REPORT ON PROGRESS IN DEVELOPMENT OF TESTING METHODS FOR FIBERBOARDS

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Introduction

The fiberboard industry (including insulation boards, hardboards, particle boards, and chipboards) has continued to grow and expand as its products have found more diverse uses and broadened markets. Of particular significance in this development is the key role played by these materials in effecting improved utilization of the forest crop through the reduction of wood waste and residues. The International Consultation on Insulation Board, Hardboard, and Particle Board, sponsored by the FAO in Geneva in 1957, was a timely recognition of the international importance and interest in this growing field.

The growth of the fiberboard industry continues to emphasize the need of reliable information on the characteristics and the physical and mechanical properties of the various types of products. Accordingly, the development of methods of test to evaluate these properties not only continues to be of interest but assumes increased importance. Because of the progress being made

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The term "fiberboard" is intended to apply to the family of ligno-cellulosic panel materials of which insulation board, hardboard, and particle board (chipboard) are the most prominent.

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by the FAO Conference on Wood Technology, the subject of testing methods for fiberboards was not included directly in the agenda of the Geneva International Consultation. However, since no discussion of these board products is complete without consideration of methods of evaluating physical and mechanical properties, a report summarizing the progress of the work in the FAO Conference on Wood Technology was included in the documentation of the International Consultation as appendix material. This summary, entitled "Survey of Testing Methods for Fiberboards," presented an overall compilation of the methods agreed on by the FAO Conference on Wood Technology and outlined further areas of needed research and development relating to testing methods (9).

Methods of Test as Related to Fiberboard Types

The three broad types of fiberboard in extensive commercial production are insulation board, hardboard (and semihardboard), and particle board (chipboard). Although different fiberboards have certain specific applications, many of them cannot be defined closely as to type, and, because of overlapping ranges in density and properties, they cannot be clearly classified with respect to specific uses, applications, or properties. This situation points to the desirability of establishing test methods for evaluating physical and mechanical properties that are applicable to all fiberboards regardless of type. Experience has already shown that there are no special technical difficulties in this approach, and that to a considerable extent fiberboard test methods and required equipment can be integrated with test methods and procedures that have long been used for related materials, such as wood, plywood, and other wood-base products.

General Principles Relating to Fiberboard Tests

Many factors must be considered in developing methods of test. These include methods for and extent of sampling, considering desirability of statistical treatment; the need of correlating test methods as far as possible with those used for other materials to afford comparable results; the desirability of establishing methods applicable to all types, densities, and thicknesses, yet as simple as possible consistent with adequacy of the evaluation; the need of establishing requirements for accuracy and for such factors as rate of loading that affect the test results; the desirability of methods that will afford reproducibility of results; and of major importance, the purpose of the tests as the controlling factor in the selection of kind and type of test, and in establishing requirements for sampling, accuracy, and other of the features involved.

Underlined numbers in parentheses refer to references at the end of this report.
From the standpoint of purpose of tests as it necessitates consideration of different testing procedures and requirements, three distinct fields of application may be considered, as follows: (1) Methods of test for the accurate engineering evaluation of physical and mechanical properties of fiberboards for structural uses; (2) Quality control procedures, for use by manufacturers in the continual checking of the product to maintain the desired quality; and, (3) Acceptance tests, as a means of establishing product quality in relation to specification requirements for general or for specific uses (8, 9).

Methods of Test for Engineering Evaluation of Physical and Mechanical Properties

Principal emphasis has so far been given by the FAO Conference on Wood Technology to the development of methods for accurately and completely evaluating the mechanical and physical properties of fiberboards, particularly for structural applications. The data obtained by these procedures may be used for comparison purposes with other engineering materials of construction, or, where applicable, to engineering design. The methods may also be used in connection with specification requirements. They are not as a whole intended for use in quality control in manufacture, where for certain properties, such as static bending, a more rapid and less complete or perhaps less accurate method may suffice.

In general, it is the objective to develop test methods to evaluate each of the important properties involved in a wide range of uses. In the testing of any particular product, however, it is recognized that the complete series of tests may not be necessary for the particular objective in mind. Rather it is the thought that from a large number of different test procedures developed for the complete engineering evaluation of physical and mechanical properties, only such tests as are needed in any particular instance would be made. Due consideration should at the same time be given to proper sampling and to the number of tests from the standpoint of statistical treatment of results.

Progress Made by the Working Party on Methods of Testing Fiberboards

The FAO Conference on Wood Technology early recognized the increasing importance of fiberboards and established a technical working party to develop methods for evaluating the physical and mechanical properties of these materials. Following an initial conference in Washington in 1947, research on methods of testing fiberboards has continued, and the subject has been considered and reported on at each of the four subsequent international conferences. Following preliminary studies and plans discussed at the 1948 and 1949 Geneva meetings, substantial agreements with respect to procedures for a number of tests were reached at the 1951 conference in Igls. The test
methods reviewed and agreed on up to that time are published in the report of the Second Conference on Mechanical Wood Technology (1951). Additional test methods were considered at the Third Conference on Wood Technology in Paris, 1954, and recommendations relating thereto are recorded in the report of the meeting, entitled "Third Conference on Wood Technology." Significant accomplishments have thus resulted from the continued effort by the technical working party and the conference members over a period of years as a result of the early recognition of the importance of the problem.

Status of FAO Test Method Developments

The following is a brief summary, mainly by title, of test methods and procedures developed by the FAO Conference on Wood Technology, together with a listing and discussion of additional kinds of tests that have been suggested for study and consideration.

1. Test methods and procedures agreed on at Second Conference on Wood Technology, Igls, Austria, 1951, and published in the Second Conference Report.
   a. Size and appearance of boards
   b. Strength properties:
      1. Static bending
      2. Tensile strength parallel to surface
      3. Tensile strength perpendicular to surface
      4. Nail holding:
         a. Lateral nail resistance test
         b. Nail withdrawal test
   c. Moisture tests:
      1. Water absorption
      2. Linear variation with change in moisture content
   d. Accelerated aging
   e. Cupping and twisting
   f. Moisture content and specific gravity

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a. Hardness test
   1. Janka ball test method
   2. Monnin test method
   3. Steel ball test method

b. Nail-head pull-through test

c. Dimensional stability under differential relative humidity exposure on different faces

d. Compression perpendicular to faces and recovery

e. Delamination:

   Test for fiberboards for interior use


a. Screw withdrawal test

b. Glue line shear test

c. Plate shear

d. Panel shear test (shear strength perpendicular to plane of the sheet)

e. Shear strength in the plane of the fiberboard

f. Glue line shear test

g. Single blow impact tests
   1. Toughness test
   2. Monnin pendulum impact test method

h. Indentation and puncture resistance
   1. Falling ball impact test
   2. Falling ball indentation test
   3. Panel impact test
   4. Izod puncture test

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Recommendations for Consideration of Working Party

Test Methods

It is desirable that each of the test methods developed be described in sufficient detail with respect to all factors affecting the results, so that uniform and comparable results can be obtained regardless of where the tests are made. It is assumed, in addition, that suitable equipment and facilities are available.

As may be noted from the report of the Third Conference on Wood Technology, the five test methods agreed on at that time were described only briefly as to the principles to be employed. Time was not available to prepare the complete detailed procedures. The tests referred to are hardness, nail-head pull-through, dimensional stability under differential humidity exposure on different faces, compression perpendicular to faces and recovery, and delamination, for boards for interior use. Suggested detailed procedures for each of these tests are now presented for consideration of the Working Party in Appendix A. Likewise, detailed procedures for a number of additional test methods previously discussed were developed for consideration of the conference and are also given in Appendix A.

Definitions of Terms

The definition of terms relating to fiberboards has not been included in previous discussions of the Working Party. However, because of possible interest in definitions, and their relation to test methods, attention is called to the definitions presented in the Secretariat Paper, Item II, Product Description, Nomenclature and Definitions, included in the program of the International Consultation on Insulation Board, Hardboard and Particle Board, Geneva, 1957 (7).

Status of Other Test Methods Under Consideration

Resistance to Decay

Resistance to decay is an important consideration in certain fiberboard uses and methods of evaluating resistance are accordingly required in the overall evaluation of properties of fiberboards. This subject was discussed at the Third Conference and recommended for further study. It appears that consideration should be given to the determination of mold resistance as well as decay resistance, in that both are important. Methods of testing against
molds may involve quite different procedures than for decay, and furthermore, mold resistance can be determined more quickly. Some further studies of such test methods as have been developed for mold and decay resistance would still seem desirable before definite recommendations regarding any specific method should be made.

As was reported previously, one promising method of evaluating decay resistance of fiberboards is the so-called soil-block method entitled "Method of Testing Wood Preservatives by Laboratory Soil-Block Cultures," (ASTM D1413-56T). Much research and development has been carried out in the establishment of this method, which has now been adopted as an American Society for Testing Materials method under the above designation. This method of testing for decay was developed primarily on the basis of tests and studies with wood and satisfactory results are obtained. It is believed that the soil-block method is a promising one for evaluating decay resistance for fiberboards, but as yet no formal tests or comparisons of test methods have been made to determine the application to these materials.

Attention is called also to the British Standard Methods of Testing Fungal Resistance of Manufactured Building Materials, B. S. 1982:1953, published by the British Standards Institution. This standard is intended for testing the fungal resistance of fiber building boards, wood chipboards, improved wood, and other building materials composed wholly or partly of organic constituents. The method covers both tests against wood-rotting fungi and methods of test against molds.

Another method that may be of interest for review in connection with tests of fiberboards is that of the Technical Association of the Pulp and Paper Industry (1954)- Tentative Standard T-487 sn-54-Fungus Resistance of Paper and Paperboard.

Perhaps other methods that have been used are also available for reference. Further study of methods of decay resistance of fiberboards is recommended with the thought of comparing and further evaluating the applicability of different methods.

Resistance of fiberboards to attack by such insects as termites is an important consideration in some areas and regions. Treatment of fiberboards and methods of test for evaluating treatments are needed where fiberboards are subject to insect attack.

Perhaps there is a need also for a resistance to decay method less severe than the soil-block test. Fiberboards are used to a large extent where conditions of exposure are not severe and only moderate decay resistance is desired. Attention should be given to the development of a test procedure for evaluating both untreated and moderately treated boards.
Test Methods for Other Materials Also Applicable to Fiberboard

The need for evaluating certain properties of a variety of different materials, particularly for use in the building industry, has led to the development of a number of test methods of previously established usage that are also applicable to fiberboards. Included in this group are tests for evaluating (a) acoustical properties, (b) thermal conductivity, (c) fire resistance (ignition, flame spread, flame penetration, and burn-out tests), and (d) racking resistance of sheathed frame walls.

A summary and discussion of fire test methods were presented in the Report of the Third Conference on Wood Technology, and special consideration is being given to this subject at the Fourth Conference. A partial list of references relating to the evaluation of acoustical properties and thermal conductivity are presented herewith in the list of references. No additional study of or recommendations regarding these methods are presently contemplated by the Working Party on Testing Methods for Fiberboards and Chipboards.

Other Problems Involving Methods of Test

The principal consideration in the program of the Working Party on Testing Methods for Fiberboards and Chipboards has been devoted to methods of test for the accurate engineering evaluation of the physical and mechanical properties of fiberboard, principally for structural and other uses. With the subject matter included in this report the requirements for tests in this field of work have appropriately been quite completely covered so that recommended test procedures are available for a wide variety of property evaluations. Other problems involving methods of test, however, include quality control procedures for use by manufacturers in the continual checking of the product to maintain the desired quality, and acceptance tests as a means of establishing product quality in relation to specification requirements for general or specific uses.

Quality Control Procedure

The basic purpose of quality control tests is to provide a check on the quality of the current product so that necessary steps can be taken to insure continuous production that will meet the standard requirements and subsequently meet appropriate acceptance tests and specification requirements. While quality control is thus recognized as an essential product requirement, the FAO Conference on Wood Technology has not yet given this problem special study or consideration except as the presently approved evaluation methods may be applicable. While it is recognized in this connection that the application of quality control methods is specifically within the province of the individual manufacturers, it would obviously be desirable to correlate them as far as possible with the present methods developed for evaluating the physical and mechanical properties.

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Acceptance Tests and Specification Requirements

Another phase of test requirements is that relating to procedures involved in evaluating material with respect to its acceptance under certain specification requirements that may be needed by the purchaser or user to insure that the quality of the building fiberboard meets the standards required. Acceptance test procedures have many of the same general requirements as quality control methods. Many included in present specifications for building fiberboards are somewhat similar to those used for quality control procedures. While it would appear desirable also to correlate acceptance tests, the great variety of specifications covering materials used for different purposes, and the large number of individual contacts involved, make this difficult.

Plans for Further Work

With the methods already approved, and the presentation, discussion, and review of the several test methods presently under consideration by the Working Party, the principal requirements with respect to the accurate engineering evaluation of physical and mechanical properties of fiberboards will have been quite effectively covered. Aside from quality control and acceptance tests, two phases of work remain for consideration, namely, the further study and development of methods not yet completed, and the possible need of review and revision of methods that have already been accepted, on the basis of further experience regarding their use. The principal method not yet completed and recommended for further study is decay and mold resistance. Consideration may also well be given to alternate methods in successful use that have not been called to the attention of the Working Party. Comments and suggestions regarding methods of testing fiberboards are invited by the Working Party.
APPENDIX A

Appendix A comprises details of a number of fiberboard test methods prepared for consideration of the Fourth Conference on Wood Technology, as follows:

1. Hardness test
2. Nail-head pull-through test
3. Screw withdrawal test
4. Compression perpendicular to faces and recovery
5. Compression parallel to faces
6. Plate shear
7. Panel shear (shear strength perpendicular to plane of the sheet)
8. Shear strength in the plane of the fiberboard
9. Glue line shear test
10. Single blow impact tests
   a. Toughness test
   b. Monnin pendulum impact test method
11. Indentation and puncture resistance
   a. Falling ball impact test
   b. Falling ball indentation test
   c. Panel impact test
   d. Izod puncture test
12. Abrasion resistance test
13. Dimensional stability under differential relative humidity exposure
14. Durability test for fiberboards for interior use
15. Dimensional stability; thickness
As reported, some of the methods here included were agreed on in principle at the Third Conference; others represent recommended procedures for additional tests that were recommended for development.

**GENERAL PRINCIPLES APPLICABLE TO ALL TESTS TO EVALUATE PROPERTIES OF FIBERBOARDS**

**Different Fiberboard Types**

It is recognized that there are three broad types of fiberboard in extensive production, coming under the general classifications of (1) insulation board, (2) hardboard and semihardboard, and (3) particle board and chipboard. Although the different fiberboards have certain specific applications, many of them cannot be defined closely as to type, and there is much overlapping among them with respect to density and properties.

This situation leads to the desirability of considering all fiberboards as a group of materials to which the test methods for evaluating physical and mechanical properties are applicable regardless of type. Experience has shown that there are no significant technical difficulties in this approach, while at the same time there is the further advantage that the results are directly comparable with those on wood, plywood, and other wood-base material for which in many instances similar methods are used.

For simplification, the term fiberboard is used in the various test procedures in its generic concept, and is intended to include the entire family of ligno-cellulosic fiber products, whether or not incorporating binding agents. The term as used thus includes insulating boards, hardboards, and particle boards (chipboards).

**Control of Moisture Content and Temperature**

In the test methods presented for consideration, requirements for conditioning of test material were not included in the procedure for each individual test because conditioning, where applicable, is a general requirement for all test material. The following requirements with respect to control of moisture content and temperature are applicable, as included in the report of the Second Conference on Mechanical Wood Technology (1951).

The physical and mechanical properties of building boards depend on the moisture content at time of test. Therefore, material for test in the dry condition shall be conditioned to constant weight and moisture content in a conditioning chamber maintained at a relative humidity of 65 ± 1 percent and a temperature of 20° ± 3° C. (68° ± 6° F.) (Notes 1 and 2). If there is any departure from this recommended condition, it shall be so stated in the report.

Note 1.--In following the recommendation that the temperature be controlled to 20° ± 3° C. (68° ± 6° F.), it should be understood.
that it is desirable to maintain the temperature as nearly constant as possible at some temperature within this range.

Note 2.--Requirements for relative humidity vary for different materials. The condition given above meets the standard for wood and wood-base materials.

Speed of Testing

The following recommendations regarding speed of testing, as included in the report of the Second Conference on Mechanical Wood Technology (1951) are applicable:

Note 1.--The testing-machine speed used shall not vary by more than ± 50 percent from that specified for a given test. The testing-machine speed used shall be recorded on the data sheet. The crosshead speed shall mean the free-running, or no-load, crosshead speed for testing machines of the mechanical-drive type, and the loaded crosshead speed for testing machines of the hydraulic-loading type.

Number of Tests

The number of specimens to be chosen for test and the method of their selection depend on the purpose of the particular tests under consideration, so that no general rule can be given to cover all instances. It is recommended that whenever possible, a sufficient number of tests be made to permit statistical treatment of the test data. In the evaluation of a fiberboard material, specimens for test should be obtained from a representative number of boards. In properties reflecting differences due to the machine direction of the board, specimens from each board shall be selected both with the long dimension parallel to the long dimension of the sheet, and with the long dimension perpendicular to the long dimension of the sheet.
1. HARDNESS TEST

Scope

1.1 Hardness tests of fiberboards may be made by (a) the Janka ball test, (b) the Monnin hardness test method, or, (c) the steel ball indentation test method.

A. JANKA BALL TEST METHOD

Test Specimen

1.2 Each specimen shall be nominally 3 in. (7.5 cm) in width and 6 in. (15 cm) in length and at least 1 in. (2.5 cm) thick. Because most fiberboards are manufactured in thicknesses of less than 1 in. (2.5 cm), the specimen for test shall be made by bonding together several layers of the fiberboard to make the required thickness. A rubber cement or other suitable low modulus flexible adhesive shall be used. The finished specimen shall be trimmed after bonding so that edges are smooth. The dimensions of the specimens as tested shall be measured to an accuracy of not less than ± 0.3 percent.

Method of Test

1.3 The modified ball test with a "ball" 0.444 in. (1.13 cm) in diameter (1 sq cm projected area) shall be used for determining hardness. The load at which the "ball" has penetrated to one-half its diameter, as determined by an electric circuit indicator or by the tightening of the collar against the specimen, shall be recorded as the measure of hardness. The test assembly with a tool of the tightening collar type is shown in figure 1-1.

Number of Penetrations

1.4 Two penetrations shall be made on each of the two flat faces of the fiberboard. Where one face is different than the other, as for example the smooth face and wire-textured back of most hardboards, the data obtained from the two faces shall be reported separately. The locations of the points of penetration shall be at least 1 in. (2.5 cm) from the edges and ends of the specimen and far enough apart so that one penetration will not affect another one.
Figure 1-1.--Janka ball test apparatus for hardness of fiberboards.
Speed of Testing

1.5 The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine of 0.25 in. (6 mm) per min.

Test Data and Report

1.6 The maximum load required to embed the "ball" to one-half its diameter shall be the measure of hardness, and shall be included in the report.

B. MONNIN TEST METHOD

Test Specimen

1.7 Each specimen shall be nominally 0.79 in. (2 cm) in width, 6 in. (15 cm) in length and at least 1 in. (2.5 cm) thick. Because most fiberboards are manufactured in thicknesses of less than 1 in. (2.5 cm), the specimen for test shall be made by bonding together several layers of the fiberboard to make the required thickness. A rubber cement or other suitable low modulus flexible adhesive shall be used. The finished specimen shall be trimmed after bonding so that edges are smooth. The dimensions of the specimen as tested shall be measured to an accuracy of not less than ± 0.3 percent.

Method of Test

1.8 A steel loading head having a right cylindrical loading surface with a radius of 30 mm and a length of 30 mm shall be used for determining hardness. The test specimen shall be placed on the flat bed of a testing machine with the long dimension of the specimen at right angles to the cylindrical axis of the loading head. The steel cylinder shall be pressed into the top face of the specimen at a load related to the type of fiberboard as indicated by the density, as follows:

<table>
<thead>
<tr>
<th>Load</th>
<th>Specific gravity of fiberboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 kg</td>
<td>0.90 - up</td>
</tr>
<tr>
<td>100 kg</td>
<td>.40 - .90</td>
</tr>
<tr>
<td>50 kg</td>
<td>.25 - .40</td>
</tr>
<tr>
<td>25 kg</td>
<td>0 - .25</td>
</tr>
</tbody>
</table>

The width of the indentation remaining on the test specimen after removal of the steel cylinder shall be measured to an accuracy of 1 percent at 2 points across the width of the specimen and the results averaged. Measurements may often be facilitated by coating the cylindrical face with carbon
or by placing a carbon paper between the steel ball and specimen. Rubbing the test area with a chalk (of contrasting color) sufficiently long to span the impression will often facilitate measurement.

Note 1.--This method of test gives a measure of the residual indentation remaining after removal of the penetrating tool rather than the actual deformation under load. For certain extremely dense boards it may be necessary to apply loads greater than those specified. The actual load used shall be indicated in the report. Certain fiberboard surfaces may fail at the tool edges by an irregular breaking making it impossible to obtain an accurate measurement of the width of impression. For such materials the actual depth of the penetration below the surrounding surface shall be measured by means of a suitable gage.

Number of Penetrations

1.9 Two penetrations shall be made on each of the two flat faces of the fiberboard. Where one face is different than the other, as for example the smooth face and wire-textured back of most hardboards, the data obtained from the two faces shall be reported separately. The locations of the points of penetration shall be at least 1 in. (2.5 cm) from the ends of the specimen and far enough apart so that one penetration will not affect another.

Speed of Testing

1.10 The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine of 0.25 (6 mm) per min.

Test Data and Report

1.11 The hardness of the fiberboard shall be computed by the following formula:

\[ d = R \sqrt{\frac{R^2 - w^2}{4}} \]

\( d \) = depth of indentation in mm

\( R \) = radius of loading cylinder (15 mm)

\( w \) = average width of indentation in mm

The reciprocal of the depth of indentation \( d \) shall be reported as the hardness of the specimen. The actual load selected to imbed the ball shall also be reported.
C. STEEL BALL TEST METHOD

Test Specimen

1.12 Each specimen shall be nominally 3 in. (7.5 cm) in width and 6 in. (15 cm) in length and at least 1 in. (2.5 cm) thick. Because most fiberboards are manufactured in thicknesses of less than 1 in. (2.5 cm), the specimen for test shall be made by bonding together several layers of the fiberboard to make the required thickness. A rubber cement or other suitable low modulus flexible adhesive shall be used. The finished specimen shall be trimmed after bonding so that edges are smooth. The dimensions of the specimens as tested shall be measured to an accuracy of not less than ± 0.3 percent.

Method of Test

1.13 A steel ball 30 mm (1.18 in.) in diameter shall be used for determining hardness. The test specimen shall be placed on the flat bed of a testing machine and the steel ball pressed into the upper face of the specimen at a load related to the type of fiberboard as indicated by the density, as follows:

<table>
<thead>
<tr>
<th>Load</th>
<th>Specific gravity of fiberboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 kg</td>
<td>0.90 - up</td>
</tr>
<tr>
<td>100 kg</td>
<td>0.40 - .90</td>
</tr>
<tr>
<td>50 kg</td>
<td>0.25 - .40</td>
</tr>
<tr>
<td>25 kg</td>
<td>0 - .25</td>
</tr>
</tbody>
</table>

The width of the impression remaining on the specimen after removal of the steel ball shall be measured on two mutually perpendicular diameters to an accuracy of at least 1 percent. The value reported for each impression shall be the average of the two readings. Measurements may often be facilitated by coating the steel ball with carbon or by placing a carbon paper between the steel ball and specimen. Rubbing the test area with a chalk (of contrasting color) sufficiently long to span the impression will often facilitate measurement.

Note 2.--This method of test gives a measure of the residual indentation remaining after removal of the penetrating ball rather than the actual deformation under load. For certain extremely dense fiberboards it may be necessary to apply loads greater than those specified. The actual load used shall be indicated in the report. Certain board surfaces may fail by an irregular breaking making it impossible to obtain an accurate measurement of the width of the impression. For such materials the maximum diameter of the disturbed area shall be reported.
Number of Penetrations

1.14 Two penetrations shall be made on each of the two flat faces of the fiberboard. Where one face is different than the other, as for example the smooth face and wire-textured back of most hardboards, the data obtained from the two faces shall be reported separately. The locations of the points of penetration shall be at least 1 in. (2.5 cm) from the edges and ends of the specimen and far enough apart so that one penetration will not affect another.

Speed of Testing

1.15 The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine of 0.25 in. (6 mm) per min.

Test Data and Report

1.16 The average diameter of the impression remaining on the specimen after removal of the ball shall be a measure of the hardness of the specimen and shall be included in the report. The actual load selected to imbed the ball shall also be reported.
2. NAIL-HEAD PULL-THROUGH TEST

Scope

2.1 Nail-head pull-through tests shall be made to measure the resistance required to pull the head of a nail or other fastener through a building fiberboard. This test is to simulate the condition encountered with forces that tend to pull paneling or sheathing from a wall.

Test Specimen

2.2 The test specimen shall be 4 by 4 in. (10 by 10 cm) by the thickness of the material. Common wire nails 0.113 in. (2.80 mm) in diameter shall be driven through the board with the head set flush with the surface of the fiberboard (Notes 1 and 2) at right angles to the face. The thickness of each specimen shall be measured to an accuracy of not less than ± 0.3 percent.

Note 1.--A sixpenny common wire nail meets this requirement.

Note 2.--For interior applications, the resistance to pull-through of a finishing nail may be preferred. For other applications, some special fastener like a staple or roofing nail may be desired instead of the common nail. If for any reason a different fastener than the common nail is used, the report of the test shall describe the fastener actually used.

Specimens Tested in the Dry Condition

2.3 When tests are made in the dry state, the pull-through shall be made immediately after the nails have been driven.

Specimens Soaked Before Test

2.4 The specimens to be tested in the soaked condition shall be submerged in water at 20° ± 3° C. (68° ± 6° F.) for 24 hr. before test and shall be tested immediately upon removal from the water. When it is desired to obtain the effect of complete saturation the specimens shall be soaked for such longer period as may be necessary. The time of soaking and the amount of water absorbed shall be reported.

Method of Loading

2.5 The assembly for the direct withdrawal test detailed in figure 2-1 shall be modified by replacing the top pair of angles in the specimen-holding fixture with a 6-in. (15-cm) length of 6- by 2-1/4-in. (15 by 6 cm) standard.
steel channel. The web of the channel shall have a 3-in. (7.5 cm) diameter opening centered in the web. The edge of this opening provides the support to the specimen during test.

Note 3.--The type of loading device illustrated in figure 2-2 also conforms to the basic requirements for conducting this test.

The specimen-holding fixture shall be centered and attached to the lower platen of the testing machine. The specimen shall be inserted in the holding fixture with the point of the nail up. The point of the nail shall be gripped by a tension grip or "Jacob's" type drill chuck, which is attached to the upper platen of the testing machine with a universal joint or toggle linkage, to provide for automatic aligning. Loads shall be applied by separation of the platens of the testing machine. For other types of fasteners than nails, it may be necessary to modify the chuck or tension-grip type of loading fixture.

Speed of Testing

2.6 Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 0.06 in. (1.5 mm) per min.

Test Data and Report

2.7 The maximum load required to pull the head of the nail or other fastener through the fiberboard shall be the measure of the resistance of the material to nail-head pull-through, and shall be included in the report. The report shall describe the type of fastener used and the failure.
Figure 2-1.—Detail of testing equipment (before modifications) for measuring nail-head pull-through.
Figure 2-2.--Alternate type of loading device for conducting the nail-head pull-through test.
3. SCREW WITHDRAWAL TEST

Scope

3.1 Screw-holding tests shall be made on screws threaded into the fiberboard to measure the resistance to withdrawal in a plane normal to the face. Three specimens shall be cut from each sheet of the sample.

Test Specimen

3.2 The test specimens shall be 3 inches (7.5 cm) in width and 6 inches (15 cm) in length. The thickness of the specimen must be 1 inch (2.5 cm). (It may be necessary to glue up two or more thicknesses of the fiberboard to obtain the specified thickness.) Wood screws of 0.190 in. (5 mm) shank diameter and 1 in. (2.5 cm) length shall be used. The screws shall be threaded into the specimen for 2/3 of their length; using bored lead holes having a diameter that is 90% of the diameter of the shank.

Note 1.—A standard USA No. 10 wood screw meets this requirement.

Specimens Tested in the Dry Condition

3.3 When the tests are made in the dry state, the withdrawals shall be made immediately after the screws have been imbedded.

Specimens Soaked Before Test

3.4 The specimens to be tested in the soaked condition shall be submerged in water at 20° ± 3° C. (68° ± 6° F.) for 24 hr. before test and shall be tested immediately upon removal from the water. When it is desired to obtain the effect of complete saturation the specimens shall be soaked for such longer period as may be necessary. The time of soaking and the amount of water absorbed shall be reported.

Method of Loading

3.5 The assembly for the screw-withdrawal test is shown in figure 3-1. The specimen-holding fixture shall be attached to the lower platen of the testing machine. The specimen shall be inserted in the fixture with the heads of the screws up as shown. The load-applying fixture, which is equipped with a slot for easy engagement of the head of the screw, shall be attached to the upper platen of the testing machine. The fitting is detailed in figure 2-1.
Figure 3-1. -- Test assembly for measuring resistance of screws to direct withdrawal.
Note 2.--It may be necessary to modify the slot in the load-applying fixture detailed in figure 2-1 to accommodate the size of screw used in the test.

Speed of Testing

3.6 Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 0.06 in. (1.5 mm) per minute.

Test Data and Report

3.7 The maximum load required to withdraw the screw shall be the measure of resistance of the material to direct screw withdrawal, and shall be included in the report.

Moisture Content

3.8 The test specimen shall be weighed immediately before test. After the test a section 2 in. (5 cm) by the width of specimen shall be cut from the body of the specimen for moisture content determination.
4. COMPRESSION PERPENDICULAR TO FACES AND RECOVERY

Scope

4.1 This test shall be used to obtain load-compression and recovery characteristics of fiberboard compressed in a direction perpendicular to the faces.

Test Specimen

4.2 The test specimens shall be 6 by 6 inches (15 by 15 cm) by the thickness of the material. The dimensions of the specimens shall be measured to an accuracy of not less than ± 0.3 percent.

Method of Test

4.3 The specimen shall be placed flatwise and centrally between two polished steel plates at least 6-3/4 in. (17 cm) square having a thickness of at least 3/4 in. (2 cm). The assembly shall be centered on the testing machine platen and a compressive load applied through a spherical bearing block at a rate of 1,000 lbs. (450 kg) per minute until a load of 1,500 lbs. (675 kg) is reached. The load shall then be released at the same rate. At least 10 equally spaced increments of load shall be used, and the amount of compressive deformation shall be obtained for both the increasing and decreasing load. The amount of compression under load, as indicated by the motion of the movable head of the testing machine, shall be measured to 0.001 inch (0.02 mm). The necessary data may also be obtained by means of an automatic recorder. The actual thickness of the specimen one minute after the compressive load has been removed shall also be obtained as a basis for determining the recovery after load.

Note 1.--Because of the wide range in properties between various insulating boards, hardboards, chipboards, and particle boards, it may be desirable to conduct tests under different load increments than indicated. When tests are made under other conditions, the actual conditions used shall be reported.

Test Data and Report

4.4 The complete load-compression curve obtained for each specimen shall be included in the report. The report shall also show the actual thickness of the specimen under maximum load and after removal of the load expressed as a percentage of the original thickness.
5. COMPRESSION PARALLEL TO FACES

Scope

5.1 Compression tests shall be made to determine the compressive strength of fiberboard parallel to the faces.

Choice of Test Procedure

5.2 Because of the great range in density and thickness of fiberboard panels, it is difficult to employ a single test method that will be satisfactory for all products. Accordingly, three types of tests are presented, with the recommendation that the method be selected that will most accurately measure the compressive strength of the particular board under study.

Types of Test

5.3 Three types of compression tests are provided, varying with respect to size and preparation of specimen, and method of test, as follows:

(a) Method A. This method is used to evaluate the modulus of elasticity, proportional limit, and maximum crushing strength. The specimen is of sufficient size to permit attachment of a compressometer, and may require the bonding of one or more thicknesses of the fiberboard to obtain a specimen of the required size.

(b) Method B. This method is used to evaluate the modulus of elasticity, proportional limit, and maximum crushing strength. It is applicable to specimens taken from thin boards that are to be tested in single thickness and require lateral support in test to avoid buckling.

(c) Method C. This method may be used when maximum compressive strength only is to be obtained. It employs a specimen whose length does not exceed six times the thickness, so that no lateral support is required.

METHOD A

Test Specimen

5.4 The specimen shall be rectangular in cross section, and care shall be taken in preparing the test specimen to make the end surfaces smooth and parallel to each other and at right angles to the length. For material over 1 in. (25 mm) in thickness, the specimen shall have a thickness equal to that of the material and the width shall be a minimum of 1 in. (25 mm). The length shall be 4 inches (10 cm). For material less than 1 in. (25 mm) in thickness,
the specimen shall be made by bonding together two or more layers of the fiberboard to provide a specimen at least 1 in. (25 mm) in thickness. A low modulus adhesive shall be used. Finished specimens shall be trimmed to provide smooth edges. The width shall be 1 in. (25 mm), and the length shall be 4 in. (10 cm).

**Loading Procedure**

5.5 The load shall be applied through a spherical bearing block preferably of the suspended, self-aligning type. The load shall be applied with a continuous motion of the movable head to maximum load at a rate of 0.003 in. per in. (cm per cm) of length of the specimen per minute.

**Load-Deformation Curves**

5.6 Data for load-deformation curves may be taken to determine the modulus of elasticity and the proportional limit. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deformation are taken to the proportional limit. The deformation shall be read to the nearest 0.0001 in. (0.002 mm). Compressometers shall be attached over the central portion of the length of the specimen and the points of attachment shall be not less than 1 in. (25 mm) from the specimen ends. Figure 5-1 shows a type of Lamb's roller compressometer, with a 2-in. (5-cm) gage length that has been found satisfactory.

**Test Data and Report**

5.7 The report shall indicate the type of test used. The maximum crushing strength shall be recorded and the maximum crushing stress calculated. The report shall also show the computed stress at proportional limit and the modulus of elasticity of the material.

**METHOD B**

**Test Specimen**

5.8 The specimen shall be rectangular in cross section and care shall be taken in preparing the test specimen to make the end surfaces smooth and parallel to each other and at right angles to the length. The specimen shall have a thickness equal to that of the material, the width shall be a minimum of 1 in. (25 mm) and the length 4 in. (10 cm).
Figure 5-1.--Method A of conducting compression-parallel-to-faces test on fiberboard, showing roller compressometer attachment (2 in. (5 cm) gage length) for obtaining average compression on two opposite faces.

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Loading Procedure

5.9 The load shall be applied through a spherical bearing block preferably of the suspended, self-aligning type. The load shall be applied with a continuous motion of the movable head to maximum load at a rate of 0.003 in. per in. (cm per cm) of length of the specimen per minute. Test specimens shall be supported laterally to prevent buckling during test, but undue pressure shall not be exerted against the sides of the specimen. This support shall not measurably restrain the normal compressive deformation under load. A satisfactory method of providing lateral support is illustrated in figure 5-2, with details of apparatus for lateral support shown in figure 5-3.

Load-Deformation Curves

5.10 Data for load-deformation curves may be taken to determine the modulus of elasticity and the proportional limit. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deformation are taken to the proportional limit. The deformation shall be read to the nearest 0.0001 in. (0.002 mm). Compressometers shall be attached over the central portion of the length of the specimen and the points of attachment shall be not less than 1 in. (25 mm) from the specimen ends. Figure 5-1 shows a type of Lamb's roller compressometer, with a 2-in. (5-cm) gage length that has been found satisfactory.

Test Data and Report

5.11 The report shall indicate the type of test used. The maximum crushing strength shall be recorded and the maximum crushing stress calculated. The report shall also show the computed stress at proportional limit and the modulus of elasticity of the material.

METHOD C

Test Specimen

5.12 The specimen shall be rectangular in cross section and care shall be taken in preparing the test specimen to make the end surfaces smooth and parallel to each other and at right angles to the length. The specimen shall have a thickness equal to the thickness of the material, a width of 2 in. (5 cm), and a length equal to six times the thickness.

Loading Procedure

5.13 The load shall be applied through a spherical bearing block preferably of the suspended self-aligning type. The load shall be applied with a continuous motion of the movable head to maximum load at a rate of 0.003 in. per in. (cm per cm) of length of the specimen per minute.
Figure 5-2.—Method B of conducting compression-parallel-to-faces test of fiberboard, showing equipment used for lateral support of the specimen and Marten's mirror compressometer for measuring deformations on two opposite faces.
Figure 5-3. --Details of apparatus for lateral support of thin specimens tested in compression.
Test Data and Report

5.14 The maximum load sustained by each specimen shall be recorded and the ultimate crushing strength calculated.
6. PLATE SHEAR

Scope

6.1 The plate shear test shall be used to determine the shearing modulus of elasticity (modulus of rigidity) of various types of fiberboards. The procedure used is similar to that employed for wood and plywood and affords an accurate measure of the mean modulus of rigidity of the specimen.

Test Specimen

6.2 The test specimen shall be square, with the thickness equal to the thickness of the material and the length and width not less than 25 nor more than 40 times the thickness. The thickness, length, and width of each specimen shall be measured to an accuracy of not less than ± 0.3 percent. Care shall be taken to select flat test specimens without any inherent curvature.

Loading Procedure

6.3 The test specimen shall be supported on rounded supports having a radius of curvature not greater than 1/4 in. (6 mm) on the opposite ends of a diagonal, and loaded in a similar manner on the opposite ends of the other diagonal. In order that the loads may be applied at the corners, metal plates shall first be attached as shown in figure 6-1. The loading and supporting frame shall be rigid. Figures 6-2 and 6-3 indicate the method of test and show details of the plate shear apparatus. The load shall be applied with a continuous and uniform motion of the movable head at a rate of 0.003 times the length of the plate in inches (cm), expressed in inches (cm) per minute.

Deformation Measurements

6.4 The deformation shall be measured to the nearest 0.001 in. (0.02 mm) at two points on each diagonal equidistant from the center of the plate. These measurements preferably shall be made at the quarter points of the diagonals, and if other points than these are chosen, care shall be taken to avoid locations near the plate corners to avoid the load and reaction effects. The plate shall not be stressed beyond its elastic range, and increments of load shall be chosen so that not less than 12 and preferably 15 load-deformation readings are taken. To eliminate the effects of slight initial curvature, two sets of data shall be obtained, the second set with the panel rotated 90 degrees about an axis perpendicular to the plane of the plate at its center. The two results shall be averaged to obtain the shear modulus for the plate. A satisfactory arrangement for measuring relative deformations is indicated in figure 6-1; the dial readings in this case give twice the average deflection of the four points.
Figure 6-1.--Plate shear test for fiberboard showing method of loading and method of observing the differential deformation along the two diagonals.
Figure 6-2.—Method of conducting plate shear test.
Figure 1. -- Experimentally derived drying-rate curves for yellow-poplar heartwood veneer 1/8 inch thick. A, pattern commonly encountered (temperature 350° F., air velocity 600 feet per minute); B, curve observed in veneer having very high initial moisture content and dried in a relatively humid atmosphere (temperature 250° F., air velocity 600 feet per minute).

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Figure 2. -- Typical veneer drying-rate curve relating moisture content during the drying cycle to drying time. Point A is determined by calculating the time required to dry the veneer to 0 percent moisture content and measuring the moisture content of the green veneer. Point B is determined by subtracting the actual measured time required to dry veneer to the desired moisture content from the calculated time required to dry it to 0 percent moisture content. For the example shown, Point A represents a green moisture content of 61.5 percent and a calculated drying time to 0 percent moisture content of 28 minutes; and Point B represents a difference between calculated and measured drying times of 8.2 minutes and a final moisture content of 5.3 percent.
The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin:

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Note: Since Forest Products Laboratory publications are so varied in subject no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous six months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.
Figure 6-3. --Details of apparatus for plate shear test.
Calculation

6.5 The shearing modulus of elasticity shall be calculated as follows:

$$G = \frac{3u^2P}{2h^3w}$$

where:  
$G =$ shearing modulus, in pounds per square inch (kg per sq cm),  
$P =$ load applied to each corner, in pounds (kg),  
$h =$ thickness of the plate, in inches (cm),  
$w =$ deflection relative to the center, in inches (cm), and  
$u =$ distance from the center of the panel to the point where the deflection is measured, in inches (cm).

Note.--The average values of $P$ and $w$ are generally taken from the slope of a previously plotted load-deflection curve.

Moisture and Specific Gravity

6.6 The moisture content and specific gravity of each test specimen shall be determined.
7. PANEL SHEAR

Scope

7.1 The panel shear test is particularly applicable to materials in sheet form and may be used for determining the shear strength of fiberboards normal to the plane of the panel. The panel shear test also provides a means of evaluating the modulus of rigidity when simultaneous observations of load and shearing deformations are taken.

Test Specimen, Equipment, and Test Procedure

7.2 The panel shear test has been extensively used for evaluating the shearing strength of plywood, and has been adapted also to some other structural materials in sheet or panel form. Accordingly the details of the test procedure with respect to size of test specimen, equipment, method of loading, and other test procedures as developed for plywood may be used for fiberboard.

Note 1.--Details of the panel shear test for plywood are presented in the Report of the Third Conference on Wood Technology (1954), pages 91-96.

Note 2.--It is possible in some instances that, in adapting the panel shear test to fiberboard, enlargement of the specimen in the contact area with the reinforcing blocks on the bolted frame may be necessary to provide increased shear area or contact area. This adjustment can be readily made as required if difficulty with the reinforcing blocks or frame is encountered.

Note 3.--The values of modulus of rigidity as determined by this method will probably be somewhat higher than the true modulus because the loads are not applied at the exact boundary of the test area of the specimen.
8. SHEAR STRENGTH IN THE PLANE OF THE BOARD

Scope

8.1 Shear strength tests shall be made on specimens prepared by laminating each specimen so that the plane of the shear failure will be in the board proper and not in the glue lines.

Note 1.--This test employs a notched specimen as shown in figure 8-1, and requires a shear tool as shown in figure 8-2. The shear tool is the same as that used for wood tests and has an offset of 1/8 in. (3 mm) between the inner face of the loading plate and the inner edge of the support base for the specimen.

Test Specimen

8.2 The shear-parallel-to-plane of fiberboard tests shall be made on 2- by 2- by 2-1/2-in. (5- by 5- by 7.5-cm) specimens notched as illustrated in figure 8-1. It is the intent in this test to have the plane of shear parallel to the surfaces of the board and to have the failure approximately midway between the two surfaces of the board. The specimen shall be glued up by laminating sufficient thicknesses (Note 2) of the board together to produce the desired 2-in. (5-cm) thickness of specimen as shown in figure 8-1. The actual area of the shear surface shall be measured.

Note 2.--When the shear strength of a thin board like hardboard is desired, it will be permissible to use a thicker material such as plywood for outer laminations to reduce the total amount of gluing. When that procedure is used, at least the center lamination and preferably the three center laminations shall be of the board under test.

Procedure

8.3 A shear tool similar to that illustrated in figure 8-2, providing a 1/8-in. (3.5-mm) offset between the inner edge of the supporting surface and the plane, along which failure occurs, shall be used. The load shall be applied to, and the specimen supported on, the ends of the specimens as indicated by the large arrow in figure 8-1. Care shall be taken in placing the specimen in the shear tool to see that the crossbar is adjusted so that the edges of the specimen are vertical and the end rests evenly on the support over the contact area. The maximum load only shall be observed.

Speed of Testing

8.4 The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.024 in. (0.6 mm) per min.
GLUE LINES IN LAMINATED SPECIMEN ORIENTED SO THAT SHEAR PLANE IS MIDWAY BETWEEN TWO GLUE LINES

Figure 8-1. --Specimen for determining shear strength in the plane of the fiberboard.
Figure 8-2. --Shearing tool used for determining shear strength in the plane of the fiberboard. The tool has an offset of 1/8 inch (3 mm) between the inner face of the loading plate and the inner edge of the support base for the specimen.
Test Failures

8.5 The character and type of failure shall be recorded. In all cases where the failure at the base of the specimen extends back onto the supporting surface, the test shall be culled.

Moisture Content

8.6 The portion of the specimen that is sheared off shall be used for determining the moisture content.
9. GLUE-LINE SHEAR TEST

Scope

9.1 The block-type glue-line shear test shall be used to evaluate glued fiberboard constructions such as are obtained when thicknesses are laminated together to provide a greater thickness than when manufactured. When desired, the specimen may be modified to evaluate glue lines between fiberboard and solid wood or veneer by laminating the specimen so that the glue line to be evaluated is so oriented in the specimen that it coincides with the plane of shear in the specimen.

Note 1.—This test procedure is adapted from the "Glue Block Shear Test," described in Sections 12.1 to 12.5 of the Methods of Test for Evaluating the Properties of Veneer, Plywood, and Other Glued Veneer Constructions, Annex 2, Report of Third Conference on Wood Technology (1954).

Test Specimen

9.2 The test specimen shall be 2 in. (5 cm) in width and 2 in. (5 cm) in height, and shall be fabricated as shown in figure 9-1. The specimen shall be from 1 to 2 in. (2.5 to 5 cm) thick, as necessary, depending on the thickness of the board (Note 2). Specimens shall be sawed from panels glued up in sizes of at least 6 in. (15 cm) square. Care shall be taken in preparing test specimens to make the loaded surfaces smooth and parallel to each other and perpendicular to the glue line in the shear plane. Care shall be exercised in reducing the lengths of the laminations to 1-3/4 in. (4.5 cm) to insure that the saw cuts extend to, but not beyond the glue line. The width and height of the specimen at the glue line shall be measured to at least the nearest 0.01 in. (.025 cm). These measurements shall determine the shear area.

Note 2.—When the glue-line shear strength of a thin fiberboard like hardboard is desired, it will be permissible to use a thicker material such as plywood for outer laminations to reduce the total amount of gluing. The material on either side of the glue line in the plane of shear shall be the fiberboard under test unless the test involves a glue line of fiberboard and another material.

Loading Procedure

9.3 The load shall be applied through a self-alining seat to insure uniform lateral distribution of load. The load shall be applied with a continuous motion of the movable head of the testing machine at a rate of 0.024 in. (0.6 mm) per min. The loading tool required for the shear in the plane...
Figure 9-1.--Fiberboard glue-line shear test specimen.
of the fiberboard test, adjusted so that failure will occur along or adjacent to the glue line (no offset), shall be used to load the specimen. The shear tool is shown in detail in figure 9-2.

Test Failures

9.4 The shear stress at failure, based on the maximum load, the overlap area between the two laminations, and the percentage of fiber failure, shall be reported for each specimen.
10. SINGLE BLOW IMPACT TESTS

Scope

10.1 Single blow impact tests of fiberboard may be made by (a) the Toughness Test Method and the (b) Monnin Pendulum Impact Test Method.

A. TOUGHNESS TEST

Scope

10.2 The toughness test provides a suitable method for conducting single blow impact tests of fiberboards. A machine of suitable capacity for the type and thickness of fiberboards to be tested shall be used.

Note 1.--Two sizes of toughness machines of different capacities, designated as intermediate and large size, are used for tests of fiberboards. The large size machine is used for testing the thicker or stronger boards, and the intermediate size machine because of its greater sensitivity is used for testing the weaker or thinner boards.

Size of Specimen

10.3 The toughness tests shall be made on specimens with a cross section 1 in. (2.5 cm) wide by the thickness of the material when the large machine is used, and on specimens 5/8 in. (1.6 cm) wide when the intermediate size is used. The length shall be 14 times the thickness plus 2 in. (5 cm). The actual height and width at the center and the length shall be measured.

Loading and Span

10.4 Center loading and a span equal to 14 times the thickness shall be used. The load shall be applied to the face representing the width of the specimen.

Bearing Block

10.5 An aluminum tup having a radius of curvature approximately 1-1/2 times the thickness of the thickness of the test specimen shall be used in applying the load.

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Apparatus and Procedure

10.6 The tests shall be made in an FPL type toughness machine (figure 10-1). The machine shall be adjusted before test so that the pendulum hangs truly vertical and shall be adjusted to compensate for friction. The cable shall be adjusted so that the load is applied to the specimen when the pendulum swings to 15 deg. from the vertical so as to produce complete failure by the time the downward swing is completed. The weight position and initial angle (30, 45, or 60 deg.) of the pendulum shall be chosen so that complete failure of the specimen is obtained in one blow. Most satisfactory results are obtained when the difference between the initial and final angle is at least 10 deg.

Calculation

10.7 The initial and final angle shall be read to the nearest 0.1 deg. by means of the vernier attached to the machine. The toughness shall then be calculated as follows:

\[ T = wL (\cos A_2 - \cos A_1) \]

where:

- \( T \) = toughness (work per specimen), in inch-pounds (cm-kg),
- \( w \) = weight of pendulum, in pounds (kg),
- \( L \) = distance from center of the supporting axis to center of gravity of the pendulum, in inches (cm),
- \( A_1 \) = initial angle (Note), in degrees, and
- \( A_2 \) = final angle the pendulum makes with the vertical after failure of the test specimen, in degrees.

Note.--Since friction is compensated for in the machine adjustment, the initial angle may be regarded as exactly 30, 45, or 60 deg., as the case may be.

Weight and Moisture Content

10.8 The specimen shall be weighed immediately before test, and after test a section approximately 2 in. (5 cm) in length shall be cut near the failure for moisture content determination.
Figure 10-1.--Toughness test machine assembly for conducting toughness tests of wood and wood-base materials including fiberboards.

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Scope

10.9 The Monnin pendulum impact test method as specified for tests of wood may also be used for single-blow tests of fiberboards.

Size of Specimen

10.10 The toughness tests shall be made on specimens 0.79 inch (2 cm) wide, 11 inches (28 cm) long, with a thickness equal to the thickness of the board.

Note 1.--It may be necessary to bond several layers of fiberboard together to provide a specimen which will give measurable results.

Loading and Span

10.11 Center loading and a span of 9.47 inches (24 cm) shall be used. The load shall be applied to the face representing the width of the specimen. When it is desired to evaluate the properties of the board in different directions, test specimens may be taken with their length parallel and perpendicular, respectively, to the length of the panel.

Test Apparatus and Procedure

10.12 The tests shall be made in a Monnin type single-blow impact tester such as the machine designed for impact tests of wood. The energy required to break each specimen as indicated on the machine in kilogram-meters shall be recorded.

Weight and Moisture Content

10.13 Each specimen shall be weighed immediately before test, and after test a section approximately 2 in. (5 cm) in length shall be cut near the failure for moisture content determination.
11. INDENTATION AND PUNCTURE RESISTANCE

Purpose

11.1 One of the important requirements of fiberboards used for sheathing and other purposes, whether for interior or exterior use, is their ability to resist puncture by suddenly applied loads. Often the area under load is comparatively small in relation to the unsupported area of fiberboards, as, for example, when fiberboards are applied to wood framing or studding.

A number of different test methods have been developed for evaluating the resistance of different fiberboards to indentation and puncture under suddenly applied loads. One or more of the following procedures may be used, depending on the particular conditions of use to be considered, the available equipment, and the type of contact surface desired;

A. Falling ball impact test
B. Falling ball indentation test
C. Panel impact test
D. Izod impact

A. FALLING BALL IMPACT TEST

Scope

11.2 The falling ball impact test shall be used to measure the impact resistance of fiberboards from the kind of damage that occurs in service when it is struck by moving objects. In the test, a fiberboard panel is supported at the edges and a 2-inch (5-cm) diameter steel ball is dropped from increasing heights until the panel fails, each drop being made at the same place in the panel. The measure of impact resistance is taken as the height of drop that produces a visible failure on the opposite face to the one receiving the impact.

Test Specimen and Equipment

11.3 The test specimens shall be 9 by 9 inches (23 by 23 cm) by the thickness of the material. No facing material other than that which is a regular part of the fiberboard shall be applied to the fiberboard prior to test. The test specimen shall be rigidly clamped at the edges between two frames of 1-1/2-in. (3.75-cm) thick plywood. The frames shall be 9 by 9 in. (23 by 23 cm) in outside dimension with a 6 in. (15 cm) square opening at the center, and shall be provided with eight equally spaced bolts for clamping the specimen. A 2-in. (5-cm) diameter steel ball weighing 1.18
pounds (0.54 kg) shall be used, and suitable means of holding and releasing it from predetermined heights shall be provided. During the test the frame and specimen assembly shall be supported on a rigid base. A suitable test arrangement for making the falling ball impact test is shown in figure 11-1.

Test Procedure

11.4 Before test the specimen shall be securely clamped between the frames. The steel ball shall be dropped so that it strikes at the center of the specimen. Repeated drops shall be made from increasing heights until a failure is produced. Increments of drop shall be 1 inch (2.5 cm), in which the distance being measured is from the bottom of the ball to the top surface of the specimen. The ball shall be stopped from rebounding after each drop so that there will be only one impact for each drop. The impact resistance is recorded as the height of drop at which a visible fracture occurs at the bottom of the specimen. The heights of drop that produce different degrees of visible indentation on the top surface shall also be recorded.

Report

11.5 The report shall present the heights of drop associated with different degrees of visible indentation of the top surface, and the final height of drop causing visible fracture at the bottom of the specimen. The type of failure shall be described.

B. FALLING BALL INDENTATION TEST

Scope

11.6 The falling ball test provides a satisfactory method of measuring the resistance of fiberboard to indentation. In this test a 2-in. (5-cm) diameter steel ball is successively dropped from different heights onto the surface of the fiberboard specimen, each drop being made at a different place on the test piece. The evaluation is based on the depth of the indentation remaining in the panel immediately after each drop.

Test Specimen and Equipment

11.7 The test specimens shall be at least 10 by 16 inches (25 by 40 cm) by the thickness of the material. The specimen shall be supported over its full area on a firm base of wood or other material to insure maximum absorption of energy in the indentation deformation. A 2-in. (5-cm) diameter steel ball weighing 1.18 pounds (0.54 kg) shall be used, and suitable means of holding and releasing it from predetermined heights shall be provided. An indicating dial with suitable base provides a convenient method of measuring the depth of the indentation.
Test Procedure

11.8 Each drop is made at a different place on the specimen, so that it is independent of and unaffected by any other drop. The equipment that may be used for this test is shown in figure 11-2. An electric magnet adjustable to different heights provides a convenient method for positioning and dropping the ball in conducting the test. The depth of each indentation with respect to the surface of the specimen shall be accurately measured.

Report

11.9 The report shall present the data on depth of indentation for each height of drop. The data may be used in graph form to establish a relationship between height of drop and residual indentation. The moisture content and density of each specimen shall be reported.

C. PANEL IMPACT TEST

Scope

11.10 The panel impact test provides an alternate method for determining the puncture resistance of fiberboard under concentrated falling loads. The test consists of dropping a rod with attached blunted cone from increasing heights on a fiberboard panel supported at the edges.

Test Specimen

11.11 The specimen shall be 12 in. (30 cm) square by the thickness of the material.

Apparatus

11.12 The test apparatus shall be as shown in figure 11-3. The combined weight of the rod, cone, and hemisphere shall be 10 lbs. (4.5 kg.)

Loading Procedure

11.13 The panel shall be freely supported along all four edges and the hemisphere shall be made to strike the center of the panel. The rod shall be dropped through heights increasing in increments of 1/2 in. (12 mm) until fracture of the panel occurs. Fracture is indicated when the spherical end has penetrated the panel and is arrested by the flange of the cone.
Figure 11-1.--Method of conducting falling ball impact test on fiberboard, showing magnetic head for holding the steel ball and adjusting height of release.
Figure 11-2.--Apparatus used to measure the resistance of fiberboard to indentation by the falling ball method. The gage is used to measure the depth of each indentation.
Figure 11-3.--Apparatus for making panel impact tests.
Figure 11-4. --Izod pendulum impact machine as modified for conducting the fiberboard puncture test.

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11.14 The height of drop required to produce fracture shall be taken as the panel impact strength.

Moisture Content and Specific Gravity

11.15 The moisture content and specific gravity shall be determined.

D. IZOD PUNCTURE TEST

Scope

11.16 The Izod puncture test may be used as an alternate method for determining the puncture resistance of fiberboards. For this test the regular Izod machine is modified by removing the anvil from the base and attaching a spherical striking head to the pendulum. The pendulum is then released from sufficient height to puncture the test specimen. The test simulates the condition where a suddenly applied concentrated load strikes the face of a fiberboard panel at an area where it is unsupported, as when applied to wood framing.

Test Specimen

11.17 The test specimen shall be 8 by 8 inches (20 by 20 cm) by the thickness of the specimen. The dimensions of the specimens shall be measured to an accuracy of ±0.3 percent.

Testing Device

11.18 A suitably modified Izod type testing device shall be used. A standard machine having a pendulum which swings through an arc of 48 inches (122 cm) with an effective pendulum weight of 60 pounds (27.2 kg) is satisfactory. The machine is modified by removing the anvil from the base of the machine, and attaching a special striking head to the pendulum. Figure 11-4 illustrates the machine as modified. The pendulum head is equipped with two counterbalanced curved steel rods having a curvature of 48 in. (122 cm) radius and carrying a 2-inch (5-cm) diameter steel striking head at the outer ends. The test specimen shall be held with clips on a rigid steel plate having a 6-inch (15-cm) diameter opening in the center. The face of the plate shall be perpendicular to the arc described by the pendulum and the center of the opening shall coincide with the center of the arc of the striking sphere. Provision shall be made for adjustment of the specimen plate so that contact between specimen and puncturing sphere will occur at the moment of maximum potential energy in the pendulum. The testing device shall permit measurement of the puncturing energy absorbed in foot-pounds or meter-kilograms.
Method of Test

11.19 The specimen shall be firmly attached to the supporting plate with special clips and the plate adjusted to the proper position in the arc. The energy required to cause complete puncture shall be determined.

Report

11.20 The amount of energy required to completely puncture the test specimen shall be taken as the puncture resistance.

Moisture Content and Specific Gravity

11.21 The moisture content and specific gravity shall be determined.
12. ABRASION RESISTANCE TEST

Scope

12.1 Abrasion resistance tests shall be made on the fiberboard to determine the wear under simulated conditions.

Test Specimens

12.2 The test specimens shall be 2 x 3 inches (5 by 7.5 cm) by the thickness of the material. The specimens shall be conditioned before the test to equilibrium at 68° ± 6° F. and 65% ± 1% relative humidity and the test should be conducted in the same conditioned atmosphere. Where circumstances require other equilibrium conditions, the actual conditions used shall be reported. The thickness of the test specimen shall be accurately measured and the weight taken.

Test Procedure

12.3 The test shall be conducted on the Navy-Type abrasion machine (figure 12-1). The abrading medium shall be new number 80 grit aluminum oxide, or equivalent. The grit shall be applied continuously to the 14-inch diameter steel disk which serves as a platform supporting the specimen and rotates at the rate of 23-1/2 revolutions per minute. The specimen shall rotate in the same direction as the steel disk at the rate of 32-1/2 revolutions per minute. A load of 10 pounds (4.5 kgs) shall be superimposed on the test specimen. The machine is designed so that twice each revolution the specimen is raised 1/16 inch (1.6 mm) above the steel disk and immediately lowered. The decrease in the thickness of the specimen shall be determined at the end of each 100 revolutions of the steel disk by measuring the thickness of the specimen to the nearest 0.001 inch (.025 mm) near each corner and at the center. The mean of the five recordings shall be taken as the loss in thickness. This procedure shall be repeated as required or until the specimen has 500 revolutions of wear.

Report

12.4 The report shall describe the loss in thickness after each 100 revolutions of wear.
Figure 12-1.--Machine used to measure the abrasion resistance of fiberboard. The specimen is rotated horizontally while held against a steel disk rotating at a different speed. Abrasive is applied to the disk continually during test.
13. DIMENSIONAL STABILITY UNDER DIFFERENTIAL RELATIVE HUMIDITY EXPOSURE

Scope

13.1 For certain applications fiberboards are used in locations which expose opposite faces of the fiberboard to different humidity conditions. This test shall be used to obtain a measure of the stability of fiberboards under such conditions.

Test Specimen

13.2 For many tests small samples cut from full-sized sheets of fiberboards may be used to evaluate the property of the sheet. For the determination of the warping and twisting characteristics of fiberboards, it is not possible to do this and it is thus necessary to make the test on the size of fiberboard as manufactured or in the size actually used in service. For example, where fiberboards are manufactured in 4-foot by 8-foot sheets, it is recommended that the tests be made on specimens of that size.

Method of Test

13.3 It is desired to expose the two opposite faces of the test specimen to a relatively large differential in relative humidity conditions. A relative humidity of 90 percent on one face and 30 percent on the other is recommended. This can be accomplished by placing an opening of suitable size between two conditioning rooms or by constructing an insulated cabinet in a room maintained at one desired condition. The test panel can be placed so as to form one wall of the cabinet and the interior of the chamber maintained at the other condition desired. For example, a cabinet placed in a room maintained at 40°F (4°C) and 90 percent relative humidity will provide the desired conditions if the interior of the cabinet is provided with thermostatically controlled heating unit capable of maintaining a temperature of 70°F (21°C) within the cabinet. Figure 13-1 shows such a cabinet used for measuring the warping characteristics of doors. The panel shall be loosely set into the opening and the edges suitably protected to prevent heat losses.

Means shall be provided for measuring the deviation of the center and quarter points of each diagonal from the original locations at intervals during test. Measurements shall be made to the nearest .01 inch (.25 mm). Figure 13-1 shows taut steel wires stretched along the diagonals to facilitate such measurements. The test shall be continued until equilibrium conditions are reached.
Figure 13-1.--Cabinet in temperature and humidity controlled room used for measuring the warping characteristics of doors under differential exposure conditions on the two faces. A cabinet such as this can be constructed or suitably modified for tests of fiberboards.
Test Data and Report

13.4 The report shall indicate the length, width, and thickness of the test panel, the actual temperature and humidity conditions used, and the progressive and final deviations of the center and quarter points of each diagonal from the original locations.
14. DURABILITY TEST OF FIBERBOARD FOR INTERIOR USE

Scope

14.1 Fiberboards may be divided into two broad use classifications, those intended for use under conditions of severe exposure particularly out-of-doors exposure, and those used under less severe conditions such as for interior use. This cycling exposure shall be used for the evaluation of boards intended for interior use. The evaluation consists in observing the damage, if any, resulting from the exposure; and if required, conducting mechanical tests on the fiberboard after the cycling to more specifically determine the deteriorating effect.

Test Specimens

14.2 The specimens for this test shall conform to the dimensions specified for the static bending, lateral nail resistance, nail withdrawal, and water absorption test specimens.

Durability Cycles

14.3 Each specimen shall be subjected to 15 complete cycles of wetting and drying. Each cycle shall consist of the following:

1. Immersed in water at 20° ± 3° C. (68° ± 6° F.) for 4 hours.
2. Heated in dry air at 38° ± 2° C. (100° ± 3° F.) for 20 hours.

After the completion of the 15 cycles of exposure, the material for test shall be further conditioned at a temperature of 20° ± 3° C. (68° ± 6° F.) and a relative humidity of 65 ± 1 percent for at least 48 hrs. before test.

Inspection of Material During Cyclic Exposure

14.4 Frequent inspection of the material shall be made during the cycles for any signs of delamination or other disintegration. If there is any apparent damage to the material, it shall be described in the report and the cycle in which the damage occurred noted.

Comparisons and Report

14.5 After the wetting and drying tests have been completed, each specimen which has not disintegrated shall be tested in accordance with the appropriate test specifications. After these tests are completed, the results shall be calculated and compared with the corresponding values obtained from tests made on material not subjected to the wetting and drying cycles.
15. DIMENSION STABILITY: THICKNESS

Scope

15.1 The dimensional stability of a fiberboard in a thickness direction is of prime importance in selecting material for many uses. This test provides a measure of the change in thickness of a fiberboard due to changes in moisture content. The exposure conditions used in this test are identical with those specified for the linear expansion test.

Test Specimen

15.2 Each specimen shall be 3 in. (7.5 cm) square by the thickness of the fiberboard.

Note 1.--When the linear expansion test is also being made, that specimen may serve as the test specimen for dimensional stability in the thickness direction.

Procedure

15.3 The test specimen shall be conditioned until practical equilibrium is obtained at a relative humidity of 50 ± 1 percent and a temperature of 20° ± 3° C. (68° ± 6° F.) The thickness at the center of the specimen shall then be measured to the nearest 0.001 inch (0.02 mm). The specimen shall then be conditioned until practical equilibrium is reached at a relative humidity of 90 ± 5 percent and a temperature of 20° ± 3° C. (68° ± 6° F.) and remeasured.

Note 2.--Where values associated with exposure to a greater humidity change are desired, equilibrium at a relative humidity of 30 ± 1 percent may be used for the lower humidity condition rather than the 50 percent specified.

Test Data and Report

15.4 The report shall show the actual change in thickness due to exposure both as a measurement to the nearest 0.001 inch (0.02 mm) and as a percentage of the thickness after the initial exposure. The actual exposure conditions used shall be reported.
References*

(1) American Society for Testing Materials

(2) Clarke, L. N.

(3) Clarke, L. N., and Kingston, R. S. T.

(4) Clarke, L. N.

(5) Food and Agriculture Organization of the United Nations

(6) Food and Agriculture Organization of the United Nations

(7) Food and Agriculture Organization of the United Nations

(8) Lewis, Wayne C.

(9) Markwardt, L. J.

*A more extended bibliography relating to methods of testing is presented in reference 9.