf. fig. 12). Before lacquering, the floor panel was always thoroughly cleaned and after that abrased with a scraper. One lacquering consisted of at least two coatings applied with some hours' interval.

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* A special foam emulsion containing hard wax in a spray from 3M A/S (Minnesota Mining and Manufacturing A/S).

4.7. Lacquering of Plastic-impregnated Panels

In May 1970, after 19 months' wear without lacquer, the three panels in positions numbers 5, 6, and 7, which had by then grown grey and very dirty, were taken up, ground on a belt sander and after re-installation lacquered once with Iso-Blitza (urethane lacquer). This mild grinding almost re-established the original appearance of the panels, but all three had more or less down-trodden dirt in the softest, i.e. the poorest impregnated, areas, an effect which had already appeared after a few months of wear (fig. 17). It was, however, remarkable that none of these plastic-impregnated panels had actual hollows or pits from gravel or stiletto heels. Fig. 18a and b shows two sections of a PMMA-impregnated ash panel and a reference panel with urethane lacquer, photographed at two places with much and with no traffic respectively.

At a re-lacquering after 15 months, these impregnated panels were not nearly so damaged by wear as the unimpregnated lacquered panels after 8 months.

5. ECONOMIC CONSIDERATIONS

Wood-plastic flooring is more expensive than ordinary wood flooring because costs for selecting a superior quality of wood and expenses for monomer and prepolymer, impregnation and irradiation, cutting and grinding, must all be added to the usual working expenses. The refining process must be inserted at a convenient place in the production line, presumably after suitable cutting of the face strips.

For parquet flooring with plastic-impregnated face strips costs can be calculated, based on different assumptions.

The price for finished, installed conventional flooring of the examined type with a wearing surface of ash or oak is approx.

60 D.kr. per m^2. *

The plastic content (in maple) is estimated at 80 g per 100 g of wood, and the cost for impregnation and irradiation etc. inclusive of overheads have been estimated (ref. 8).

Varying parameters are the thickness of the strips, the type and cost of plastic, and the way of irradiation, though the choice of this appears to be without importance for the final price.

The cost for the four types of plastic was chosen as follows:

Methylmethacrylate	:	3.- D.kr/kg
Styrene/acrylonitrile 60/40	:	4.50 "
Polyester/styrene 50/50	:	5.- "
Acrylic prepolymer/MMA	:	10.- "

The following six cases illustrate the effect of the various factors upon the price of the installed floor.

Case 1, 3.5 mm face strip, acryl prepolymer, electron accelerator: 137 kr. per m^2.

Case 2, 2 mm face strip, acryl prepolymer, electron accelerator: 112 kr. per m^2.

Case 3, 3.5 mm face strip, PMMA, cobalt-60: 106 kr. per m^2.

Case 4, 3.5 mm face strip, styrene/acrylonitrile, cobalt-60: 110 kr. per m^2.

Case 5, 3.5 mm face strip, polyester/styrene, electron accelerator or cobalt-60: 114 kr. per m^2.

Case 6, 2 mm face strip, polyester/styrene, electron accelerator or cobalt-60: 101 kr. per m^2.

* 1 D.kr. approximately equals 15 US cents.

6. DISCUSSION

6.1. Advantages and Drawbacks

Wood-plastic face strip parquet flooring can be produced industrially in one of the following ways:

Either a simple monomer (or a mixture) is cured by gamma-irradiation, or a "tailor-made" prepolymer mixture is hardened by electron irradiation. Further a thermal curing with a chemically catalyzed monomer is a method used, with a hot-press which has the advantage of simultaneous curing and glueing.

Under any circumstances such wood-plastic floorings will be more expensive than the same type of conventionally lacquered parquet flooring. The additional cost seems only to be justified if at least one of the following advantages can be achieved:

1. A more beautiful and consequently more attractive floor
2. A more wear-resistant floor
3. An almost maintenance-free floor
4. An easily cleaned floor

Re 1. This is a matter of taste and can therefore hardly be discussed. A marketing analysis would scarcely give any information. Maybe an audacious sales drive would show whether the product is attractive. Many visitors found the styrene/acrylonitrile flooring rather pleasant (figs. 6 and 19).

Re 2. The greater hardness of well-impregnated wood prevents gravel particle and stiletto heel marks in the surface, cf. fig. 18a.

It is incontestable that the three plastic-impregnated, but never surface-treated, panels of ash which have been down for three years and consequently exposed to almost one million person passages, have been remarkably worn at the poorest impregnated areas. Figure 20a, b, and c illustrates the "micro-washboard" appearance of these never surface-treated panels, and that no significant difference in wearability of the three tested wood-plastics can be observed. However, no measurements of the wear have been performed.

Although the three plastic-impregnated maple panels have only been down for half as long as the just mentioned panels of

ash, we consider the maple flooring to be worn to a much smaller degree. This might be because maple impregnates more homogeneously than ash.

The electron-beam-cured maple test flooring was installed in a not surface-treated condition for too short a time to show noticeable wear at visual inspection.

Re 3. Maintenance of a wood-plastic floor could of course be omitted, but after the floor has been in use for a short time, it gets so grey and "old" an appearance that most people would find it unacceptable. In order to maintain an acceptable aesthetic appearance for a longer period a single coating with e.g. urethane lacquer applied by the manufacturer is necessary. This single lacquering will last at least twice as long as two coatings of lacquer on a non-impregnated floor.

Grinding of the impregnated floor before re-lacquering does not need to go very deep to achieve an appearance almost as that of a new floor. Furthermore it can be re-polished to any finish wanted. A conventional, lacquered floor, the lacquer of which has been completely worn through, very often has dark spots at heavily worn places even after the re-lacquering.

Re 4. Depending on the level of cleanness wanted, the frequency and thoroughness of the cleaning must be chosen. There is no doubt that the old-fashioned method - washing with luke-warm soap water, rinsing with clean water, and mopping up - is generally the best method to remove most dirt, but it is only fit for small areas, unless it can be done with a machine. Whether using special hand tools or a floor washing machine, one must be aware that the use of wax-containing emulsions causes a slowly increasing deposit of wax on the floor, which will consequently never be quite clean. With wood-plastic flooring experience shows that more dirt has to be removed from unlacquered than from lacquered surfaces. The unsealed, plastic-impregnated floorings simply gather considerably more dirt and hence cannot be characterized as easily cleaned.

On the basis of these experiments no specific method of cleaning or any special products for this purpose can be recommended. Although it is possible with wax-containing polishes in the washing water to keep an acceptable level of cleanness, the best results were obtained by machine polishing with a special, sprayed cleaner. The costs of this method are, however, somewhat higher as e.g. semi-industrial washing with hand tools, especially on account of the rather expensive spray product.

6.2. Dimensional Stability

It is well known (ref. 5) that fully impregnated wood-plastic combinations are more dimensionally stable towards changes in humidity than untreated wood. This seems, however, to be of no significant importance for the use of these materials for face strip parquet flooring. The fact that in a few cases some of the face strips in this experiment were detached from the support might have been caused by insufficient glueing, and is probably not due to differences in dimensional changes of the impregnated face strips and the unimpregnated supporting material.

6.3. Economy

Considering that plastic impregnation of the face strips of a parquet flooring would increase the flooring costs by around 70-130%, at the same time as most of the above-mentioned claims cannot be fulfilled, the economic aspects of wood-plastic parquet flooring do not seem very promising.

Possible savings gained by a thinner lacquering can hardly be of any consequence in this estimate. It is probably counter-balanced by additional expenditure for a more expensive glue.

The maintenance costs for re-lacquering of a wood-plastic floor will be less than usual, but as the floor will not be cheaper to clean, this saving may be ignored.

The decisive influence on the final cost arises from the amount and cost of the plastic used. The amount mainly depends on the thickness of the face strips, whereas only considerable differences in monomer cost, as e.g. between the acrylic pre-

polymer system and the other three types of plastic, will have any significant influence.

7. CONCLUSION

Plastic-impregnated parquet floorings will very quickly loose their beautiful appearance if they are not maintained carefully, which can be done by frequent polishing or even better by lacquering, which it is, however, not necessary to perform as often as on ordinary floors.

The unlacquered plastic-impregnated floorings will not be much scratched even at intensive traffic over a long period, but they accumulate more dirt. The lacquered ones do not get marks from stiletto heels or down-trodden gravel. Both of them can comparatively easily be brought back to the original appearance if they have been neglected.

Maple is better suited for impregnation than ash, and there is no difference in wear of the three tested types of plastic, nor in maintenance and cleaning. Poly(styrene/acrylonitrile) is less crack-forming and nicer-looking.

Face strip parquet flooring is roughly twice as expensive in purchase price as conventional flooring. If the floor is maintained with lacquer, it will remain "new" for a very long time.

ACKNOWLEDGEMENTS

We wish to thank Mr. J. Schmidt, Mr. M. Hallenberg, and Mr. H. Mikkelsen from JUNCKERS SAVVAERK A/S for their ready co-operation in delivering, cutting, and manufacturing of the parquet floor.

We also thank Mr. K.E. Andersen from 3M A/S, Mr. Henning Aamodt, and Mr. Claus Møller from ISS (Darenas). They were all very helpful in procuring the machine, tools, and various products for the cleaning experiments as well as advice concerning the best way of maintenance.

Not least, we are most grateful to Mr. Per Dalager, RADEST A/S, for his continuous collaboration.

REFERENCES

1) A. Villiere, Etude des bois plastiques irradiés pour leur emploi dans la fabrication de parquets. EURISOTOP-Working Document-77 (1968).

2) P.R. Hills, The Use of Wood-Plastic Composites by the Flooring Industry. AERE-M-2269 (1969).

3) K. Hunnius, Zur Einführung von Polymerholz in die Parkett-industrie. Parkett + Fussbodentechnik, No. 7 (1970) 155-161.

4) G.B. Taylor, G.R. Dietz, and R.M. Duff, Economics of Radiation versus Heat-Catalyst Curing for Wood-Plastic Flooring Plant. Nucl. Techn. 13 (1972) 72-77.

5) K. Singer, A. Vinther, and Th. Thomassen, Some Technological Properties of Wood-Plastic Materials. Risø Report No. 211 (1969).

6) W.E. Loos and J.A. Kent, Performance of Some Commercial Adhesives for Gluing Wood-Plastic Combinations. Forest Prod. J. 18, No. 3 (1968) 23-27.

7) P. Dalager and K. Singer, Electron Beam Polymerization of Wood-Plastic Combinations. 3rd Symposium on Radiation Chemistry, Tihany, May 1971.

8) Private communication from JUNCKERS SAVVAERK A/S and RADEST A/S.

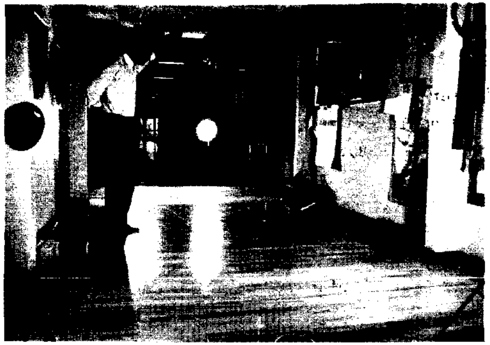


Fig. 1. Occasional photographing of the test floor.

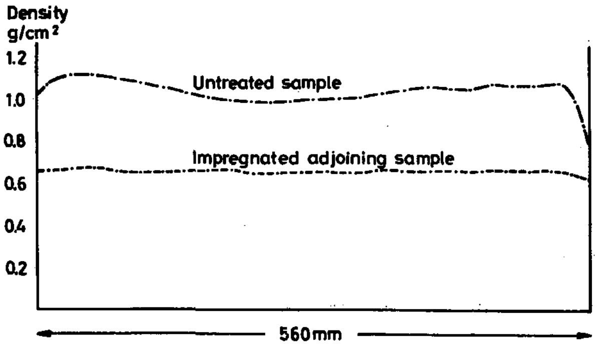


Fig. 2. Depletion of polymer from the ends of the sticks as seen in variation of density.

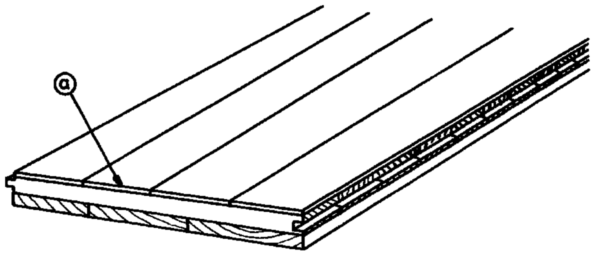


Fig. 3a. Impregnated face strips (a) glued on a two-layer board with tongue and groove.

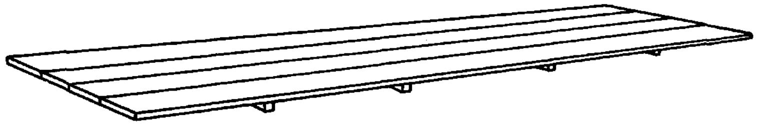


Fig. 3b. Assembled floor panel consisting of four boards.

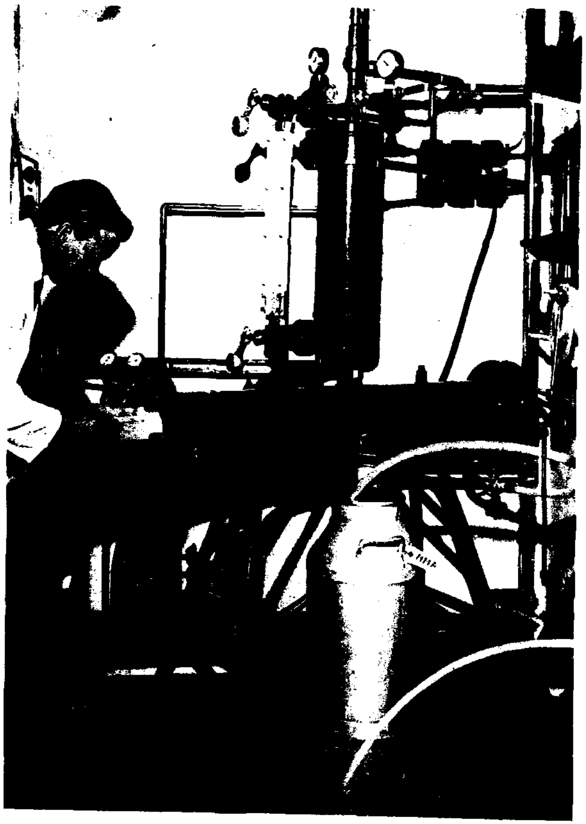


Fig. 4. Loading of vacuum-pressure impregnation equipment.

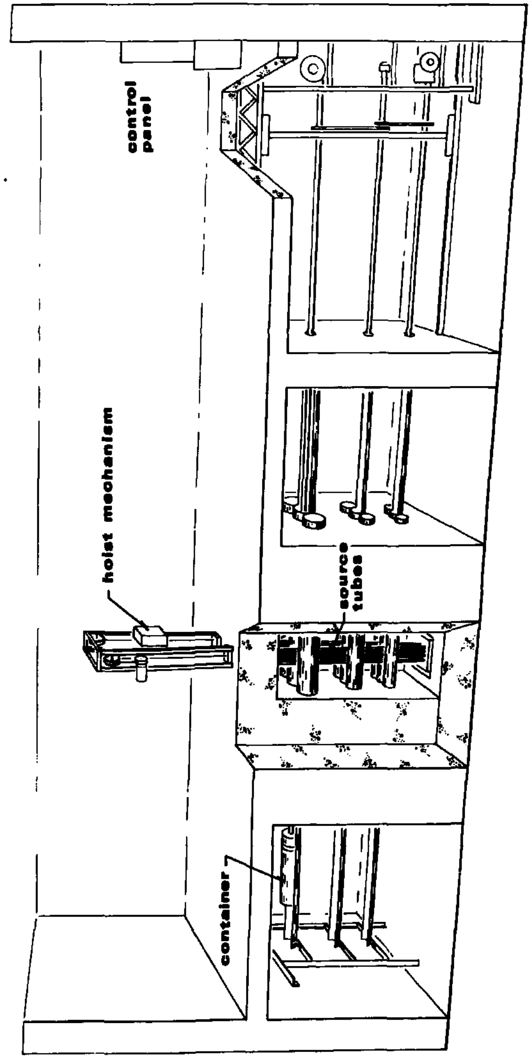
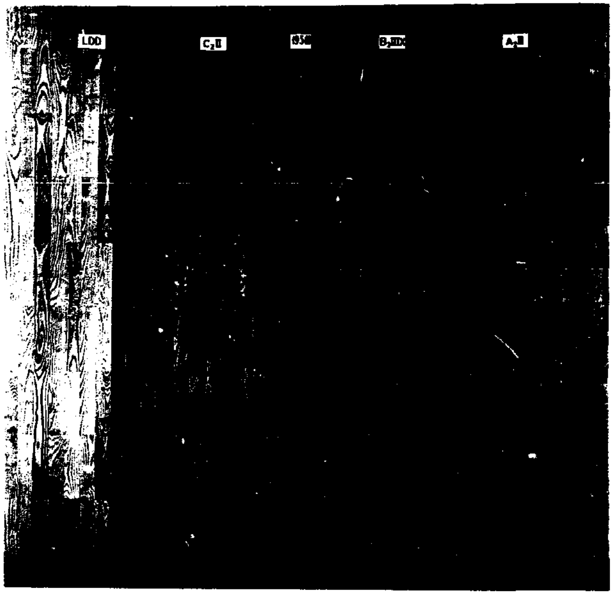


Fig. 5. Cobalt-60 gamma irradiation plant at Risø.



a b c d

Fig. 6. Plastic-impregnated ash parquet flooring
a: Polyurethane-laquered reference
b: PMMA
c: P(ST/AN)
d: PE/ST

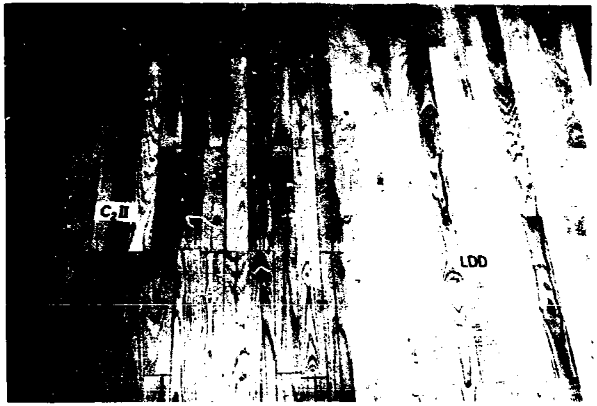


Fig. 7a. Crack formation in PMMA-impregnated ash strips (C_2II). LDD is a non-impregnated lacquered reference panel.

Fig. 7b. Close-up showing cracks in PMMA-impregnated ash strips.

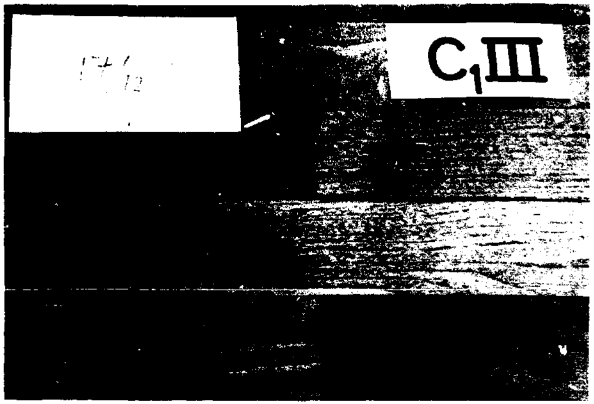


Fig. 8. Impregnated face strip detached from the support owing to insufficient glueing with urea adhesive.

Fig. 9. Polished surface of P(ST/AN)-impregnated maple.

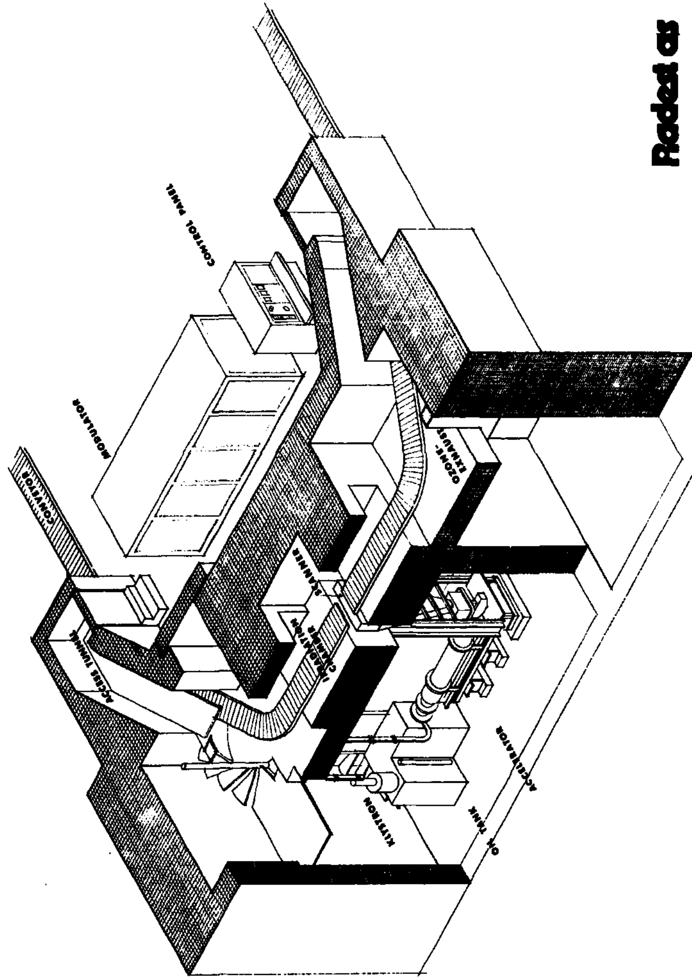


Fig. 10. Layout of 10-MeV electron accelerator plant at RADEST A/S.

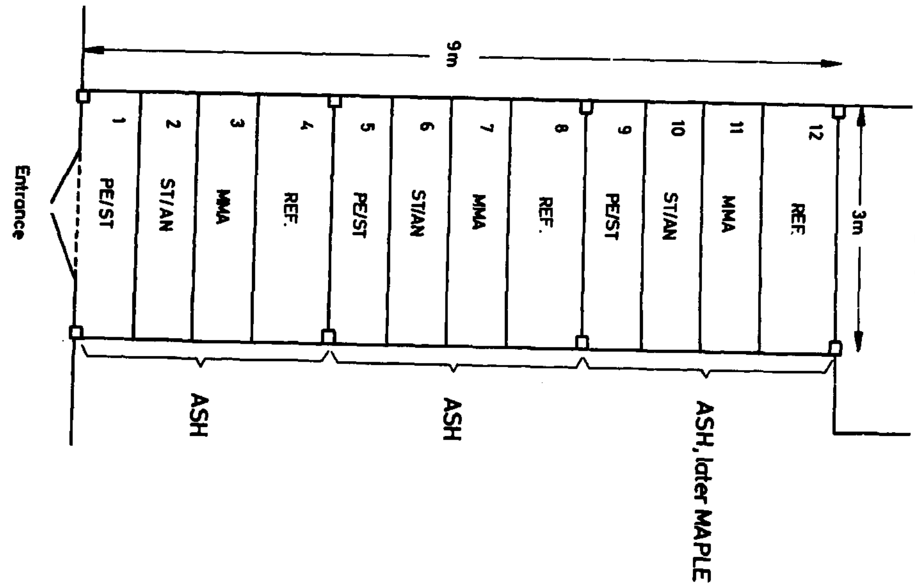


Fig. 11. The test area in the corridor of the Risø canteen.

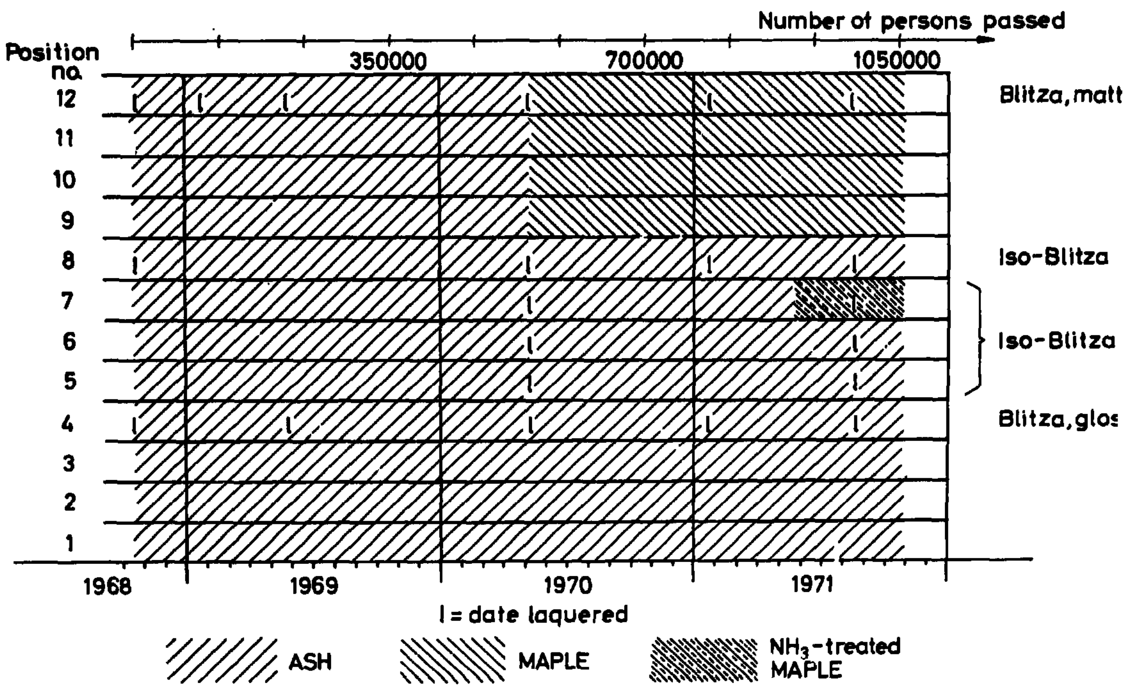


Fig. 12. Table showing the chronology of the performance test.

Fig. 13. Impregnated panels (positions 1, 2, and 3) just sealed with wax (upper part of picture).

Fig. 14. Cleaning by machine

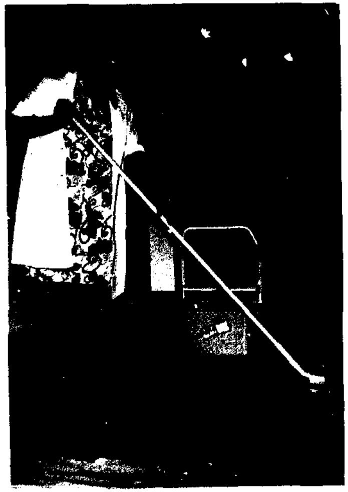


Fig. 15. Cleaning with special hand tool.

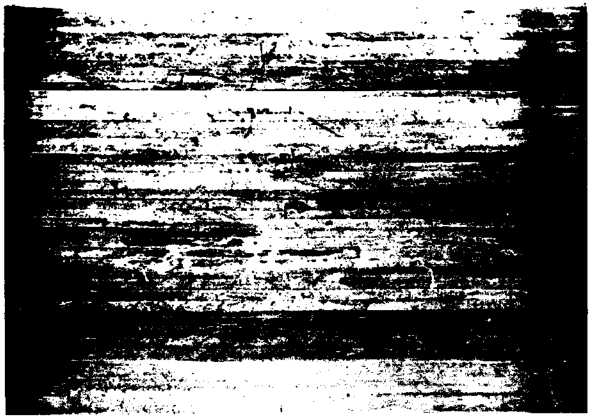


Fig. 16a. Impregnated maple panels (positions 9, 10, and 11) in October 1970 after 5 months of wear.

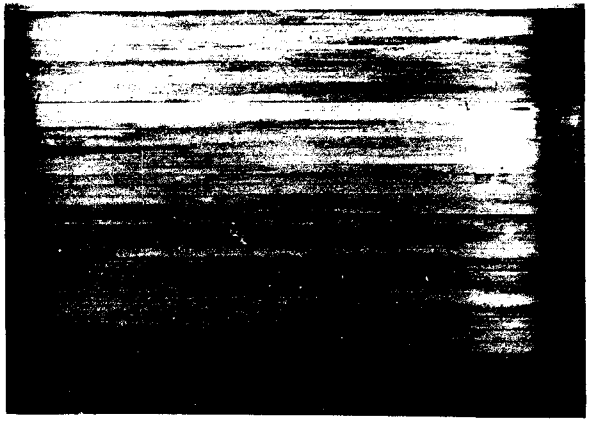


Fig. 16b. Same panels as in the preceding figure, just after re-establishing of the finish.

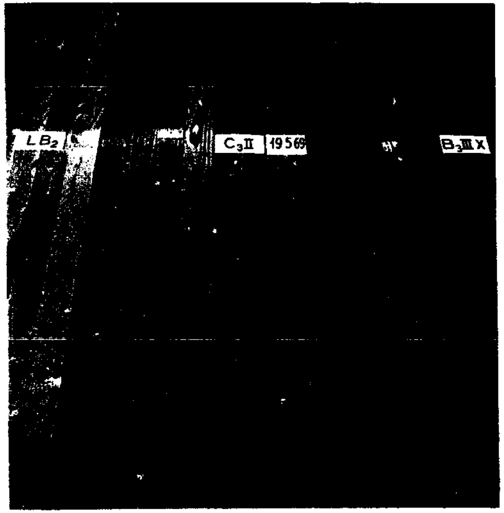


Fig. 17a. Ash PMMA panel after 7 months of wear.

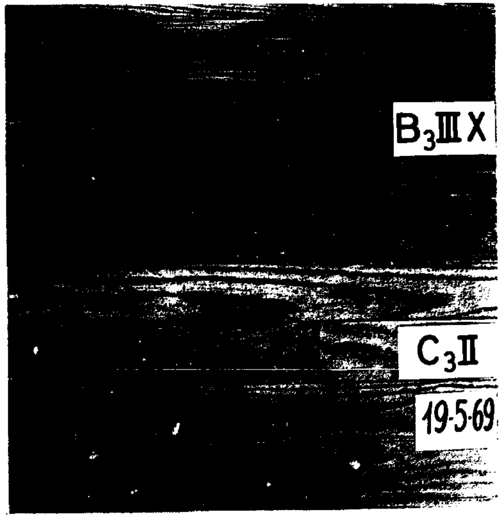


Fig. 17b. Ash panels with PMMA (C_3II) and P(ST/AN) (B_3IIIX) after 7 months of wear.

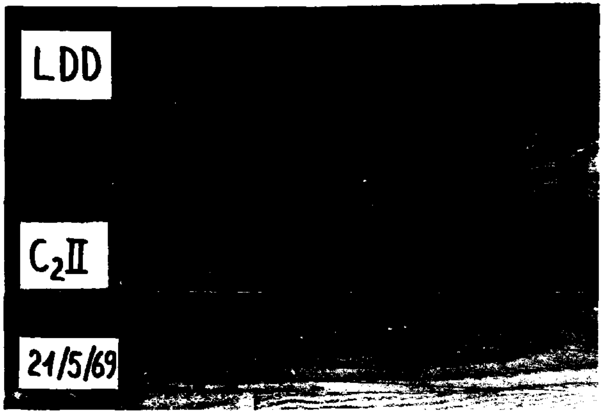


Fig. 18a. Close-up of reference (LDD) and PMMA-containing panel (C_2II) exposed to heavy traffic.

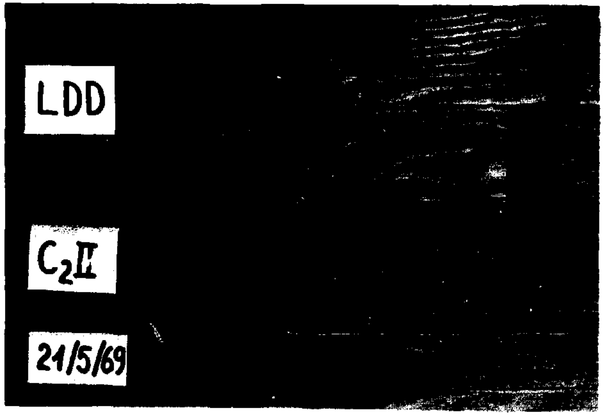
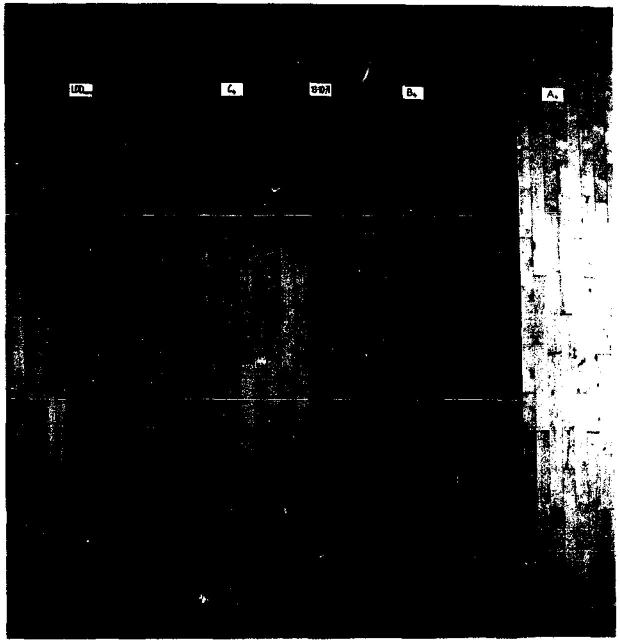


Fig. 18b. Same panels as in figure 18a, but exposed to low traffic near wall of corridor.



a b c d

Fig. 19. Plastic-impregnated maple parquet flooring

a: Polyurethane-laquered reference

b: PMMA

c: P(ST/AN)

d: PE/ST

Fig. 20a, b, and c. The "micro-washboard" appearance of the never surface-treated panels.