ANALYSIS OF GLOSS VALUES OF UNPOLISHED AND POLISHED FLOOR SURFACES AND FINISHES

by

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The objectives of this study were to determine differences in gloss values among various unpolished and polished resilient floor coverings, hard floor materials, and wood floor finishes; and to compare differences in gloss values (1) among various floor materials, (2) between unpolished and polished floor materials, and (3) among various types of floor polishes.

Nine resilient floor coverings were tested under ten surface conditions--unpolished worn condition and after the application of each of nine brands of polish. Seven hard floor materials were investigated under five surface conditions--unpolished new and worn conditions and after the application of each of three kinds of polish. Seven wood floor finishes were applied to red and white oak. These finishes were tested in unpolished new and worn conditions and after the application of each of four types of polish.

Gloss measurements were obtained on each material in each surface condition with the Sixty Degree Gardner Portable Glossmeter. Gloss data obtained from the investigations were subjected to an analysis of variance.

The hypotheses tested were that: (1) there are no differences in gloss values among resilient floor coverings, among hard floor materials, and among wood floor finishes; (2) there are no differences in gloss values between unpolished and polished floor materials; and (3) there are no differences in gloss values among the various types of polish when tested on the floor materials and finishes.

Results of the study indicated a wide range in gloss of the floor materials and finishes tested. Generally gloss values for the resilient floor materials were higher than those for hard floor materials and

wood floor finishes. The new unpolished wood floor finishes showed higher gloss values than either the worn unpolished or the polished finishes. Gloss values were generally higher for all worn materials and finishes after polish was applied. Polish increased the glossiness to the greatest degree on the resilient floor materials. The type of polish which showed the highest gloss values on one group of floor materials did not show the highest values on the other groups of materials. It was concluded that the glossiness of the floor materials was affected more by the inherent characteristics of the material than by the type of polish applied.

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CHAPTER I

INTRODUCTION

Apparently, gloss is one of the most important characteristics of floor polishes from the standpoint of homemakers and of floor-polish manufacturers. Homemakers seem to prefer a floor that is shiny and the floor polish industry is concerned with glossiness during the formulation of its products. The industry has capitalized upon homemakers' desires for floor polishes with high gloss by using in its advertisements such phrases as "shine that conquers time," "outshines all others," "lets the beauty shine through," "dries clear as glass - never yellows," and many others.

Manufacturers of floor materials and finishes are also concerned with gloss. New materials are being developed, such as vinyls, which have higher gloss than conventional floor materials. A variety of wood floor finishes are also being developed which provide the consumer with a wide range of glossiness.

Cleanliness is associated with a glossy floor. In 1963, Hoopes and Patton conducted a study to determine homemaker reactions to various methods of floor care. Results indicated that homemakers' ratings of general appearance were higher for polished floors than unpolished floors. Ratings of marks, dents, and dust were lowest for floors without polish.[1]

[1]Johnnie Ray Hoopes and Mary Brown Patton, Energy Expenditures of Homemakers Performing Floor-Care Activities and an Evaluation of Floor Appearance, Ohio Agricultural Experiment Station, Research Bulletin 946 (Wooster, Ohio, 1963), pp. 18-19.

I. THE PROBLEM

Statement of the Problem

It was the purpose of this study (1) to determine differences in gloss values among various unpolished and polished resilient floor coverings, hard floor surfaces, and wood floor finishes, and (2) to compare differences in gloss values (a) among various floor materials, (b) between unpolished and polished floor surfaces, and (c) among various types of floor polishes.

Importance of the Study

Although homemakers compare brands of polish in selecting one for use, and manufacturers conduct research on their products; no research was found which compared the products of various manufacturers. In addition, little research has been conducted which compared the effect of different types of floor polishes on the glossiness of floor materials and finishes. The inherent characteristics of the materials are thought to affect the initial gloss of floors; however, little research is available to support this.

Limitations of the Study

Data used in this study were assembled from three separate experiments contributing to Agricultural Experiment Station Project 3115 - "Testing of Smooth Floor Surfaces and Finishes from the Standpoint of Safety." This larger project includes three major phases: skid resistance, gloss, and the correlation of these two factors. Gloss readings utilized in this study were recorded concurrently with the skid resistance measurements. Small floor panels of predetermined size of resilient floor coverings, hard floor surfaces, and wood floor finishes were used in the tests.

II. DEFINITIONS OF TERMS USED

Floor polish. A temporary coating used on floors for added beauty and protection which solidifies after application.

Gloss. A property of surfaces which causes them to have a shiny or mirrorlike appearance.

Gloss value. A numerical value based on a gloss scale of 1 to 100 adopted by glossmeter manufacturers for the measurement of gloss.

Hard floor surface. Flooring materials which have little or no cushioning effect such as terrazzo, quarry or ceramic tile.

Resilient floor covering. A smooth-surfaced material which has some capacity to compress when weight is applied and to gradually return to its original state when the weight is removed.

Surface conditions. New, worn, and polished flooring materials and finishes.

Wood floor finish. A coating or sealer applied to wood floor surfaces to protect and preserve the surface appearance.

III. ORGANIZATION OF REMAINDER OF THE THESIS

Included in the following chapter is a brief review of the literature concerning gloss evaluation of floor materials. Chapter III includes a discussion of the experimental procedure. The analyses and interpretation of the data are presented in Chapter IV. The summary and conclusions are given in the final chapter.

CHAPTER II

REVIEW OF THE LITERATURE

Investigations concerned with the gloss of floor surfaces and finishes are limited. This review covers gloss in a general context; a brief history of floor polishes, especially water-emulsion polishes; and studies concerned with instrument measurement and visual estimation of gloss of specific floor surfaces.

I. GLOSS MEASUREMENT

In 1949, Harrison summarized the research which had been done concerning gloss. His work also incorporated research in progress. Although his prime interest was in the area of paper and ink gloss, much of the information presented is general and is applicable to this study.

Some of the ideas presented by Harrison are that:

> Gloss, smoothness and texture are not physical objects or quantities that can be measured in the same way as mass and length; they are sensations, or more correctly sense data; they are neither material nor purely mental; they are dependent on our minds.[2]

> Surface finish can be analyzed into at least five different sets of sense data, three of which come to us through the sense of sight and two from the sense of touch: these are - gloss (lustre), sharpness of mirror image, texture, smoothness and frictional resistance. These qualities are independent of one another.[3]

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[2] V. G. W. Harrison, Definition and Measurement of Gloss (Cambridge, England: W. Heffer & Sons Ltd., 1949), p. 6.

[3] Ibid., p. 117.

> Gloss is not a single sensation, but a complex of at least three simpler sensations. These were found to be: sharpness of mirror image, variations in the brightness of the surface when viewed at different angles, and the parallactic effect in which we seem to be looking at one surface through another.[4]

> While measurements made with instruments are usually taken at fixed angles of incidence and viewing, in making a visual estimation of gloss, we use many angles of incidence and viewing . . . and our final judgment is based, not on a single observation, but on a whole series of observations.[5]

Smith, in 1949, supported Harrison by saying that the problem of gloss is not simple and requires physical and psychological investigation. Specifically Smith said:

> . . . an individual does not consider the reflectance from a surface as a function of an angle when he looks at it but rather he gets an impression which he is most likely at a loss to explain, but which he does not hesitate to evaluate.[6]

In 1950, Hammond and Nimeroff were co-authors of a paper devoted to the measurement of gloss. Of principal concern to the authors were the factors affecting glossmeter accuracy; these being, receiver aperture, source of aperture, position of source image, and specular angle. These authors reiterated statements of Harrison and Smith concerning the appearance of objects. They said that "the appearance of an object depends upon several factors; the illuminant, the reflection characteristics of the material, the surface texture, the illuminating and viewing geometry, and the observer."[7]

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[4]*Ibid.*, p. 135.

[5]*Ibid.*

[6]Daniel Smith, "Gloss and Its Evaluation in Floor Waxes," *Soap and Sanitary Chemicals*, XXVI (March, 1950), p. 133.

[7]Harry K. Hammond, III, and Isadore Nimeroff, "Measurement of Sixty-Degree Specular Gloss," *Journal of Research of the National Bureau of Standards*, XLIV (June, 1950), p. 585.

Gloss and color, according to Hammond and Nimeroff are two of the main attributes for evaluating the appearance of objects. The glossiness and color of materials are determined by the spectral composition and the geometrical distribution of the incident light and upon the transformations that take place upon reflection from the specimen.[8] A distinction should be drawn between body and surface reflection. Body reflectance is that re-emission of light penetrated on the surface and which re-emerges at the incident face.[9] According to Hunter, specular reflection (responsible for glossiness or shininess) occurs at the skin of the surface while diffuse reflection (responsible for color) occurs in the granular structure beneath the skin.[10]

Hunter concluded from his studies that gloss is made up of at least six criteria - actually six different types of gloss. These are defined as follows:

1. Specular gloss - shininess, brilliance of highlights (medium-gloss surfaces of paint, plastics, etc.).

2. Sheen - shininess at grazing angles (low-gloss surfaces of paint, paper, etc.).

3. Contrast gloss - contrast between specularly reflected areas and other areas (low-gloss surfaces of paints, textile cloth, etc.).

4. Absence of bloom gloss - absence of haze, or milky appearance adjacent to reflected highlights (high- and semi-gloss surfaces in which reflected highlights may be seen).

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[8] Ibid.

[9] Ibid., p. 586.

[10] Richard S. Hunter, "Gloss Evaluation of Materials," ASTM Bulletin No. 186 (December, 1952), p. 49.

5. Distinctness-of-image gloss - the distinctness and sharpness in which mirror images may be seen.

6. Surface uniformity gloss - surface uniformity, freedom from visible nonuniformities (medium to high gloss surfaces of all types).[11]

Of particular importance to this study is specular gloss. Specifications for the measurement of specular gloss have been set up by The American Society for Testing Materials and were followed in this study.

II. FLOOR POLISHES

Wax has been used to protect the beauty of objects and surfaces for many centuries. Floor polishes had their origin in Europe during the Renaissance when parquetry floors in France were kept highly polished with beeswax. The first of many steps in the development of today's floor polishes occurred when beeswax was dissolved in turpentine. Until about forty years ago, the floor polishes, referred to as "liquid waxes" and "paste waxes," were actually a dispersion of hard and soft waxes in organic solvents. The wax industry was greatly augmented with the discovery of a self-polishing, water-emulsion polish. Today, water base or bright drying polishes are said to account for approximately four-fifths of the total sales with solvent base liquid and paste floor polishes making up the remaining one-fifth.[12] The majority of research on floor polishes conducted during the past forty years has been concerned with the water-emulsion polishes - particularly in obtaining high gloss and further developing synthetic ingredients.

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[11] Ibid., p. 51.

[12] Walter J. Hackett and Cyril S. Kimball, The Value of Waxing Resilient Smooth Surface Floor Coverings. Research sponsored by the Wax and Floor Finishes Division, Chemical Specialties Manufacturers Association, Inc., (May, 1960), p. 3.

In 1929, floor polish manufacturers found that wax from the Carnauba palm in Brazil could be used to impart a gloss on floors without buffing. As the demand for this product increased, so did price, and research failed to produce a wax which possessed the degree of hardness characteristic of the Carnauba wax. Shellac added to this wax increased the glossiness of the final product. It was not until 1950 that a product - 80% shellac/20% wax emulsion - unique in glossiness, was developed. However, as with other materials that had been used, shellac increased in cost; and the industry sought to develop a completely synthetic product.[13]

At this time polystyrene emulsions began to show promise of replacing natural and synthetic waxes and resins - supply and price being strong influences. In addition, these emulsions showed promise of producing high gloss. Conversely, they produced a high molecular weight, poor color, poor plasticization, dusting off and degradation in the presence of light.[14]

Hackett, Berkeley, and Clark concluded from research on floor polishes that as molecular weight increased, there were also increases in hardness, abrasion resistance, and cohesive strength.[15] As the latex was increased, the following results were obtained:

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[13] L.N. Prince and Dr. J. Zevallos, "Recent Trends in Aqueous Floor Polish," Soap and Chemical Specialties, XXXV (May, 1959), p. 135.

[14] Ibid., p. 143.

[15] Walter J. Hackett, B. Berkeley, and R. E. Clark, "Polyethylene Latex in Floor Polishes," Soap and Chemical Specialties, XXXVIII (April, 1962), p. 72.

1. Soil and heel resistance were improved.
2. Discoloration was reduced.
3. No effects on stability or removal properties were observed over the range tested.
4. Bright-dry gloss (self-polishing effect) was unaffected.
5. Buffability, levelling, and water spot and slip resistance decreased.[16]

Low molecular weight is desirable in the preparation and processing of floor polishes. Rosenbaum and others found by the addition of a low molecular weight emulsifiable polyethylene that desired properties such as slip and water resistance, buffability, and increased traffic wear could be obtained with water-emulsion floor polishes.[17]

Hackett, Berkeley and Clark also inferred that gloss is probably the most important property in the development of floor polishes. Other considerations mentioned were: (1) levelling, (2) non-discoloration, (3) removability, (4) water-spot resistance, (5) resistance to powdering, (6) soil resistance, (7) heel mark resistance, (8) scuff resistance, (9) slip resistance, and (10) stability.[18]

Recent research has led to the formation of aqueous emulsion polishes with some of these improved properties. These polishes consist of a polymer dispersion, an emulsified wax, and an alkali-soluble resin, together with such additives as plasticizers. These have

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[16] Ibid., p. 73.

[17] Robert Rosenbaum, Ralph Bock, and Robert E. Clark, "Property Changes of Emulsion Floor Polishes," Soap and Chemical Specialties XXXIII (August, 1957), p. 83.

[18] Hackett, Berkeley, and Clark, op. cit., p. 75.

produced an improvement in gloss, hardness, levelling, spreading, removability, and slip and water resistance. These polishes are removed by washing with weak acid solutions but are resistant to washing with normal light detergents, water, or mild alkalis.[19]

While considerable emphasis has been placed on gloss, safety also has an important place in the use of floor polishes. Antislip colloidal silica had been used for ten to fifteen years but was not compatible with the newer polymer polishes. However, with the addition of aluminum to the silica molecule, compatibility and subsequently slip resistance, removability, buffability, and stability were increased.[20]

The future will continue to reveal developments in the water-emulsion polish industry. Acrylics and vinyls are being used to some extent and attempts are being made to completely eliminate the use of plasticizers.

Brown and others, in 1963, pointed out that while "water is a desirable vehicle for many types of polishes, certain surfaces are corroded or degraded by contact with water or an aqueous cleaning solution."[21] They believe a large potential exists for the renewal of the

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[19] L. Chalmers, "Formulation of Emulsion Polishes," Reprint from Paint Manufacture (April, 1962) for Eastman Chemical Products, Inc., p.l.

[20] F. A. Simko, "Modified Antislip Polish Additive," Soap and Chemical Specialties, XXXIX (January, 1963), pp. 99-101.

[21] George L. Brown, Michael Pezzuto, and Harry Silverstein, "Formulating Solution Polishes," Soap and Chemical Specialties, XL (May, 1964), p. 127.

solvent-base polishes using a combination of hard polymers and hydrocarbons due to their low cost, low odor, and low toxicity.[22]

In 1965, Malitschek and Sapper presented a paper to the Chemical Specialties Manufacturers Association on liquid solvent floor polishes. Of primary concern to the authors was the stability of these products, influenced largely by the formulating techniques and the processing conditions, in relation to floor maintenance. They pointed out that solvent base liquid polishes play an important part in the European market, due to the cleaning power of the solvents and the highly water resistant films offered by these products.[23]

Until recently all polishes recommended for use on hardwood floors were solvent base liquid and paste polishes which required buffing. According to a recent article new polymer emulsions for floor polishes (dry-bright polishes) should provide serious competition to the paste polish manufacturers. Rapid acceptance of this product for residential use is expected although the higher cost of the acrylic may deter wide commercial use.[24]

III. INSTRUMENT MEASUREMENT AND VISUAL ESTIMATION OF GLOSS

In a 1960 report to the Chemical Specialties Manufacturers Association, Inc., Hackett and Kimball of Snell Laboratories discussed an

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[22] Ibid.

[23] Otto Malitschek and Wolfang Sapper, "Liquid Solvent Floor Polishes," Soap and Chemical Specialties, XLI (May, 1965), p. 123.

[24] "Dry Bright Shine on Hardwood Floors," Canadian Chemical Processing, XLVII (October, 1964), p. 53.

investigation on gloss concerned with the value of waxing resilient floor coverings. Asphalt, vinyl, asbestos, homogeneous vinyl, and rubber tiles were tested, as well as vinyl and linoleum sheet. Representative floor samples of the different materials were installed in areas of the Snell Laboratories building. The test panels were subjected to heavy duty traffic. Selected panels were treated with three types of water-emulsion polish while identical materials were left in an untreated condition. All panels within each test area, and between each test area were subjected to like treatments relative to traffic exposure, periodic cleaning, and wax application. Appearance was evaluated, using the Gardner Glossmeter to obtain gloss measurements, prior to traffic exposure and at two week intervals thereafter for a period of sixteen weeks.[25]

Hackett and Kimball found that waxing enhanced the beauty of the floor coverings tested by increasing gloss on the average of from two to four times.[26] Among other results, they found that with regular waxing, all floor coverings showed a 300 to 400 per cent increase in gloss compared to those on which no polish was used. In addition regular waxing increased resistance to soiling and provided protection against scratching and dulling. Tabular data were presented which allowed for comparison of the materials tested. In each instance, one of the vinyls, treated and untreated, ranked highest in gloss; while linoleum had the lowest gloss value.[27]

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[25] Hackett and Kimball, _op_. _cit_., pp. 3-14.

[26] _Ibid_., p. 5.

[27] _Ibid_., p. 13.

A similar study on resilient floor coverings was conducted by Penn at The Woman's College of the University of North Carolina, Greensboro. This investigation was concerned with gloss of both untreated and polished floor coverings and with correlation of instrument measurements and visual estimations of gloss. Test panels included in this study were battleship linoleum, greaseproof asphalt, plain cork, opaque and translucent solid vinyl, vinyl asbestos, asphalt, and rubber. Duplicate panels, designated Set A and Set B, of the materials were prepared and gloss readings were taken in an untreated condition and after the application of three kinds of water emulsion polish. The Gardner Sixty-Degree Glossmeter was used to obtain gloss measurements.[28]

Results of Penn's study showed that in Set A, the gloss values of untreated materials ranged from 4.90 for battleship linoleum to 71.65 for rubber. Values for Set B ranged from 5.90 for plain cork to 63.70 for translucent solid vinyl. As in the Hackett and Kimball study, a wide range of gloss existed for the materials tested. Battleship linoleum and cork were lowest in gloss and rubber and translucent vinyl highest.[29]

Analysis of variance revealed that there was a greater difference in gloss among materials than among polishes. It was suggested that differences between Set A and Set B were due to heterogeneity among the same types of materials made by different manufacturers.[30]

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[28]Janice Carol Penn, "Appraisal of Gloss and Slipperiness of Resilient Floor Covering Materials," (Unpublished Master's thesis, The Woman's College of the University of North Carolina, Greensboro, 1963), pp. 18-22.

[29]*Ibid.*, p. 30. [30]*Ibid.*, p. 34.

Students selected from the School of Home Economics were asked to visually rank the untreated and polished test panels according to gloss.[31] Correlation coefficients for gloss values and gloss rankings were .906 for Set A and .952 for Set B. After application of polish, correlation coefficients were obtained as follows:[32]

	Set A	Set B
Polish A	.978	.979
Polish B	.975	.984
Polish C	.977	.951

Penn concluded that it is possible for individuals to effectively evaluate the glossiness of resilient floor covering materials and to rank them accordingly.[33]

In a 1962 study by Illing, instrument measurements and visual estimations were compared in relation to the gloss of glazed ceramic tile. The American Society for Testing Materials Committee C-21 on Ceramic Whitewares and Related Products conducted an interlaboratory test in order to establish broad ranges for the classification of bright, semi-mat and mat tiles.[34] Specifically, the study attempted to determine which, if any, instrument could be used with satisfactory precision; the

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[31] Ibid., p. 25.

[32] Ibid., p. 43.

[33] Ibid., p. 50.

[34] Arno M. Illing, "Comparison of Instrument Measurement and Visual Estimation of Specular Gloss of Glazed Ceramic Tile," Material Research and Standards, II (February, 1962), p. 117.

extent to which numerical values compared with visual estimates; and the ASTM method best suited to set up limits for the desired classifications of ceramic tile.[35]

Sixty specimens were obtained for study, of which 27 were designated by the manufacturer as bright; 5, as semi-mat; and 28 as mat tiles. Each tile was coded as to manufacturer, group, and gloss designation. The entire group of specimen was sent to four different organizations; three of which were equipped with Sixty-Degree Gardner glossmeters only. The fourth organization used the Hunter Photometric Unit which measured 60, 45, and 20 degree specular gloss. Using the same instrument and standard procedures, several operators at each organization took readings. Twenty persons from one organization were chosen as visual observers. Untrained in visual gloss evaluation, the observers, under identical conditions, were asked to evaluate the tiles by placing them in groups.[36]

From the results obtained, it was concluded that:

> . . . with proper care specular gloss readings can be reproduced to within ± 8.0 units . . . which is sufficiently close for the intended purpose, namely, classification of ceramic glazed tile into groups having broad ranges of specular gloss.[37]

> . . . correlation between instrument measurement and visual gloss estimates is sufficiently close . . . to establish broad numerical ranges for bright, semi-mat, and mat glazes.[38]

> The Sixty-Degree Glossmeter was recommended for establishing numerical classification for the three groups of tile.[39]

Results from the two preceding investigations indicate that visual observations correlate highly with instrument measurement of gloss.

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[35] Ibid. [36] Ibid., pp. 118-119. [37] Ibid., p. 119.

[38] Ibid., p. 121. [39] Ibid.

Shamburger, in 1965, correlated instrument measurement of gloss and skid resistance for specific floor materials. Results indicated that "the degree of skid resistance of floor surfaces cannot be predicted by the degree of glossiness of the surface."[40]

Considerable research has been conducted on gloss evaluation in general, but few studies were located relative to the gloss of floor surfaces. Much of the gloss evaluation of floor polishes has been limited to tests during the formation of the polishes. No studies were located on the glossiness of wood floor finishes. Only two studies were found on the glossiness of resilient floor coverings; and one study on the glossiness of one type of hard floor surface.

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[40] Elizabeth Shamburger, "The Relationship of Gloss and Skid Resistance of Specific Floor Surfaces," (Unpublished Master's thesis, University of North Carolina at Greensboro, Greensboro, 1965), p. 42.

CHAPTER III

EXPERIMENTAL PROCEDURE

An analysis of gloss values of unpolished and polished resilient and hard floor materials and wood floor finishes comprised this study. This chapter includes a description of flooring selection and preparation of the test panels; selection, application, and removal of floor polishes; procedures used for obtaining gloss measurements; and designation of data analyses.

I. SELECTION OF TEST SAMPLES

Resilient Floor Covering Materials

The samples included nine different resilient floor covering materials. These materials were: asphalt, greaseproof asphalt, plain and vinyl cork, rubber, vinyl asbestos, battleship linoleum, and translucent and opaque solid vinyl. Three samples of each floor covering material were secured from each of two manufacturers. These six samples were used as replications of each material in the experiment. A total of 54 test samples were selected.

Hard Floor Surfaces

The samples included seven locally available hard floor surface materials. The materials were: aggregate, glazed and unglazed ceramic tile in a mortar base, unglazed ceramic tile in vinyl or rubber base, concrete, quarry tile, and terrazzo. Four samples of each of the hard floor surface materials, two samples from each of the two manufacturers, were secured for testing. A total of 28 test panels were selected.

Wood Flooring Materials and Finishes

Seven floor finishes were selected for testing. Four of the finishes -- penetrating floor seal, shallac, varnish, and lacquer - were recommended by the National Oak Flooring Manufacturers Association for use on oak flooring.[41] Both gloss and satin varnish were used. The other two finishes, epoxy and polyethylene, were relatively new products on the market. Since hardwoods are more widely used than softwoods and ninety-one per cent of all hardwood flooring is red or white oak,[42] the finishes were applied to these two types of oak flooring. Twenty-eight test panels were constructed in tongue and groove strip oak flooring in the standard pattern, 25/32 inch thick and $2\frac{1}{4}$ inch face width. Fourteen test panels were of red oak and a like number were of white oak. Grain direction of the panels was alternated when the samples were mounted.

II. SELECTION OF FLOOR POLISHES

Resilient Floor Covering Materials

Nine brands of water-emulsion (self-polishing) polishes from the local market were selected for testing on the resilient floor coverings: three clear polishes, particularly recommended for light floors; three

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[41] The Hardwood Flooring Handbook, A Manual Prepared by the National Oak Flooring Manufacturers' Association (Memphis, Tennessee: 1962), p.9.

[42] James T. Micklewright, A Problem Analysis of Hardwood Flooring Markets (U.S. Forest Service, 1964), p. 2.

labelled as either slip or skid resistant; and three ordinary polishes commonly used on resilient floors but not classified in other categories.

Hard Floor Surfaces

One brand from each of the three kinds of water-emulsion polish: ordinary, clear, and skid resistant; was selected for testing on the hard floor surfaces. The particular brands of polish were chosen for the following reasons: (1) the ordinary polish was found to be the most widely sold polish in this locale;[43] (2) the clear polish was commonly used and readily available; and (3) the skid resistant polish was the only one of its kind found on the grocery store shelves in the local area.

Wood Floor Finishes

The floor finishes were polished with four wood floor polishes. These included a self-polishing polish, a liquid solvent base polish, and two paste solvent base polishes one of which carried a skid resistant seal on the label. The self-polishing polish was one of several of its type now on the market. The liquid and one of the paste solvent base wood floor polishes were the best sellers on the local market, and the slip resistant paste was the only one of its kind that could be found locally.

III. TESTING PROCEDURE

Floor samples were cut into trapezoidal shapes, randomly assigned, and mounted on a plywood ring which was attached to the circular surface

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[43] Penn, op. cit., p. 26.

of the Bowen Friction Tester. Illustrations showing the arrangement of the floor samples on the plywood ring are included in the Appendix. Gloss measurements were taken concurrently with skid resistance measurements utilized in other investigations.[44] Readings were recorded on the unpolished and polished resilient floor covering materials. Like readings were recorded on the wood floor finishes and the hard floor surfaces, unpolished new and worn, and when polished.

Instrument

The Gardner 60° Portable Glossmeter, Model No. GG 9042, was the instrument used in this study to obtain specular gloss measurements of the resilient, hard, and wood floor specimens in accordance with the ASTM D523 test method. Estimation has been made that seventy-five per cent of all gloss measurements made today use this method.[45] Gloss readings were obtained on the untreated panels and after treatment with each polish. Five glossmeter readings were taken for each panel, one in the center and one in each of the four corners. An average was computed of these readings for each test sample.

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[44] Savannah S. Day and Elizabeth Shamburger, "Factors Affecting Skid Resistance of Resilient Floor Coverings," Hospitals, XXXIX (April 16, 1965), pp. 104-106, 111,119.

Marianne Berry Hodges, "Testing of Skid Resistances of Hard Floor Surfaces Using Various Shoe Heel Materials," (Unpublished Master's thesis, The University of North Carolina at Greensboro, Greensboro, 1965).

Katherine D. Smythe, "Skid Resistance of Wood Floor Finishes Under Varying Surface Conditions," (Unpublished Master's thesis, The University of North Carolina at Greensboro, Greensboro, 1966).

[45] Richard S. Hunter, "New Directions in Material Testing...Color, Gloss, Texture," Materials in Design Engineering, LXIII (June, 1961), p. 138.

Accelerated Wear Method

New floor surfaces were worn by an accelerated method using 400-A carborundum paper attached to the weight platform of the Bowen Friction Tester. The testing surface was revolved twenty times beneath the platform.

Application of Floor Polishes

The procedure used for the application of the polishes to the resilient and hard floor materials was a modification of the one recommended by the ASTM designation No. 3-1436.[46] Applicator pads, made of No. 50 grade cheesecloth, were cut into two-inch strips weighing .60 grams each. The area of the trapezoidal test panel was determined and the volume of polish (.1 ml of polish per 4 square inches) was calculated for this area. The required amount of polish (1.7 ml) was pipetted into the middle of a cheesecloth applicator and was distributed evenly over the surface of the test panel. As soon as the polish had been applied, the applicator pad was placed in a ground glass stoppered weighing bottle. This was weighed in order to calculate and record the net weight of the used wet applicator. The weight of the spent applicators could not vary by more than 0.15 grams since a constant film thickness was desired. If the weight variation exceeded 0.15 grams the test panel was cleaned and repolished. The coated surfaces were allowed to dry overnight.

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[46] "Tentative Methods for Application of Emulsion Floor Polishes to Substrates for Testing Purposes," ASTM Designation: D-1436-56T. (Reprinted from Copyrighted 1956 Supplement to Book of ASTM Standards, Part 4), pp. 111-114.

Application of the self polishing polish and the liquid solvent base polish to the wood floor finishes was done in accordance to the same ASTM method followed for polishes applied to the resilient and hard floor surface materials. No standard method could be found for the application of the paste polishes. Therefore, the amount of paste polish applied to each panel was weighed and equaled the weight of the liquid polish used. Inasmuch as possible the paste polishes were applied by the same method as the liquid polishes.

The solvent base liquid and paste polishes required buffing. This was done with an electric polisher which was held in one position on the Bowen Friction Tester while the test panels revolved underneath. Each panel was buffed with brushes during five revolutions of the testing surface and with buffer pads a like number of revolutions.

Removal of Polishes

After gloss readings were obtained for each of the polished resilient and hard floor surfaces, the test panels were stripped of the polish with a solution of one part detergent and one part ammonia to six parts of water. The solution was applied with a sponge to the floor materials and allowed to stand a few minutes. The floor materials were scrubbed with a piece of steel wool, rinsed, and thoroughly dried. The polish on the wood floor finishes was removed with a mineral spirit. Gloss measurements were obtained and compared with the gloss readings for the untreated materials to assure complete removal of the polish.

IV. DESIGNATION OF DATA ANALYSES

Analyses of variance procedures, formulated by statisticians at North Carolina State University at Raleigh, were utilized in the analysis of the gloss data. Separate analysis of variance models were used in each of the three experiments: (1) resilient floor coverings, (2) hard floor surfaces, and (3) wood floor finishes. Mean gloss values were computed and tabulated for those sources of variation from the separate analyses which were significant beyond the 0.01 level of probability.

Resilient Floor Coverings

The resilient floor covering experiment was a split plot design. Floor materials, the experimental units, were regarded as the subunits and the polish types as the whole units. The plan of the split plot experiment was as follows:

Source of variation	Degrees of freedom
Replicates	5
Polish type	2
Brands within polish type	6
Error (a)	40
Floor materials	8
Floor materials x polish types	16
Floor materials x brands within polish type	48
Error (b)	360

The F ratios for the whole units and for the subunits and their interactions were determined by dividing the mean squares by the mean square of error (a) and error (b) respectively.

Hard Floor Surfaces

The experiment on hard floor surfaces was a randomized block design. The 28 test panels were divided into two equal blocks each composed of two test samples of the seven floor materials. The two test samples of each material were from a different manufacturer. The plan of the randomized block design was as follows:

Source of variation	Degrees of freedom
Floor materials	6
Manufacturers within floor materials	7
Duplicates within manufacturers within floor materials	14
Conditions	4
Conditions x floor materials	24
Conditions x manufacturers within floor materials	28
Conditions x duplicates by manufacturers within floor materials (Experimental error)	56

The F ratios for the hard floor surfaces were determined by dividing the mean squares of the main effects and the first order interactions by the experimental error mean square, conditions by duplicates within manufacturers within floor materials.

Wood Floor Finishes

The experiment on the wood floor finishes was basically a factorial design. Wood floor finishes (7), type of oak flooring (2), and grain direction of oak flooring (2) required 28 test specimens (7 x 2 x 2 = 28). Each test specimen was considered an experimental unit in the analysis of main effects and interactions among these three factors. A further factor - surface conditions (6) was introduced in essentially a split plot manner. All combinations of these factors were tested on each of the 28 test specimens. Thus, the main effects and all interactions involving this latter factor were not influenced by random variation among the test specimens.

An analysis and interpretation of the data are presented in the following chapter.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF RESULTS

Analysis of gloss of unpolished and polished resilient floor coverings, hard floor surfaces, and wood floor finishes was the major objective of this study. The hypotheses tested were that: (1) there are no differences in gloss values among resilient floor coverings, among hard floor surfaces, and among wood floor finishes; (2) there are no differences in gloss values between unpolished and polished floor materials; and (3) there are no differences in gloss values among various types of polishes when tested on the floor materials and finishes.

I. ANALYSIS OF GLOSS VALUES OF RESILIENT FLOOR COVERINGS

Gloss values of resilient floor coverings were treated by an analysis of variance. This analysis, presented in Table I, revealed highly significant differences in gloss at the 0.001 level among floor materials, among polish types, and among brands within polish types. The greatest difference was among floor materials. The differences among types of polish were greater than the differences among brands within types of polish. Analysis of the data also revealed significant interactions between floor materials and polish types, and between floor materials and brands within polish types. Because of the large number of degrees of freedom, these two significant first-order interactions would appear to be of little practical importance.

TABLE I

ANALYSIS OF VARIANCE OF GLOSS OF POLISHED RESILIENT FLOOR COVERING

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio
Replicates	5	3045.05	609.01	
Polish types	2	2855.9330	1427.9665	161.65**
Brands in polish types	6	2793.8558	465.6426	52.71**
Error (a)	40	353.3518	8.8338	
Floor materials	8	171540.3191	21442.5398	2212.26**
Floor materials x polish types	16	529.2649	33.0791	3.41**
Floor materials x brands in polish types	48	1227.8204	25.5796	2.64**
Error (b)	360	3489.3506	9.6926	
Total	485	185834.9456		

** Highly significant ($P < 0.001$).

The results obtained from this experiment led to the rejection of the following null hypotheses: (1) there are no differences in gloss values among resilient floor coverings, (2) there are no differences in gloss values between unpolished and polished resilient floor materials, and (3) there are no differences in gloss values among the various types of polish when tested on the resilient floor materials.

Floor Coverings and Types of Polish

Application of polish increased the glossiness of all resilient floor materials tested. The mean gloss values for the unpolished floor coverings ranged from 6.6 for linoleum to 34.8 for rubber (Figure 1, and Appendix A, Table XVI). The order of increasing glossiness for the worn unpolished materials was as follows: linoleum, plain cork, vinyl asbestos, greaseproof asphalt, asphalt, vinyl cork, opaque solid vinyl, translucent solid vinyl, and rubber. The range in gloss for the polished resilient materials was from 9.3 for linoleum to 65.7 for translucent solid vinyl. The order of increasing glossiness for the polished materials was relatively consistent with that of the unpolished materials with the exception of the polished rubber which had lower gloss values than the polished opaque and translucent solid vinyl.

Of the three types of polish tested on the resilient floor coverings, the clear polish showed consistently higher gloss readings than the ordinary or skid resistant polishes. Conversely the skid resistant polish showed consistently lower gloss readings on the materials, with an overall mean of 38.2, compared to an overall mean of 41.8 for the

Figure 1. Mean gloss values of unpolished and polished resilient floor coverings

ordinary polish, and 44.1 for the clear polish. The floor materials polished with the skid resistant polishes ranged from a low gloss reading of 8.4 for the linoleum to a high of 61.1 for translucent solid vinyl. Gloss readings for the ordinary polishes ranged from a low of 9.1 for linoleum to a high of 67.2 for solid vinyl, compared to a low of 10.3 and a high of 68.8 for the clear polishes. There was little difference in gloss, irrespective of the type of polish, between vinyl asbestos and greaseproof asphalt, between vinyl cork and rubber, and between opaque and translucent solid vinyl.

The percentages of gloss increase after the application of polish to the worn resilient floor samples are shown in Table II. Analysis of the percentages of gloss increase revealed that linoleum, originally lowest in gloss, had the lowest percentage of increase in gloss after the application of polish and the translucent and opaque solid vinyls showed the highest increase. Percentages of gloss increase for the floor materials ranged from a low of 27 per cent to a high of 172 per cent. Application of polish consistently increased the glossiness by more than 100 per cent on five of the materials: plain and vinyl cork, vinyl asbestos, and opaque and translucent solid vinyl. Plain cork and the vinyls increased to the greatest degree. Percentages of gloss increase for rubber, originally highest in gloss, ranged from 55 per cent to 72 per cent.

The range in gloss increase for the skid resistant polishes on the resilient floor materials was from 27 per cent to 153 per cent, consistently lower than for the other two polishes. The ordinary polishes increased the gloss of the materials from 38 per cent to 161 per cent.

TABLE II

PERCENTAGES OF GLOSS INCREASE OF RESILIENT FLOOR COVERINGS AFTER APPLICATION OF POLISH TO THE WORN SURFACES

Floor covering	Type of polish		
	Skid resistant	Ordinary	Clear
Linoleum	27	38	56
Rubber	55	67	72
Asphalt	61	74	89
Greaseproof asphalt	79	93	113
Vinyl cork	117	138	147
Vinyl asbestos	116	133	159
Plain cork	133	149	172
Opaque solid vinyl	131	161	170
Translucent solid vinyl	153	157	164

Consistently higher percentages of gloss increase were noted for the clear polishes which ranged from 56 per cent to 172 per cent.

Floor Coverings and Brands within Polish Type

Gloss values for the floor materials by the three brands within each polish type ranged from a low overall mean of 35.1 to a high of 41.2 for the skid resistant polishes, from a low of 39.3 to a high of 45.6 for the standard polishes, and from a low of 41.7 to a high of 46.4 for the clear polishes (Table III). One brand of each type of polish consistently increased the gloss of the floor materials higher than the other two brands. Brand E, among the skid resistant polishes, gave consistently higher readings on all floor materials except linoleum than brands D and F. Of the ordinary polishes, brand K gave consistently higher values than brands G and C. Brand H of the clear polishes showed higher gloss than brands I and J. However, differences among types of polish were greater than differences among brands within polish type.

II. ANALYSIS OF GLOSS VALUES OF HARD FLOOR SURFACES

Gloss readings for hard floor surfaces were treated by an analysis of variance. This analysis, presented in Table IV, revealed significant differences in gloss at the 0.001 level among floor materials, among surface conditions, and among manufacturers within floor materials. The greatest variability was among floor materials. The differences between manufacturers of floor materials suggest that there was heterogeneity

TABLE III

MEAN GLOSS VALUES OF RESILIENT FLOOR COVERING UNPOLISHED AND POLISHED WITH THREE BRANDS OF THREE TYPES OF POLISH

Floor covering	Unpolished worn	Polished									
		Skid resistant polish			Ordinary polish			Clear polish			Overall mean
		D	F	E	G	C	K	I	J	H	
Linoleum	6.6	8.2	8.8	8.1	8.7	8.9	9.8	9.8	9.9	11.2	9.3
Plain cork	8.5	18.2	20.3	21.0	20.2	20.9	22.7	21.5	24.2	23.5	21.4
Vinyl asbestos	13.3	25.2	30.1	30.7	29.6	28.9	34.6	32.8	35.0	36.2	31.4
Greaseproof asphalt	16.2	25.5	30.8	30.8	30.3	28.8	34.7	32.7	35.6	35.2	31.6
Asphalt	20.9	30.0	33.7	37.1	34.7	33.3	41.1	37.8	40.0	40.4	36.5
Vinyl cork	24.0	47.7	51.8	56.8	53.4	55.3	62.4	56.7	59.0	62.1	56.1
Rubber	34.8	50.4	51.6	59.8	56.9	58.1	61.0	57.1	60.5	61.9	57.2
Solid vinyl opaque	24.7	52.3	57.9	61.1	58.2	63.7	71.7	61.3	66.3	72.8	62.8
Solid vinyl translucent	26.1	58.2	59.6	65.6	61.4	68.1	72.1	65.4	66.7	74.4	65.7
Overall mean	19.5	35.1	38.3	41.2	39.3	40.7	45.6	41.7	44.1	46.4	41.3

TABLE IV

ANALYSIS OF VARIANCE OF GLOSS OF UNPOLISHED AND POLISHED HARD FLOOR MATERIALS

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio
Floor materials	6	13416.8770	2236.1462	689.19**
Manufacturers within floor materials	7	1756.4420	250.9203	77.33**
Duplicates within manufacturers within floor materials	14	102.5840	7.3274	2.26
Conditions	4	2623.0932	655.7733	202.11**
Conditions x floor materials	24	966.3488	40.2645	12.41**
Conditions x manufacturers/floor materials	28	356.2180	12.7221	3.92**
Conditions x duplicates/manufacturers within floor materials	56	181.6960	3.2446	
Total	139	19403.2590		

**Highly significant ($P \leq 0.001$).

among the same types of materials made by different manufacturers. Analysis of variance led to the rejection of the following hypotheses: (1) there are no differences in gloss values among the hard floor surfaces, (2) there are no differences in gloss values between unpolished and polished hard floor surfaces, and (3) there are no differences in gloss values among the various types of polishes when tested on the hard floor materials.

Hard Floor Surfaces and Surface Conditions

Gloss values varied little between the unpolished new and the unpolished worn hard floor surfaces (Figure 2, and Appendix B, Table XVIII). The range for the new materials was from 2.4 to 25.7, compared to 2.4 to 19.5 for the worn materials. The overall gloss mean for the new surfaces was 10.8 compared to 9.3 for the worn floor surfaces. Application of polish increased the glossiness of all hard floor surfaces. The order of increasing glossiness for the hard floor surfaces, whether unpolished or polished, was as follows: quarry tile, unglazed ceramic tile, ceramic tile in vinyl or rubber, terrazzo, cement, glazed ceramic tile, and aggregate.

Gloss readings for the hard floor surfaces polished with the ordinary polish were consistently higher than when polished with the clear or skid resistant polishes. Generally the skid resistant polish increased the gloss values more than the clear polish with the exception of two materials, ceramic tile in vinyl or rubber and terrazzo, in which the clear polish produced higher gloss. The overall mean gloss value for the

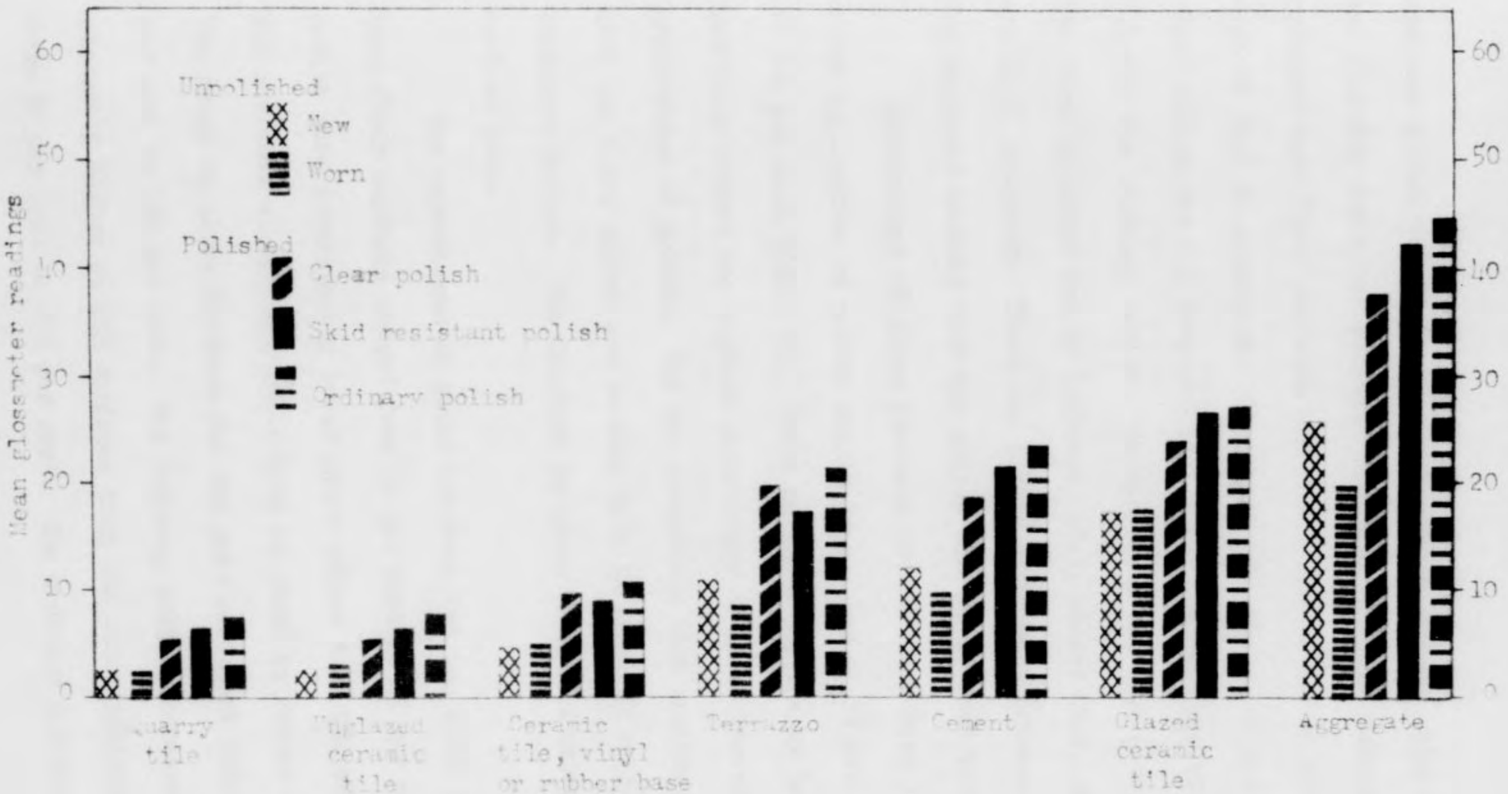

Figure 2. Mean gloss values of unpolished and polished hard floor materials

ordinary polish was 20.3, compared to 18.4 for the skid resistant polish, and 17.2 for the clear polish. The range of gloss values for the polished hard floor surfaces was from a low of 4.7 on quarry tile to a high of 33.9 on aggregate. On quarry tile the gloss reading for the clear polish was 5.3 compared to 6.3 for the skid resistant polish, and 7.4 for the ordinary polish. On aggregate the high gloss reading for the three polishes was as follows: 37.7, clear; 42.1, skid resistant; and 44.7, ordinary. There was little difference between the gloss values for unglazed ceramic tile and quarry tile or between terrazzo and cement.

Percentages of gloss increase for the worn hard floor surfaces after application of polish ranged from a low of 38 per cent to a high of 208 per cent (Table V). Those surfaces originally lowest in gloss generally showed the highest percentages of gloss increase after the application of polish. The two exceptions were unglazed ceramic tile with the clear polish and ceramic tile in vinyl or rubber with the skid resistant polish. The increase in gloss of glazed ceramic tile was 57 per cent or less.

The percentages of gloss increase for the clear polish on the hard floor surfaces ranged from 38 per cent to 85 per cent. The clear polish gave consistently lower gloss values than the other polishes on all surfaces except on ceramic tile in vinyl or rubber and terrazzo. The range in gloss increase for the skid resistant polish was from 53 per cent to 163 per cent. The ordinary polish increased the gloss consistently higher on all surfaces than the other polishes having a range from 57 per cent to 208 per cent. The ordinary polishes increased the

TABLE V

PERCENTAGES OF GLOSS INCREASE OF HARD FLOOR MATERIALS AFTER APPLICATION OF POLISHES TO THE WORN SURFACES

Floor material	Type of polish		
	Clear	Skid resistant	Ordinary
Glazed ceramic tile	38	53	57
Ceramic tile in vinyl or rubber	100	84	116
Aggregate	93	116	128
Cement	89	115	134
Unglazed ceramic tile	87	113	157
Terrazzo	135	104	151
Quarry tile	121	163	208

glossiness of all surfaces by at least 100 per cent with the exception of glazed ceramic tile.

Floor Materials by Manufacturers

Differences in gloss values between duplicates within manufacturers of floor materials were not significant when treated by an analysis of variance. However, differences in gloss values between the duplicate samples of materials from manufacturer 2 were greater than those from manufacturer 1. The greatest differences were between the cement and aggregate floor samples provided by manufacturer 2 (Table VI). Mean gloss values for duplicate materials provided by manufacturer 1 were 13.5 and 13.7, compared to means for duplicate samples from manufacturer 2 of 17.4 and 16.3.

Analysis of variance revealed highly significant differences in gloss between the same types of floor materials from different manufacturers. Examination of Table VI however, revealed small differences in gloss between the materials--quarry tile, cement, and unglazed ceramic tile--provided by the two manufacturers. Overall mean gloss values for materials from manufacturer 1 were 13.6 compared to 16.8 for the same type of materials from manufacturer 2.

Surface Conditions and Floor Materials by Manufacturers

Test samples from manufacturer 2 showed consistently higher gloss readings under the various surface conditions than samples from manufacturer 1 with the exception of terrazzo and cement in all conditions and quarry tile in new and worn conditions (Table VII). Under all

TABLE VI

MEAN GLOSS VALUES OF DUPLICATE SAMPLES OF HARD FLOOR MATERIALS BY MANUFACTURERS

Floor material	Manufacturer one		Manufacturer two	
	Duplicate one	Duplicate two	Duplicate one	Duplicate two
Quarry tile	4.5	4.9	4.7	4.9
Unglazed ceramic tile	4.0	4.6	5.2	6.6
Ceramic tile in vinyl or rubber	5.1	5.3	11.1	9.7
Terrazzo	17.5	19.1	12.4	12.9
Cement	18.6	17.3	18.3	13.9
Glazed ceramic tile	17.5	17.7	27.5	26.6
Aggregate	27.2	26.7	42.6	39.3
Overall mean for duplicates	13.5	13.7	17.4	16.3
Quarry tile	4.7		4.8	
Unglazed ceramic tile	4.3		5.9	
Ceramic tile in vinyl or rubber	5.2		10.4	
Terrazzo	18.3		12.7	
Cement	17.9		16.1	
Glazed ceramic tile	17.6		27.1	
Aggregate	26.9		40.9	
Overall mean for manufacturers	13.6		16.8	

TABLE VII

MEAN GLOSS VALUES OF UNPOLISHED AND POLISHED HARD FLOOR MATERIALS BY MANUFACTURERS

Floor material	Manu-facturer	Unpolished		Polished			
		New	Worn	Clear polish	Skid resistant polish	Ordinary polish	Overall mean
Quarry tile	1	2.6	2.5	5.3	6.1	7.2	4.7
	2	2.2	2.3	5.3	6.4	7.7	4.8
Unglazed ceramic tile	1	2.3	2.2	4.9	5.4	6.8	4.3
	2	3.3	3.8	6.4	7.4	8.6	5.9
Ceramic tile in vinyl or rubber	1	2.8	3.0	6.5	6.6	7.3	5.2
	2	6.6	6.9	13.2	11.5	14.0	10.4
Terrazzo	1	15.3	11.5	23.0	17.8	24.0	18.3
	2	6.6	5.4	16.5	16.5	18.3	12.7
Cement	1	13.5	11.1	19.3	21.9	24.2	18.0
	2	10.7	8.8	18.1	20.8	22.2	16.1
Glazed ceramic tile	1	13.2	14.8	19.2	20.4	20.1	17.6
	2	21.0	19.8	28.6	32.4	33.7	27.1
Aggregate	1	18.9	19.2	30.4	31.8	34.3	26.9
	2	32.5	19.7	45.0	52.4	55.1	40.9
Overall mean		10.8	9.3	17.2	18.4	20.3	

surface conditions gloss values were substantially higher for samples of aggregate and glazed ceramic tile from manufacturer 2 than like samples from manufacturer 1.

III. ANALYSIS OF GLOSS VALUES OF WOOD FLOOR FINISHES

Gloss values for the wood floor finishes were treated by an analysis of variance. This analysis, presented in Table VIII, revealed significant differences in gloss at the 0.001 level among floor finishes, between types of oak flooring, between grain directions of oak flooring, and among surface conditions. Also significant at the 0.001 level were the interactions between surface conditions and wood floor finishes, between surface conditions and grain directions, and among surface conditions, wood floor finishes, and grain directions. Significant at the 0.01 level were the interactions between wood floor finishes and grain directions, and between surface conditions and types of oak flooring. The greatest differences in gloss were among floor finishes, among grain directions of oak flooring, and among surface conditions. Analysis of variance led to rejecting the following hypotheses: (1) there are no differences in gloss values among the wood floor finishes, (2) there are no differences in gloss values between the unpolished and polished wood floor finishes, and (3) there are no differences in gloss values among the various types of polish when tested on wood floor finishes.

Wood Floor Finishes and Surface Conditions

Mean gloss values of the wood floor finishes by surface condition are presented in Figure 3, and Appendix C, Table XX. The range in gloss

TABLE VIII

ANALYSES OF VARIANCE OF GLOSS OF WOOD FLOOR FINISHES UNDER VARIOUS SURFACE CONDITIONS

Source of variation	Degrees of freedom	Sums of squares	Mean square	F ratio
Floor finish	6	40209.11	6701.518	291.180**
Type of oak flooring	1	886.421	886.421	38.514**
Grain direction of oak flooring	1	6013.25	6013.25	261.275**
Wood floor finish x type of oak flooring	6	400.553	66.758	2.9
Wood floor finish x grain direction	6	1683.409	280.568	12.19*
Type of oak flooring x grain direction	1	50.711	50.711	2.203
Wood floor finish x type x grain direction of oak flooring	6	138.094	23.015	
Surface condition	5	4997.283	999.456	269.032**
Surface condition x wood floor finish	30	4306.576	143.552	38.641**
Surface condition x type of oak flooring	5	87.856	17.571	4.729*
Surface condition x grain direction	5	163.556	32.711	8.805**
Surface condition x wood floor finish x type of oak flooring	30	156.983	5.232	1.408
Surface condition x wood floor finish x grain direction	30	377.258	12.575	3.384**

*Significant at 0.01 level.

**Significant at 0.001 level.

Table VIII (Continued)

Source of variation	Degrees of freedom	Sums of squares	Mean square	F ratio
Surface condition x grain direction x type	5	11.834	2.366	.636
Surface condition x wood floor finish x type x grain direction	30	111.463	3.715	
Total	167	59594.357		

*Significant at 0.01 level.

**Significant at 0.001 level.

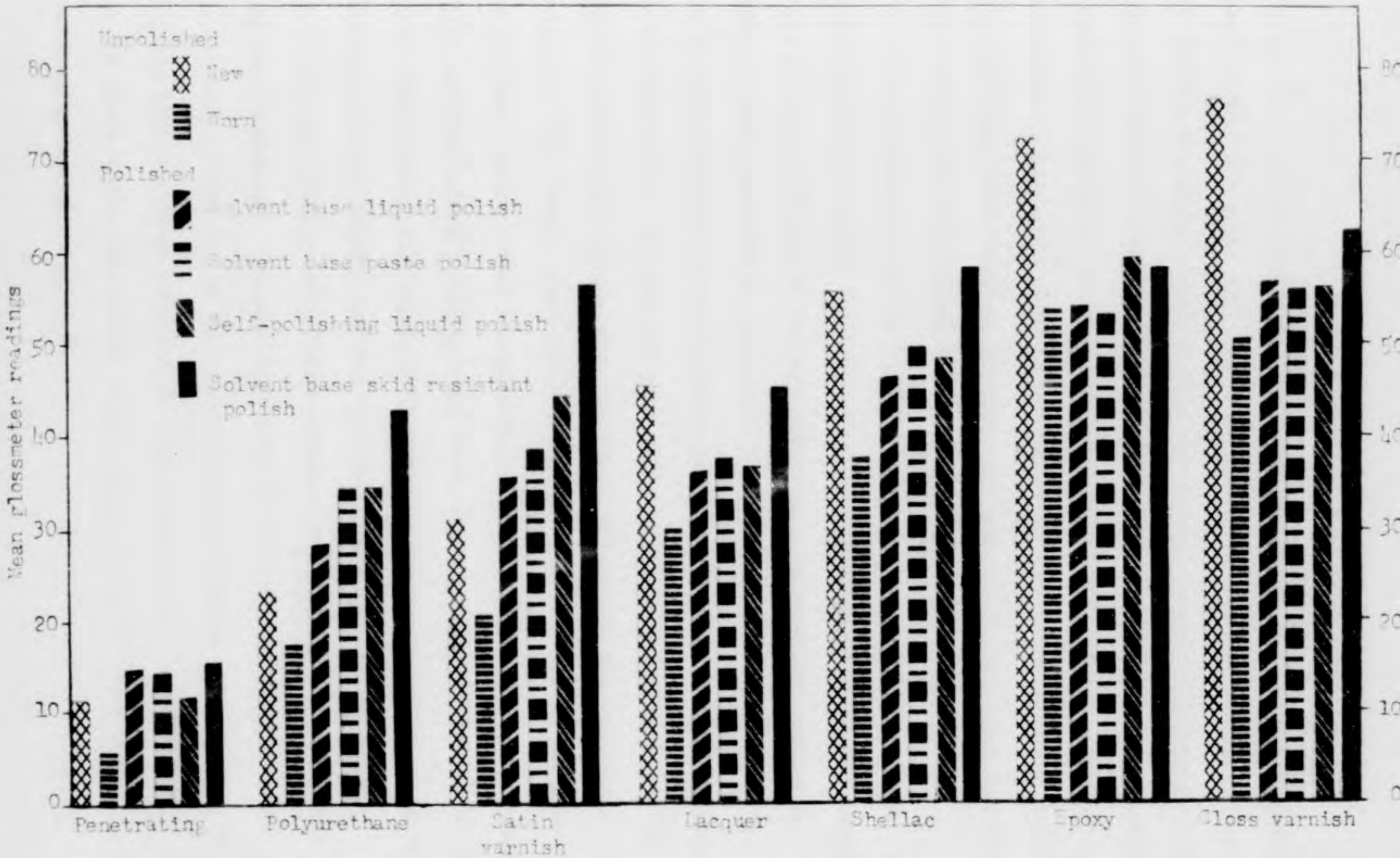

Figure 3. Mean gloss values of unpolished and polished wood floor finishes

values for the new unpolished floor finishes was from 11.3 for penetrating seal to 76.3 for gloss varnish, compared to the worn unpolished values of 5.8 for penetrating seal to 53.5 for epoxy. The overall mean for the new unpolished finishes was 44.8 compared to a mean of 30.7 for the worn unpolished finishes. The floor finishes in the new condition ranked according to increased gloss in the following order: penetrating seal, polyurethane, satin varnish, lacquer, shellac, epoxy, and gloss varnish. In the worn condition, gloss varnish and epoxy reversed positions.

Application of polish failed to restore the glossiness of the worn finishes--lacquer, shellac, epoxy, and gloss varnish--to the glossiness of these finishes in the new condition. Polyurethane and satin varnish both increased in gloss with the application of polish, while there was little difference between the gloss values of new and polished penetrating seal. The solvent base skid resistant polish consistently showed higher gloss values than the other polishes on the wood floor finishes. The overall mean gloss values for the polishes tested were as follows: solvent base liquid polish, 38.8; solvent base paste polish, 40.5; self-polishing liquid polish, 41.4; solvent base skid resistant polish, 48.3. While there were small differences in the overall gloss means of the solvent base liquid, solvent base paste, and the self-polishing polishes, the pattern among these polishes for specific floor finishes was not consistent. The self-polishing liquid polish showed a higher gloss reading than any of the other polishes on epoxy, but gave a lower reading than the other polishes on penetrating seal. Little difference in the gloss values were noted between satin varnish and lacquer and between epoxy and gloss varnish.

Percentages of gloss increase were determined after the application of polish to the worn wood floor finishes (Table IX). Application of polish increased the gloss on the wood floor finishes to a lesser degree than on the resilient and hard floor materials. The worn finishes originally lowest in gloss increased more after the application of polish than the finishes which were relatively high in gloss. The range in gloss increase for the three finishes, originally low in gloss--penetrating seal, polyurethane, and satin varnish--was from 66 per cent to 177 per cent. The range for the finishes, originally high in gloss--lacquer, shellac, epoxy, and gloss varnish--was from -1 per cent to 55 per cent.

The range in percentage of gloss increase for the solvent base liquid polish on the floor finishes was from 1 per cent to 155 per cent compared to the range for the solvent base paste polish from -1 per cent to 152 per cent. Overall means for the floor finishes polished with the solvent base paste polish were higher than when the finishes were polished with the solvent base liquid polish. These two solvent base polishes increased the gloss on all finishes less than 100 per cent with the exception of penetrating seal. The floor finishes polished with the self polishing liquid polish ranged in gloss from 10 per cent to 118 per cent. The skid resistant polish showed higher gloss values than the other polishes tested, with a range from 9 per cent to 177 per cent.

Type of Oak Flooring and Grain Direction

Mean gloss values were significantly lower for each finish on red oak than on white oak flooring. Overall mean gloss values for finished red oak were 38.5 compared to 43.1 for finished white oak.

TABLE IX

PERCENTAGES OF GLOSS INCREASE OF WOOD FLOOR FINISHES AFTER APPLICATION OF POLISHES TO THE WORN FINISHES

Floor finish	Type of polish			
	Solvent base liquid	Solvent base paste	Self-polishing liquid	Skid resistant
Epoxy	1	-1	10	9
Gloss varnish	12	10	11	23
Lacquer	21	25	21	51
Shellac	23	32	28	55
Polyurethane	66	99	100	148
Satin varnish	75	90	118	177
Penetrating seal	155	152	100	162

Mean gloss values were significantly higher for both red and white oak in the lengthwise grain direction than in the crosswise grain direction. The means by grain direction were as follows:

	Crosswise grain	Lengthwise grain
Red oak	33.0	43.9
White oak	36.5	49.6

Overall mean gloss values for crosswise grain direction were 34.8 compared to 46.7 in the lengthwise grain direction.

Wood Floor Finishes and Grain Directions

Gloss values were consistently higher for each floor finish in the lengthwise grain direction. Grain direction appeared to have a greater effect on the gloss of satin varnish, gloss varnish, and lacquer than on the other floor finishes. Small differences between grain directions were noted for penetrating seal, which had values of 11.4 in the crosswise grain direction compared to 13.0 in the lengthwise grain direction, Table X. Conversely, the greatest difference between grain directions was noted in the gloss varnish floor finish, which had gloss values of 51.4 in the crosswise grain direction and 67.6 in the lengthwise grain direction.

Wood Floor Finishes, Surface Conditions, and Oak Types

When treated by an analysis of variance this interaction was not significant; however, with a few exceptions, white oak showed higher gloss readings than red oak for the floor finishes tested under the various surface conditions. The greatest difference in gloss was found

TABLE X

MEAN GLOSS VALUES OF WOOD FLOOR FINISHES BY GRAIN DIRECTION

Wood floor finish	Grain direction		Overall mean
	Crosswise	Lengthwise	
Penetrating seal	11.4	13.0	12.2
Polyurethane	27.2	33.1	30.1
Satin varnish	33.0	42.2	37.6
Lacquer	27.7	49.1	38.4
Shellac	42.6	55.7	49.1
Epoxy	50.1	66.6	58.4
Gloss varnish	51.4	67.6	59.5
Overall mean	34.8	46.7	

for the gloss varnish, which had mean gloss values of 54.4 on red oak and 64.6 on white oak (Table XI). The smallest differences were found between oak types finished with penetrating seal and polyurethane. In all cases but one the solvent base skid resistant polish showed the highest gloss values among the surface conditions. The exception was the epoxy on white oak, where the self polishing polish gave higher values.

Surface Conditions and Types of Oak Flooring

Mean gloss values for surface conditions by types of oak flooring are presented in Table XII. White oak, with an overall mean of 43.1 was consistently higher, whether unpolished or polished, than red oak which had an overall mean of 38.5. Greater differences were noted between the two types on the finishes polished with the solvent base liquid polish. In contrast, the smallest differences were noted for the two solvent base paste polishes.

Surface Conditions and Grain Direction of Flooring

Overall mean gloss values for each surface condition were substantially higher for the flooring in a lengthwise grain direction than the crosswise grain direction (Table XIII). The overall mean gloss value for the crosswise grain direction was 34.8 compared to 46.7 for the lengthwise grain direction. The difference in gloss between lengthwise and crosswise grain was greatest for the finishes polished with the solvent base skid resistant polish.

TABLE XI

MEAN GLOSS VALUES OF WOOD FLOOR FINISHES BY SURFACE CONDITIONS AND TYPE OF OAK FLOORING

Wood floor finish	Type of oak flooring	Surface Condition: Unpolished — New	Unpolished — Worn	Polished — Solvent base liquid polish	Polished — Solvent base paste polish	Polished — Self polishing liquid polish	Polished — Solvent base skid resistant polish	Overall mean
Penetrating seal	Red	10.5	5.4	13.8	15.1	10.7	15.3	11.8
	White	12.0	6.3	15.7	14.2	12.3	15.2	12.6
Polyurethane	Red	23.7	17.3	23.0	34.4	33.6	43.0	29.1
	White	22.4	17.2	34.4	34.7	35.6	42.8	31.2
Satin varnish	Red	27.3	19.0	31.3	35.5	42.2	55.2	35.1
	White	34.3	21.7	39.8	41.8	46.2	57.1	40.1
Lacquer	Red	40.9	24.6	31.7	35.3	32.5	43.0	34.6
	White	49.6	35.4	40.8	39.8	40.1	47.6	42.2
Shellac	Red	51.8	34.3	44.1	49.1	45.4	57.5	47.0
	White	58.4	40.9	48.4	50.2	51.3	58.6	51.3
Epoxy	Red	72.8	52.2	52.3	52.4	57.0	57.0	57.2
	White	71.8	54.9	55.7	54.0	61.2	58.5	59.5
Gloss varnish	Red	71.2	45.9	50.3	49.9	51.4	57.8	54.4
	White	81.5	55.0	62.9	61.4	60.5	66.4	64.6
Overall mean		44.8	30.7	38.8	40.5	41.4	48.3	

TABLE XII

MEAN GLOSS VALUES OF SURFACE CONDITIONS BY TYPE OF OAK FLOORING

Surface condition	Type of oak: Red	Type of oak: White	Overall mean
Unpolished			
New	42.6	47.1	44.8
Worn	28.4	33.0	30.7
Polished			
Solvent base liquid polish	35.2	42.5	38.8
Solvent base paste polish	38.8	42.3	40.5
Self polishing liquid polish	39.0	43.9	41.4
Solvent base skid resistant polish	47.0	49.6	48.3
Overall mean	38.5	43.1	

TABLE XIII

MEAN GLOSS VALUES OF SURFACE CONDITIONS BY GRAIN DIRECTION

Surface condition	Grain direction		Overall mean
	Crosswise	Lengthwise	
Unpolished			
New	38.3	51.4	44.8
Worn	25.9	35.5	30.7
Polished			
Solvent base liquid polish	33.3	44.3	38.8
Solvent base paste polish	35.1	46.0	40.5
Self polishing liquid polish	35.8	47.1	41.4
Solvent base skid resistant polish	40.4	56.1	48.3
Overall mean	34.8	46.7	

Surface Conditions, Wood Floor Finishes, and Grain Direction

The lengthwise grain direction gave substantially higher gloss values than the crosswise grain direction for the lacquer, shellac, epoxy, and gloss varnish finishes under all surface conditions (Table XIV). Smaller differences between lengthwise and crosswise grain were noted for penetrating seal, polyurethane, and satin varnish under most conditions.

TABLE XIV

MEAN GLOSS VALUES OF WOOD FLOOR FINISH BY SURFACE CONDITIONS AND GRAIN DIRECTION OF OAK FLOORING

Wood floor finish	Grain direction	Surface condition						Overall mean
		Unpolished		Polished				
		New	Worn	Solvent base liquid polish	Solvent base paste polish	Self polishing liquid polish	Solvent base skid resistant polish	
Penetrating seal	Crosswise	11.0	5.6	13.5	12.4	11.7	14.3	11.4
	Lengthwise	11.5	6.1	16.1	16.9	11.5	16.2	13.0
Polyurethane	Crosswise	22.7	17.0	26.0	30.8	32.8	34.2	27.2
	Lengthwise	23.4	17.5	31.3	38.3	36.4	51.6	33.1
Satin varnish	Crosswise	27.9	18.1	32.3	34.0	38.7	47.2	33.0
	Lengthwise	33.7	22.6	38.8	43.4	49.7	65.2	42.2
Lacquer	Crosswise	31.1	19.3	26.6	29.0	26.1	34.4	27.7
	Lengthwise	59.4	40.6	45.8	46.1	46.5	56.2	49.1
Shellac	Crosswise	46.0	33.3	39.9	43.8	43.7	49.4	42.6
	Lengthwise	64.2	42.0	52.6	55.6	52.9	66.8	55.7
Epoxy	Crosswise	63.2	44.4	46.3	46.5	50.1	50.1	50.1
	Lengthwise	81.4	62.6	61.6	59.9	68.0	66.9	66.6
Gloss varnish	Crosswise	66.7	43.6	48.9	49.0	47.4	53.5	51.4
	Lengthwise	86.5	57.3	64.3	62.3	64.5	70.7	67.6
Overall mean		44.8	30.7	38.8	40.5	41.4	48.3	

CHAPTER V

SUMMARY, CONCLUSIONS, AND APPLICATION OF FINDINGS

I. SUMMARY

This study involved an analysis of gloss values determined by instrument measurement for resilient floor coverings, hard floor surfaces, and wood floor finishes under varying surface conditions. Review of the literature indicated that exploration in the area had been confined primarily to gloss in general with limited studies on the glossiness of floor surfaces.

The specific objectives of this study were: (1) to determine differences in gloss values among various unpolished and polished resilient floor coverings, hard floor surfaces, and wood floor finishes; and (2) to compare differences in gloss values (a) among various floor materials, (b) between unpolished and polished floor surfaces, and (c) among various types of floor polishes.

A Gardner 60° Portable glossmeter was used to obtain gloss measurements for each surface condition of the wood, hard, and resilient floor materials. Each of the three types of floor materials constituted a separate experiment.

The nine resilient floor materials were: linoleum, asphalt, vinyl asbestos, rubber, vinyl cork, greaseproof asphalt, plain cork, opaque and translucent solid vinyl. Gloss readings were recorded for these materials in ten surface conditions, unpolished worn condition, and after each application of three brands of three different types of water-emulsion polish.

Seven hard floor surfaces--aggregate, unglazed and glazed ceramic, ceramic in vinyl or rubber, concrete, quarry tile, and terrazzo--were tested under five surface conditions. These included new, worn, and after the application of three types of polish.

Seven wood floor finishes--penetrating seal, satin and gloss varnish, shellac, lacquer, epoxy, and polyurethane--were applied to red and white oak flooring. Grain direction of the flooring was alternated when the floor samples were mounted. Six surface conditions were tested--new, worn, and after the application of four types of polish.

Small floor panels of identical size were constructed of the resilient, hard, and wood floor materials. Five gloss readings were taken on each floor sample, and an average of these was computed.

The data for each of the three experiments were subjected to an analysis of variance. Highly significant differences in gloss were found among the polishes and among the floor materials and finishes tested. Significant differences were also noted between same type of materials from different manufacturers in the hard floor surfaces experiment. Grain direction and type of oak flooring were significant in the experiment on the wood floor finishes.

Analysis of variance led to the rejection of the following hypotheses: (1) there are no differences in gloss values among the resilient floor coverings, among the hard floor surfaces, and among the wood floor finishes; (2) there are no differences in gloss values between unpolished and polished floor materials; and (3) there are no differences in gloss values among the various types of polishes tested.

Gloss values for the unpolished resilient floor coverings ranged from a low of 6.6 for linoleum to a high of 34.8 for rubber. The order of increasing glossiness was as follows: linoleum, plain cork, vinyl asbestos, greaseproof asphalt, asphalt, vinyl cork, opaque solid vinyl, translucent solid vinyl, and rubber. Application of polish increased the gloss of the resilient floor coverings. Percentages of gloss increase after the application of polish to the floor materials ranged from 27 per cent to 172 per cent. The order of increasing glossiness after the application of polish was the same as for the unpolished materials with the exception of translucent and opaque solid vinyl which showed higher gloss values than rubber. Of the three types of polish tested on the resilient floor coverings, the clear polish showed the highest gloss values and the skid resistant polish the lowest. One brand of each type of polish generally increased the gloss on the floor materials more than the other two brands.

Gloss values for the new unpolished hard floor materials ranged from a low of 2.4 for quarry tile to a high of 25.7 for aggregate. Small differences were noted between the new and worn unpolished surfaces. The order of increasing glossiness for the unpolished and polished surfaces was as follows: quarry tile, unglazed ceramic tile, ceramic tile in vinyl or rubber, terrazzo, cement, glazed ceramic tile, and aggregate. Application of polish increased the glossiness of the hard floor surfaces. Percentages of gloss increase after the application of polish to the worn floor surfaces ranged from 38 to 208 per cent. Glazed ceramic tile increased to a lesser degree than the other floor materials. Of the three types of polish tested on the hard floor surfaces, the ordinary polish gave the highest gloss and the clear polish the lowest.

Gloss values for the new unpolished wood floor finishes ranged from a low of 11.3 for penetrating seal to a high of 76.3 for gloss varnish. The overall mean for the new unpolished finishes was 44.8 compared to 30.7 for the worn unpolished finishes. The order of increasing glossiness for the wood floor finishes, unpolished and polished, was as follows: penetrating seal, polyurethane, satin varnish, lacquer, shellac, epoxy, and gloss varnish. Gloss values were higher for finished oak flooring in the lengthwise grain direction than crosswise grain direction. Finishes applied to white oak showed higher gloss values than finishes applied to red oak.

Generally, application of polish increased the glossiness of the wood floor finishes. Percentages of gloss increase after the application of polish to the worn finishes ranged from 1 to 177 per cent. Epoxy, polished with the solvent base paste polish, showed a decrease of 1 per cent. Penetrating seal, originally lowest in gloss, showed the greatest percentage of increase. Of the four types of polish tested, the solvent base skid resistant polish showed higher gloss values than either the self-polishing polish or the other solvent base polishes.

II. CONCLUSIONS

The following conclusions were drawn from the gloss data analyzed in this study of resilient floor coverings, hard floor surfaces, and wood floor finishes:

1. Gloss values varied more widely among the resilient floor coverings and wood floor finishes than among hard floor surfaces.

2. Differences in gloss were greater between the new and worn wood floor finishes than between the new and worn hard floor surfaces.

3. Polish increased the glossiness of the floor materials.

4. The inherent characteristics of the floor materials appeared to have greater effect on the glossiness of the material than did the type of polish applied.

5. Floor materials, relatively low in gloss in an untreated condition, were not necessarily low in gloss after the application of polish.

6. The order of increasing glossiness for the polished floor materials was relatively consistent with that of the unpolished materials.

7. Application of polish increased the glossiness of the resilient floor coverings to a greater degree than of the hard floor surfaces or the wood floor finishes.

8. The newer resilient floor materials were higher in gloss than the conventional materials.

9. The type of polish which showed the highest gloss values on one group of floor materials did not show the highest values on the other two groups of materials.

III. APPLICATION OF FINDINGS

The following implications are drawn based on the results of this study on the glossiness of resilient floor coverings, hard floor materials, and wood floor finishes.

Floor materials and finishes in a wide range of glossiness are available on today's flooring market. For homemakers who prefer a resilient floor material with high gloss, the selection of a vinyl or part-vinyl material may be desirable. Conversely, low gloss is available in linoleum, cork, and asphalt floor materials. Gloss values for the hard floor materials are generally low. Aggregate, a relatively new hard floor material; however, is comparable in gloss to that of resilient floor materials.

Manufacturers of wood floor finishes have increased the range of gloss available to the homemaker. A much wider range of gloss, however, exists for finishes in a new condition than for like finishes in a worn condition. Therefore, if a homemaker desires a medium gloss on her floor, the selection of a finish originally high in gloss may be desirable.

Most homemakers seem to prefer polished floors because of the increased gloss or protection offered by the polish. Application of polish to hard floor materials increases the gloss very little, and it would seem that polish does little to enhance the beauty of these materials. Conversely, polish increases the glossiness to a greater degree on the resilient floor materials. While polish generally increases the glossiness of worn wood floor finishes, gloss values are usually not as high as those for the new finishes.

The degree of glossiness obtainable on a floor surface depends on the nature of the floor material selected and on the floor polish applied.

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BIBLIOGRAPHY

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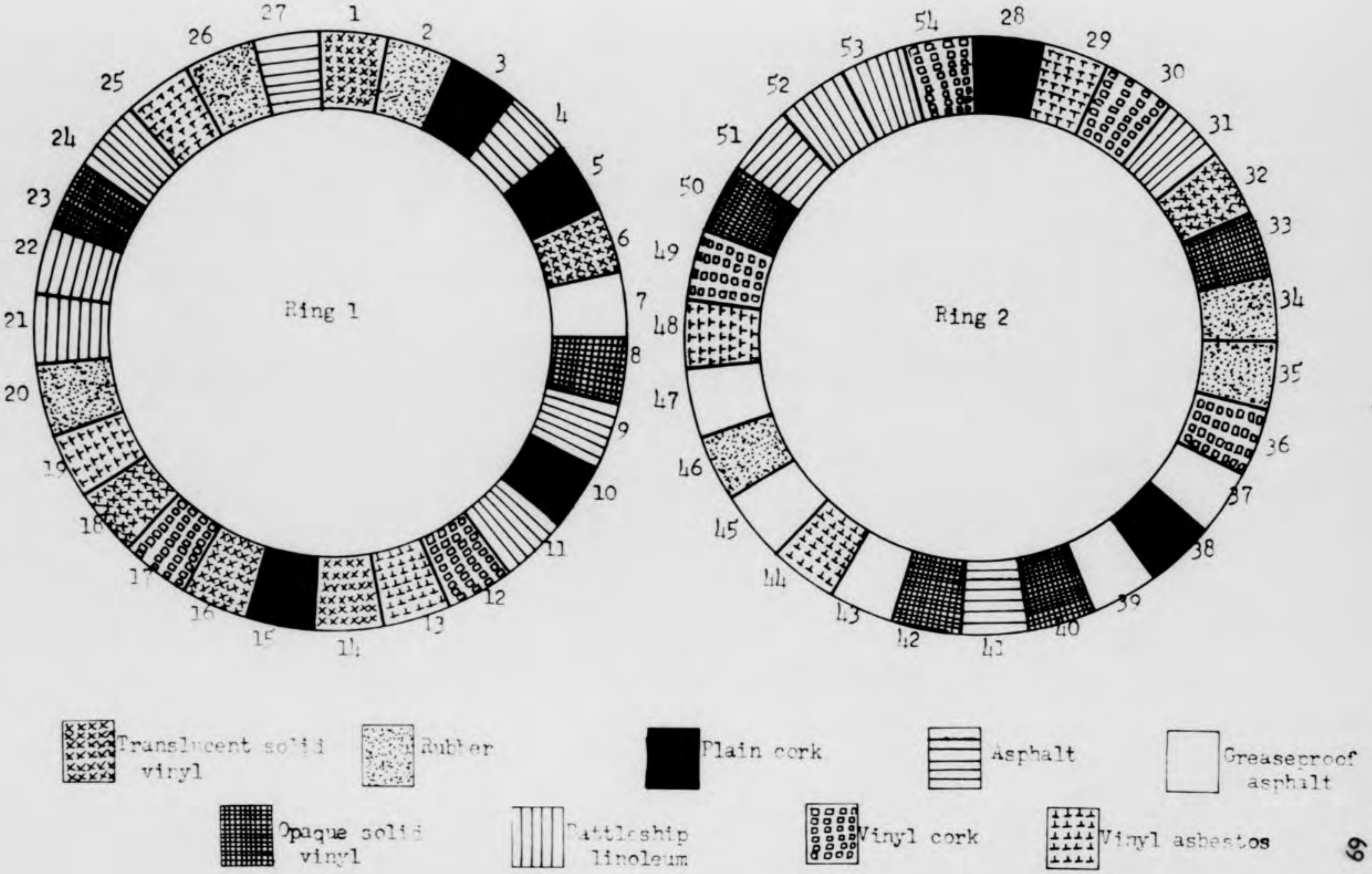
APPENDIX A

Figure 4. Arrangement of test samples of resilient floor coverings on plywood ring



APPENDIX TABLE XV

MANUFACTURERS AND ORDER OF ARRANGEMENT OF RESILIENT FLOOR COVERINGS ON PLYWOOD RING

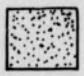
Floor material	Symbol	Replicate	Test panel	Manufacturer
Translucent solid vinyl		1	1	American Biltrite Rubber Co.
		2	6	American Biltrite Rubber Co.
		3	14	American Biltrite Rubber Co.
		4	16	The General Tire and Rubber Co.
		5	18	The General Tire and Rubber Co.
		6	32	The General Tire and Rubber Co.
Rubber		1	2	Kentile, Inc.
		2	20	Kentile, Inc.
		3	26	B. F. Goodrich Co.
		4	34	B. F. Goodrich Co.
		5	35	B. F. Goodrich Co.
		6	46	Kentile, Inc.
Plain cork		1	3	Kentile, Inc.
		2	5	Kentile, Inc.
		3	10	Armstrong Cork Co.
		4	15	Kentile, Inc.
		5	28	Armstrong Cork Co.
		6	38	Armstrong Cork Co.
Asphalt		1	4	Armstrong Cork Co.
		2	21	Flintkote Co.
		3	22	Flintkote Co.
		4	27	Armstrong Cork Co.
		5	41	Armstrong Cork Co.
		6	51	Flintkote Co.
Greaseproof asphalt		1	7	Kentile, Inc.
		2	37	Flintkote Co.
		3	39	Flintkote Co.
		4	43	Kentile, Inc.
		5	45	Flintkote Co.
		6	47	Kentile, Inc.

Table XV (Continued)

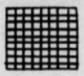
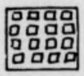
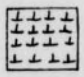
Floor material	Symbol	Replicate	Test Panel	Manufacturer
Opaque solid vinyl		1	8	Robbins Floor Products, Inc.
		2	23	Kentile, Inc.
		3	33	Robbins Floor Products, Inc.
		4	40	Kentile, Inc.
		5	43	Kentile, Inc.
		6	50	Robbins Floor Products, Inc.
Battleship linoleum		1	9	Armstrong Cork Co.
		2	11	Armstrong Cork Co.
		3	24	Congoleum-Nairn, Inc.
		4	31	Congoleum-Nairn, Inc.
		5	52	Congoleum-Nairn, Inc.
		6	53	Armstrong Cork Co.
Vinyl cork		1	12	Armstrong Cork Co.
		2	17	Armstrong Cork Co.
		3	30	Dodge Cork Co.
		4	36	Armstrong Cork Co.
		5	49	Dodge Cork Co.
		6	54	Dodge Cork Co.
Vinyl asbestos		1	13	Flintkote Co.
		2	19	Kentile, Inc.
		3	25	Flintkote Co.
		4	29	Flintkote Co.
		5	44	Kentile, Inc.
		6	48	Kentile, Inc.

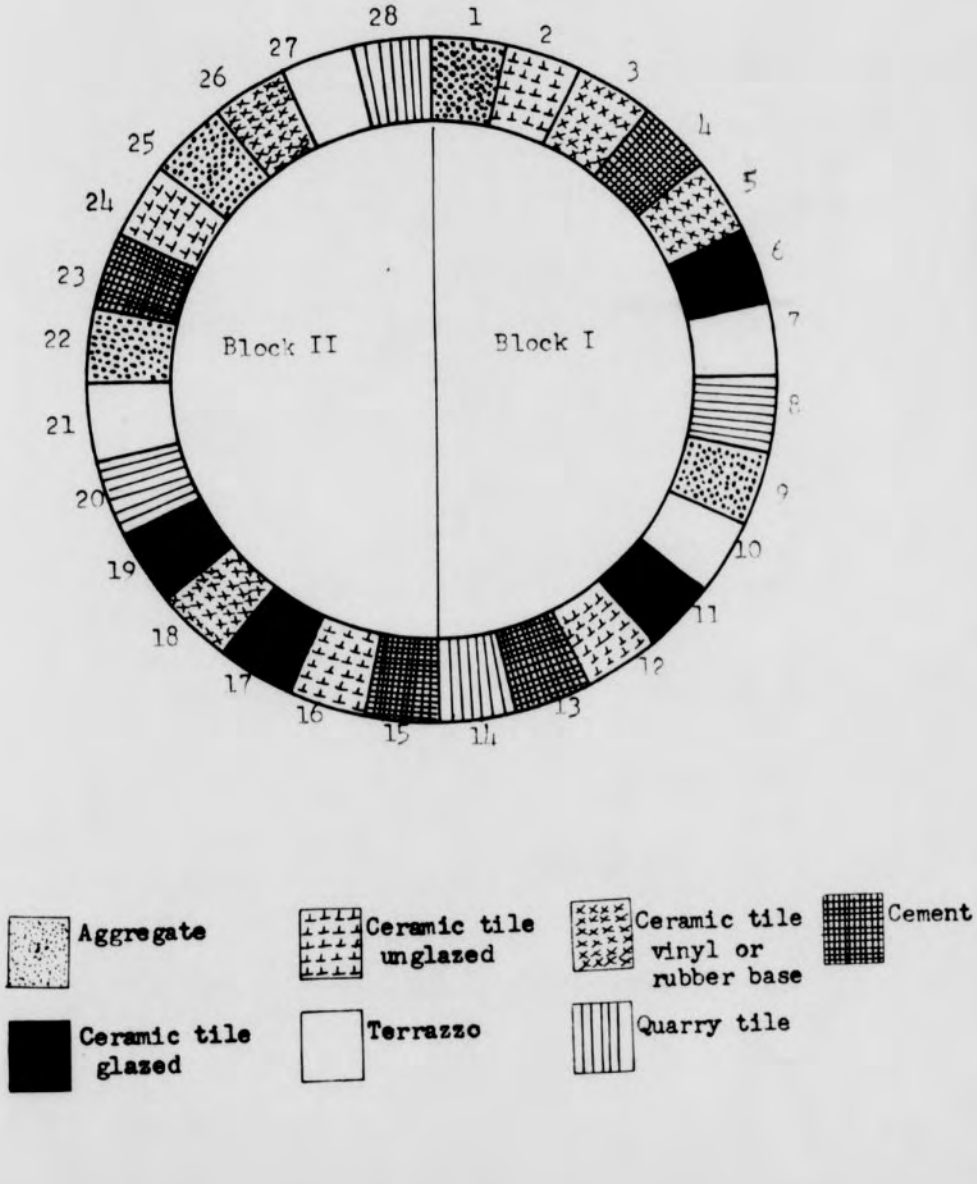
TABLE XVI

MEAN GLOSS VALUES OF RESILIENT FLOOR COVERINGS UNPOLISHED AND POLISHED WITH THREE TYPES OF POLISH

Floor covering	Unpolished worn	Polished			Overall mean
		Skid resistant polish	Ordinary polish	Clear polish	
Linoleum	6.6	8.4	9.1	10.3	9.3
Plain cork	8.5	19.8	21.2	23.1	21.4
Vinyl asbestos	13.3	28.7	31.0	34.4	31.4
Greaseproof asphalt	16.2	29.0	31.3	34.5	31.6
Asphalt	20.9	33.6	36.4	39.4	36.5
Vinyl cork	24.0	52.1	57.0	59.3	56.1
Rubber	34.8	53.9	58.0	59.8	57.2
Solid vinyl opaque	24.7	57.1	64.5	66.8	62.8
Solid vinyl translucent	26.1	61.1	67.2	68.8	65.7
Overall mean	19.5	38.2	41.8	44.1	

APPENDIX B

Figure 5. Arrangement of test samples of hard floor materials on plywood ring



APPENDIX TABLE XVII

MANUFACTURERS AND ORDER OF ARRANGEMENT OF HARD FLOOR MATERIALS ON PLYWOOD RING

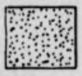
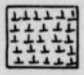
Floor material	Symbol	Block	Test panel	Manufacturer
Aggregate		I	1	J. C. Canaday Co.
			9	Weimar Products, Inc.
		II	22	Weimar Products, Inc.
			25	J. C. Canaday Co.
Unglazed ceramic tile		I	2	United States Ceramic Tile Co.
			12	American Olean Tile Co.
		II	16	American Olean Tile Co.
			24	United States Ceramic Tile Co.
Ceramic tile in vinyl or rubber		I	3	Stylon Corporation
			5	United States Ceramic Tile Co.
		II	18	Stylon Corporation
			26	United States Ceramic Tile Co.
Cement		I	4	Ready Mix Concrete Co.
			13	F. D. Lewis and Son, Inc.
		II	15	Ready Mix Concrete Co.
			23	F. D. Lewis and Son, Inc.
Glazed ceramic tile		I	6	American Olean Tile Co.
			11	Stylon Corporation
		II	17	Stylon Corporation
			19	American Olean Tile Co.
Terrazzo		I	7	Marus Marble and Tile Co.
			10	Ward Tile Co.
		II	21	Ward Tile Co.
			27	Marus Marble and Tile Co.
Quarry tile		I	8	Mosaic Tile Co.
			14	Murray Tile Co.
		II	20	Murray Tile Co.
			28	Mosaic Tile Co.

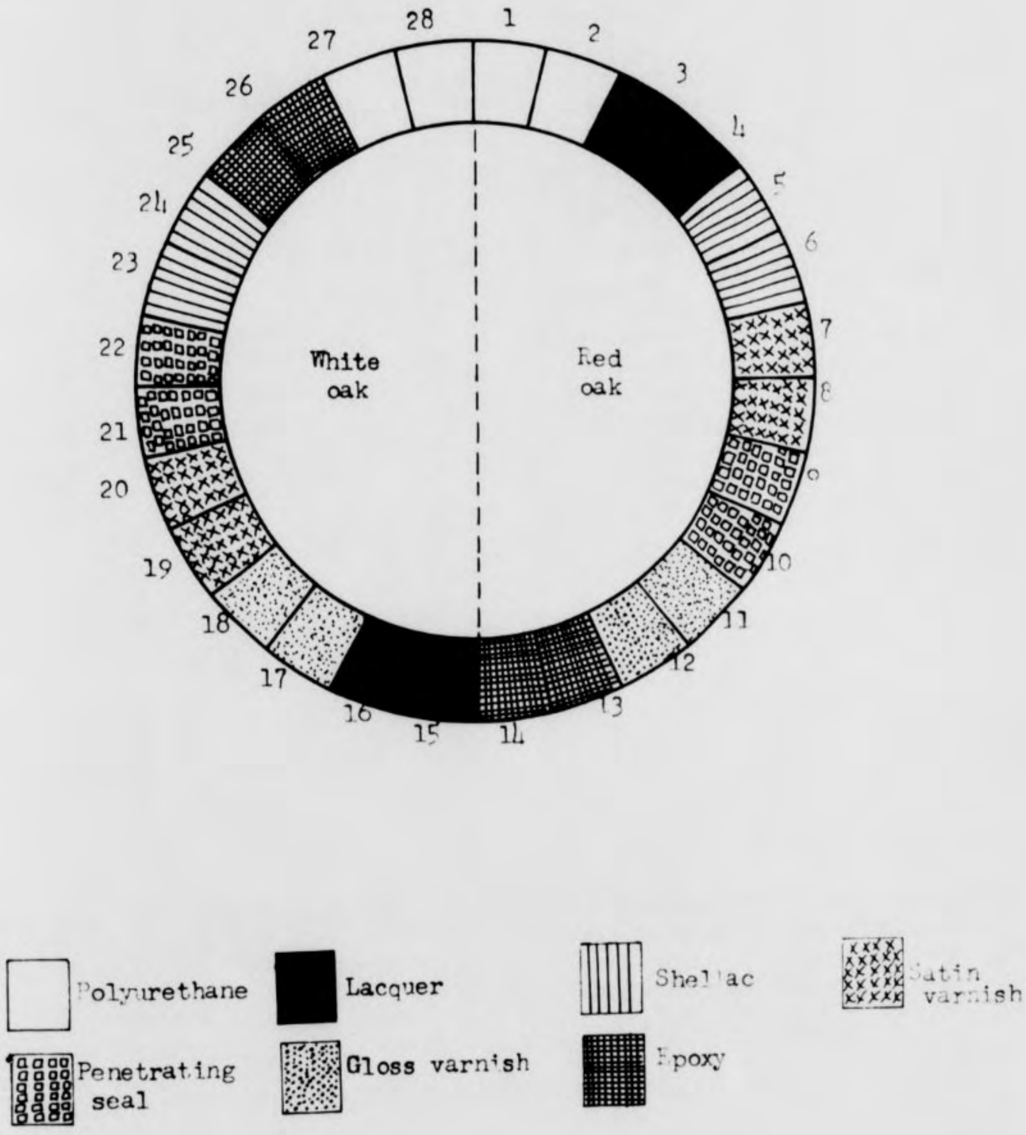
TABLE XVIII

MEAN GLOSS VALUES OF UNPOLISHED AND POLISHED HARD FLOOR MATERIALS

Hard floor material	Unpolished		Polished			Overall mean
	New	Worn	Clear polish	Skid resistant polish	Ordinary polish	
Quarry tile	2.4	2.4	5.3	6.3	7.4	4.7
Unglazed ceramic tile	2.8	3.0	5.6	6.4	7.7	5.1
Ceramic tile in vinyl rubber	4.7	4.9	9.8	9.0	10.6	7.8
Terrazzo	10.9	8.4	19.7	17.1	21.1	15.5
Cement	12.1	9.9	18.7	21.3	23.2	17.0
Glazed ceramic tile	17.1	17.3	23.9	26.4	27.1	22.3
Aggregate	25.7	19.5	37.7	42.1	44.7	33.9
Overall mean	10.8	9.3	17.2	18.4	20.3	

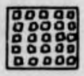
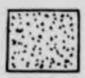
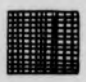
APPENDIX C

Figure 6. Arrangement of test samples of wood floor finishes on plywood ring



APPENDIX TABLE XIX

MANUFACTURERS AND ORDER OF ARRANGEMENT OF WOOD FLOOR FINISHES ON PLYWOOD RING

Floor finish	Symbol	Type of oak	Test panel*	Manufacturer
Polyurethane		Red	1	Glidden Paint Company
			2	Glidden Paint Company
		White	27	Glidden Paint Company
			28	Glidden Paint Company
Lacquer		Red	3	The Seaboard Lacquer Company
			4	The Seaboard Lacquer Company
		White	15	The Seaboard Lacquer Company
			16	The Seaboard Lacquer Company
Shellac		Red	5	The Sherwin-Williams Company
			6	The Sherwin-Williams Company
		White	23	The Sherwin-Williams Company
			24	The Sherwin-Williams Company
Satin varnish		Red	7	Keystone Paint and Varnish Corp.
			8	Keystone Paint and Varnish Corp.
		White	19	Keystone Paint and Varnish Corp.
			20	Keystone Paint and Varnish Corp.
Penetrating seal		Red	9	The Sherwin-Williams Company
			10	The Sherwin-Williams Company
		White	21	The Sherwin-Williams Company
			22	The Sherwin-Williams Company
Gloss varnish		Red	11	Keystone Paint and Varnish Corp.
			12	Keystone Paint and Varnish Corp.
		White	17	Keystone Paint and Varnish Corp.
			18	Keystone Paint and Varnish Corp.
Epoxy		Red	13	The Sherwin-Williams Company
			14	The Sherwin-Williams Company
		White	25	The Sherwin-Williams Company
			26	The Sherwin-Williams Company

*Odd numbers lengthwise grain; even numbers crosswise grain.

TABLE XX

MEAN GLOSS VALUES OF UNPOLISHED AND POLISHED WOOD FLOOR FINISHES

Wood floor finish	Unpolished		Polished				Overall mean
	New	Worn	Solvent base liquid polish	Solvent base paste polish	Self polishing liquid polish	Solvent base skid resistant polish	
Penetrating seal	11.3	5.8	14.8	14.6	11.6	15.2	12.2
Polyurethane	23.0	17.3	28.7	34.5	34.6	42.9	30.1
Satin varnish	30.8	20.3	35.5	38.6	44.2	56.2	37.6
Lacquer	45.2	30.0	36.2	37.6	36.3	45.3	38.4
Shellac	55.1	37.6	46.2	49.7	48.3	58.1	49.2
Epoxy	72.3	53.5	54.0	53.2	59.1	58.2	58.4
Gloss varnish	76.3	50.5	56.6	55.7	56.0	62.1	59.5
Overall mean	44.8	30.7	38.8	40.5	41.4	48.3	

APPENDIX D

TABLE XXI

MANUFACTURERS OF POLISHES TESTED ON THE FLOOR MATERIALS

Type of floor material	Polish	Manufacturer
Resilient floor coverings	Clear	
	Brand H	Purex Industrial Co.
	Brand I	S. C. Johnson and Son, Inc.
	Brand J	Simoniz Company
	Ordinary	
	Brand C	E. L. Bruce Company, Inc.
	Brand G	John C. Stalfort and Son, Inc.
	Brand K	S. C. Johnson and Son, Inc.
	Skid resistant	
	Brand D	Vestal Laboratories
	Brand E	Continental Wax Corp.
	Brand F	Simoniz Company
Hard floor surfaces	Clear	S. C. Johnson and Son, Inc.
	Ordinary	S. C. Johnson and Son, Inc.
	Skid resistant	Continental Wax Corp.
Wood floor finishes	Self-polishing liquid	S. C. Johnson and Son, Inc.
	Solvent base liquid	S. C. Johnson and Son, Inc.
	Solvent base paste	S. C. Johnson and Son, Inc.
	Solvent base skid resistant	The Trewax Manufacturing Company of the Midwest