IICL TB 001 - January 02, 2019
(Revision 3) - Introduces the requirement shown on 1.9 F & 3.7 B.

Performance Standard

For

New and Unused

Structural Container Floor Panels

To Be Installed In

International Freight Containers

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The purpose of this document is to outline performance requirements for marine grade plywood, bamboo and OSB structural container floor panels to be used in general cargo containers. The manufacturer and/or supplier have ultimate responsibility for the design and quality of the product and should incorporate and adopt all standards and practices necessary to ensure that the product will meet the intended service requirements and requirements herein.

Buyer(s) retain the right of final acceptance for products manufactured according to this bulletin.

IICL TB 001 was prepared under the supervision of a subcommittee chaired by representatives from IICL member companies, and a wood science and engineering consulting laboratory:

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INTRODUCTION

This Technical Bulletin outlines performance requirements for new and unused marine grade plywood, bamboo and OSB structural container floor panels. These performance requirements are based on historical performance of Apitong, Keruing, and similar traditional species of marine grade hardwood plywood. This document recommends minimum, but by no means absolute, panel requirements to suit the service to which these panels will be subjected. The performance requirements set forth in this bulletin focus on ensuring floor panel bond strength, new panel planar shear strength, and long-term adhesive bond durability, as well as other more traditional requirements aimed at achieving a minimum of **12-15 years of service life** from installed panel floors.

Current ISO fork truck and container gross weight test procedures were developed when container floors were manufactured from solid and laminated hardwood planks. This document adds performance requirements and test procedures to the ISO requirements for container floor panel testing. The added test procedures include test procedures to examine structural adhesive bond durability and strength retention after exposure for plywood**,** bamboo and OSB panels.

Plywood, when overloaded and supported by closely spaced cross members, will fail internally due to what is known as a rolling shear failure within the middle veneers of the panel. This internal failure is frequently without, or before any visible, external bending failure occurs. As internal rolling shear failure is difficult to detect, strength tests in this bulletin are designed with such a defect, amongst others, in mind.

Mechanical tests, adhesive bond durability, and exposure tests are introduced in this bulletin which has been specifically selected to examine rolling shear failures within panels, as well as the long term serviceability of the adhesive bond performance. **All floor panel tests are intended to be performed on new and unused floor panels and are not intended or appropriate for floor panels that have been used and already put into service.**

SCOPE

This document covers the following:

1. General Specifications for Structural Container Floor Panels.

2. Performance requirements for the Manufacture and Testing of Structural Container Panels.

3. References and Technical Information.

1. GENERAL SPECIFICATIONS

The following outlines the recommended minimum requirements for structural container floor panels.

1.1 Standards

All structural panels should comply with the standards listed below, except where specifically exceeded by any other IICL requirements.

- **BS EN 636: 2003, Class 3**, Plywood Specifications
- **BS 1088-1:2003 including Annexes A & B**, Requirements for Standard Marine Plywood with Phenolic Resin
- **BS EN 314-1: 2004, Part 1**, Test Methods
- **BS EN 314-2: 1993, Part 2**, Requirements for Plywood-Bonding Quality, non covered exterior service requirements.
- **BS 1203: 2001**, Classification and Test Methods for hot setting Phenolic and Amnioplastic wood adhesives to meet **H4 adhesive requirements**
- **DD EN 1099: 1998**, Plywood-Biological Durability-Guidance for Assessment of Plywood for Use in Different Hazard Classes
- **ASTM D 2718-00**, Planner Shear Test
- **ASTM D 4442**, Moisture Content Determination
- **ASTM D 2395**, Method B, Specific Gravity
- **APA, The Engineered Wood Association. Voluntary Product Standard PS 1-09, Structural Plywood.**
- **APA, The Engineered Wood Association. Voluntary Product Standard PS 2-10, Performance Standard for Wood-Based Structural –Use Panels.**

> ***NOTE****: Additionally, all plywood, bamboo and OSB panels must be capable of withstanding repeated high horizontal shear loads applied through forklift truck wheels or other loading equipment, as experienced and expected in its normal operational environment.*

[1] British Standards – See B.S.I. Website: http://www.bsi-global.com

1.2 Floor Panel Species

All panels must **match or exceed the performance of traditional Apitong/Keruing** plywood panels. Suppliers are required to provide evidence of satisfactory performance for all panels regardless of the species used in the manufacture of the panel.

Performance details must include the following:

- Type(s) of species
- Minimum ultimate bending and shear strengths of panel assembly
- Specific Gravity
- Decay resistance
- Type of adhesive to be used, its cured strength, and proof of long range compatibility to species and its resins, and to container service environment
- Adhesive tension & shear and bonding strengths in proposed species.
- Adhesive bonding guidelines to be followed
- Expected panel service life in container normal service, w/ background for prediction. Final panel acceptance will be up to the owners' decisions.

1.3 Plies

A minimum of 19 plies is required for plywood and bamboo panels. Plies do not apply to OSB panels except for the plies used above and below an OSB core. Bamboo plies refer to bamboo curtains or bamboo mats. No minimum ply requirements have been established for bamboo or OSB panels at this time.

Unless a specific lay-up is specified by owner, manufacturer(s) may use any ply lay-up that will allow the panel to meet all of the requirements outlined in this document, as well as in all ISO requirements. However, the panel manufacturer is to specify lay-up which will be provided to the owner, and will not change until any revised lay-up is offered for owner review.

***NOTE**: Longitudinal plies carry both bending and shear loads. They have long been used in container floor panels in the top, bottom, and core of the panel.*

Increasing the quantity of exterior (top & bottom) longitudinal plies over 3 has been seen to result in surface cracks in some panels. Increasing the center longitudinal plies from one to three has been seen to slightly increase strength in some panels, and technically would be predicted to result in more resistance against panel shear failure – the usual panel failure cause. These results are not always certain.

1.4 Veneer Quality

Per **BS 1088-1, 2003, 4.1.1.9 Table 1**, Top veneer must be one (1) piece.

If the floor panel surface uses Phenolic Surface Film (PSF) or other similar type of covering or coating, the layer to which it will adhere must also be one (1) solid piece.

1.5 Moisture Content

Per **BS EN 322**, not to exceed 14% at the time of manufacture.

Each panel shall have all edges sealed with a suitable exterior grade varnish or equivalent coating to minimize moisture ingress.

1.6 Density/Specific Gravity

Density

At least 700 kg/m^3, at time of manufacture

Specific Gravity

At least 0.70, at time of manufacture

1.7 Adhesive and Bond Performance Requirements

1.7.1 Plywood

Structural plywood panels manufactured according to this performance standard should, at a minimum, meet the following adhesive and bond performance requirements.

- **BS 1203:2003 with B.S. H4 rating** and bond quality for all adhesives must be **Class 3 (per EN 314-2:1993**), or

- Voluntary Product Standard PS 1-09 Structural Plywood, Exterior bond classification.

1.7.2 Bamboo and OSB

Structural bamboo or OSB panels manufactured according to this performance standard should, at a minimum, meet the following adhesive and bond performance requirements.

- Voluntary Product Standard PS 2-10 Performance Standard for Wood-Based Structural-Use Panels, Exposure 1 bond classification.

1.7.3 Adhesive Treatment

All adhesives shall incorporate an approved treatment as required by **Australian Commonwealth Department of Health Division of Plant Department (TCT)**. Any pesticide treatment used must be compatible with multiple species of wood and bamboo.

NOTE: The ease of bonding varies between wood species. Some wood species are easily bonded while others are difficult to bond. Therefore, some wood species may need special adhesive formulations to overcome the difficulty in achieving a satisfactory adhesive bond. Where multiple species are involved in a single panel, an adhesive formulation compatible with both species is required. Proposed multi-species panels must include adhesive details and in-depth background data to prove long range service capability.

1.8 Panel Dimensions

1.8.1 Thickness

Overall thickness must be 28 mm minimum (±1mm).

1.8.2 Flatness

Maximum of 1mm per floor panel.

1.8.3 Length

Should approximate the IICL standard design for 20 ft and 40 ft containers. (See attached drawings on Section 3.5 and 3.6)

1.8.4 Width

Variable, depending on the container factory's design and the customer's choice of center floor divider, such as, flat bar, omega, etc.

1.8.5 Rout Dimensions

For either center floor divider (flat bar, omega, etc.) the minimum clearances are:

- Rout height tolerance: Divider thickness +1.0 mm/-0.0 mm
- Rout width tolerance: Divider width under panel +2.0 mm/-0.0 mm

1.8.6 Squareness

Diagonal dimensions must be to requirements stated in **BS 1088-1, Table 4**, or to container factory requirements, whichever is less.

1.8.7 Chamfers

1mm - 2mm x 45º chamfered edges shall be provided on top edges of all panels.

1.8.8 Tolerances

As per **B.S. 1088-1:2003** requirements unless noted otherwise.

NOTE: Buyers, at their discretion, may consider different tolerances.

1.9 Identification

Product Identification and Traceability

Each panel manufactured must be branded or stamped, or otherwise permanently identified to allow tracing in case of quality defects or product (and/or test) failures. Identification must follow the recommended practices outlined in Section 3.5.

At a minimum, each floor panel should be identified with:

A. Panel manufacturer's brand and specific factory
B. Date of manufacture of the panel
C. Number glue spreader
D. Number of hot press
E. Production line
F. Strength rating (see table 1.9 below)

Permanent identification must be placed on the longitudinal edges along the thickness of each panel, per latest IICL requirements for markings that will be legible for the service life of the panels.

Table 1.9
T 7 - Only floor boards manufactured to pass ISO** floor strength test at 7.2 tons and above
T 6 - Only floor boards manufactured to pass ISO floor strength test at between 6.0 and 7.2 tons
T 5 - Only floor boards manufactured to pass ISO floor strength test at between 5.0 and 6.0 tons
** ISO floor test 1496 - 1 Sixth Edition 2013-07-01 – 6.9 Test No. 8

1.10 Miscellaneous

1.10.1 Floor coatings

Coatings can be applied when required. Some examples of possible floor coatings include Polyurethane, Phenolic Surface Film, etc. With or without the use of a floor panel coating, the top surface coefficient of friction (COF) must be a minimum of 0.5 in the wet condition.

NOTE: Coatings may differ according to buyer(s).

1.10.2 Additional requirements

Each user can add additional requirements to the general specifications.

1.10.3 PSF - TBD

2. PERFORMANCE REQUIREMENTS FOR THE MANUFACTURE AND TESTING OF PLYWOOD FLOOR PANELS

All floor panels manufactured for use in general cargo containers, regardless of species used or layup design must successfully meet the performance requirements outlined in the following testing criteria. **All the floor panel tests mentioned in this document are intended to be performed on new and unused floor panels, and not intended on floor panels that have already been put into service.**

2.1 All Floor Panels

- IICL short span test with a test failure load greater than 6,780N (690 kgs-force, or 1,525 lbs-force).

- IICL floor panel strength test (with details added to the latest ISO floor strength test).

  Note: For details on the above IICL tests, see section 3 of this bulletin.

2.1.1 Plywood

- Bonding test per **BS EN 314-1:2004.**

- Bonding Quality Test Methods per **BS EN 314-1:2004, Part 1** and Bond Quality per **BS EN 314-2:1993, Class 3** requirements.

- Determination of bonding quality using knife test, per **BS 1088-2:2003**.

  Use this standard for qualification of knife test, and then only for optional internal factory bond quality checks, if needed for process control.

- Planar shear test per **ASTM D 2718-00**, latest revision.

2.1.2 Bamboo and OSB Bonding

- **APA, The Engineered Wood Association. Voluntary Product Standard PS 2-10, Performance Standard for Wood-Based Structural –Use Panels.**
  - Bond Classification, 4.1.1
  - Bond Performance, 5.3.3
  - Probe test for delamination, 7.13
  - Moisture cycle test for bond performance, 7.16
  - Moisture cycle test for delamination and strength retention, 7.17

2.2 Quality Control

Floor panel manufacturers are required to perform the above mentioned tests to verify and ensure all panels meet or exceed the performance requirements outlined in this bulletin.

All tests must be carried out on a minimum of three (3) different panels per shift of floor production. Test panels must be chosen randomly to ensure adequate cross sampling. It is recommended that one panel be selected at the beginning of each shift, another during the shift and another near the end of each shift.

Test samples must be identified in the same manner as the indicated in Section 1.9 of this bulletin and the test results must be kept for a minimum of three (3) months.

All testing data and results must be available for inspection and/or review upon request.

3. REFERENCES AND TECHNICAL INFORMATION

3.1 IICL Short Span Test ("254 mm Span Shear Test")[3]

3.1.1 Preface

In the container industry, engineered panels are often used for the construction of container floors. These floors are frequently subjected to dynamic loading conditions from loaded forklifts. The panels used for these floors are commonly 28 mm (1.10") thick, with mixed species. The panels are currently manufactured in many Asian countries. Wood Advisory Services, Inc. was retained to recommend a test procedure to be used for evaluating the shear strength of small clear test specimens fabricated from these types of panels.

Three point bending test is recommended for estimating the shear strength of these types of plywood panels. This bending test is a straightforward test, which induces a bending load to specimen(s) with a short support length (i.e. span to depth ratio of 1:10) that in turn induces high levels of horizontal shear in the test specimen.

The minimum horizontal shear stress required to pass this test in the short span specimen is related to the minimum horizontal shear developed in the portions of the panel that are under the wheels of the test truck during the Floor Strength Test. Performance of these small specimens suggests performance in the floor strength test.

3.1.2 Scope

This procedure is only a test procedure for estimating the full panel capability from a small sample, and not a performance standard. There are no minimum structural requirements for evaluating these types of panels and this test procedure does not promulgate any minimum structural criterion for these types of floor panels. It is up to the discretion of the panel producer or purchaser to set and establish those criterions and to monitor those criterions through the use of this test procedure. Also, this test procedure does not establish any criterion to test for panel variations such as panel construction, species, or panel dimensions.

3.1.3 Test Sample Size

A minimum of three (3) (different) panels per shift of production should be selected randomly to ensure adequate cross sampling. It is recommended that one panel be selected at the beginning of each shift of production, one during the shift and another near the end of each shift.

3 Developed by Wood Advisory Services Inc., 3700 Route 44, Suite 102, Millbrook, NY 12545, USA. Tel: 845-677-3091, Fax: 845-677-6547, Website: http://www.woodadvisory.com

3.1.4 Frequency of Tests

- The "IICL Short Span Bending Test" - should be performed on a minimum of 3 test specimens per panel selected. Panels exhibit within panel and between panel variability, both of which are unknown quantities. Characteristics of these panels that can influence the variability are panel construction, knots, slope of grain, lap marks and species. It is up to the discretion of the individuals conducting the test to determine the number of test specimens to be evaluated per panel. If only one (1) test specimen is evaluated then it is assumed that no variability exists within the panel. *[It is recommend to test more than one test specimen per panel]*

- Structural Adhesive Testing - should be performed once per production day on one (1) of the panels selected for the Short Span Bending Test.

3.1.5 Control of Moisture and Temperature

Specimens to be tested using this procedure should be equilibrated to a constant moisture content of approximately 10% prior to testing. To establish and remain at constant moisture conditions, it is recommended that the samples be stored in a room, prior to and during testing, that has the capability of maintaining equilibrium moisture content (EMC) in the test specimens of approximately 10% (i.e. an approximate temperature of 21ºC or 70°F and relative humidity of 55%). If these conditions are not possible, then the variability of the EMC of this type of floor panel will need to be evaluated and a relationship will need to be established between relative humidity and EMC.

3.1.6 Specimen Preparation and Testing

The tests shall be conducted on test specimens 50 mm x thickness x 305 mm length (2" x thickness x 12" length). Figure 1 illustrates a typical test specimen. The test specimens shall be fabricated using appropriate sawing equipment (e.g. table saw). Also, the specimens shall be fabricated to ensure that no strength reducing defects are included in the test specimens.

However, if strength reducing defects are determined to be typical to the floor panel (or the whole floor panel production) strength test results shall be applicable.

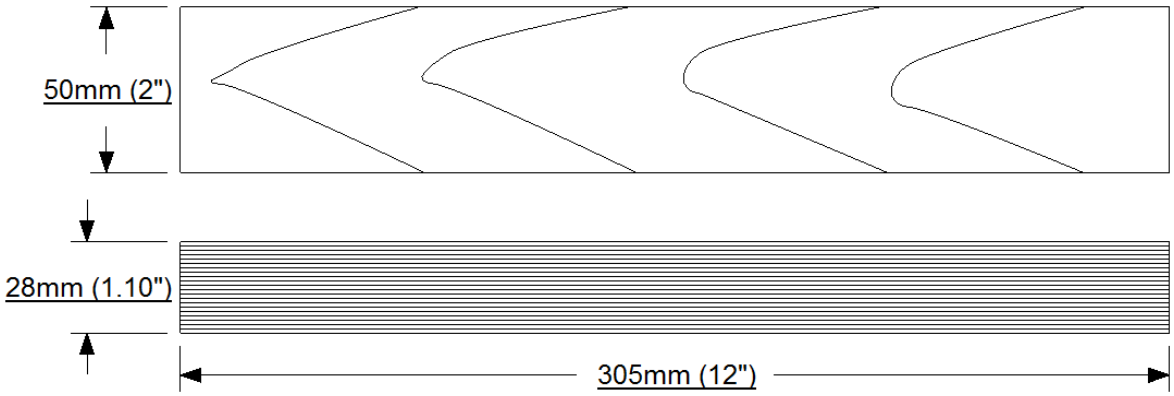


Figure 1 - Typical Test Specimen

3.1.6.1 Test Span, Load Support, Bearing Block and Center Loading

The test specimens shall be tested over a 254 mm (10") span using an applicable load support. The supports shall either be rounded or if knife-edges are used then rounded supports shall be placed over the knife-edges. The supports shall be designed to ensure that no localized crushing occurs in the test specimens at these points. Figure 2 illustrates an applicable test assembly.

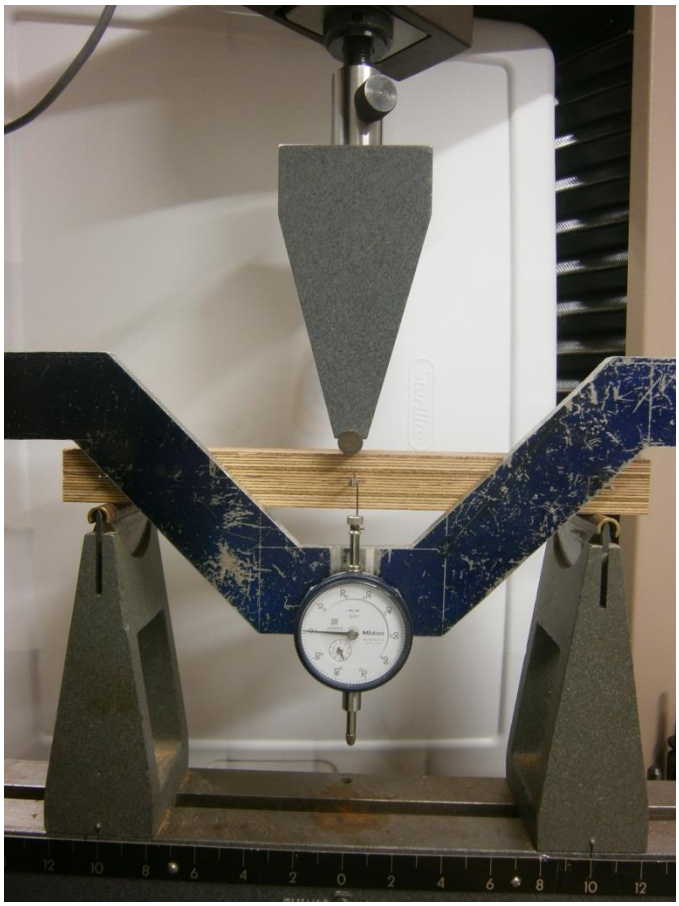


Figure 2 - Test Assembly

A loading block with a radius of 6.35 mm (0.25”) shall be used to apply a constant load at the center span of the test specimen. The loading block shall also contact the entire width of the test specimens at the center point.

The test specimen shall be positioned in the load support such that the top of the panel is face up. The top of the panel is the face that would be loaded in the field, as from within the interior of the container.

3.1.6.2 Measurements

The panel length, and width and thickness at center span shall be recorded to the nearest 0.25 mm (0.01”) prior to testing using calipers. A drawing illustrating the panel construction shall also be recorded. The test specimens shall also be weighed prior to testing to the nearest 0.01g using an appropriate balance.

3.1.6.3 Speed of Testing

Each test specimen shall be tested using a constant loading block rate of motion of 2.0 mm/min (0.08 in/min) until maximum load is attained and failure has occurred. Record the maximum load upon test specimen failure.

3.1.6.4 Load Deflection Data

Load and deflection data shall be recorded during the test to the nearest 0.025 mm (0.001”) using a yoke and dial gauge assembly. Figure 3 illustrates a typical yoke and dial gauge assembly. Deflection shall be recorded every 0.15 mm (0.005”) at the neutral axis. Enough data must be recorded in the linear portion of the load-deflection curve.

Figure 3 - Typical Yoke and Dial Gauge Assembly

3.1.6.5 Description of Failure

Classify and provide a drawing or photograph of each failure. Failures are classified as rolling shear or bending tension. Rolling shear occurs in the center of the test specimen near the neutral plane, and manifests horizontally within a ply(s), the core, or within a glue-line(s) along the length of the test specimen. Each rolling shear failure shall be classified as occurring within a ply(s), the core, or within glue line(s). A bending tension failure occurs on the bottom face and/or edge of a test specimen usually close to the mid-span. It generally occurs across the width of a test specimen and usually propagates vertically upward from the bottom face and/or edge a short distance. In addition to classifying each test specimen failure, the location of the failure within a test specimen shall also be recorded.

Often a combination of these failures can occur. If they do, then classify the failure as a rolling shear/bending tension failure and record the rolling shear failure accordingly. If only a bending tension failure occurs, the test may not be acceptable if a low strength was recorded. If a low strength is recorded again this may be indicative of material anomalies.

3.1.7 Determination of Moisture Content and Specific Gravity

3.1.7.1 General

It is important to report the moisture content and resulting specific gravity at the time of testing because mechanical properties of wood are affected by variation in moisture content. A 25 mm (1") test piece cut from the test specimen will be used to determine both the moisture content and specific gravity at the time of the testing.

3.1.7.2 Moisture Content

Moisture Content (MC) is described in **ASTM D 4442 Method A, Oven-Drying** and is expressed as a percentage (%). Immediately following each test a 50 mm wide x thickness x 25 mm long (2" wide x thickness x 1" long) test piece shall be cut from the test specimen nearest to the point of failure but shall not include the failure. This test piece shall be used to determine the moisture content at the time of testing. The weight of each piece shall be recorded to the nearest 0.01g using an appropriate balance. Each piece shall be dried in a vented oven at a temperature of 103 + 2°C (217 + 36ºF) until constant weight, or oven dry weight, has been attained (approximately 24 hours). Oven dry weight is verified by two successive hourly test piece weights with no change in weight recorded. Once oven dry weight has been attained, weigh the test

piece to the nearest 0.01g using a balance and calculate moisture content using the following equation:

$$MC = \left[\frac{(TestWeight - OvenDryWeight)}{OvenDryWeight} \right] \times 100$$

3.1.7.3 Specific Gravity

As described in **ASTM D2395 Method B, Volume by Water immersion**.

Specific gravity (SG) is determined using the oven dry weight and oven dry volume of the test piece. After the oven dry weight of the test piece had been determined, the oven dry volume of the test piece is determined by water immersion. First, dip the 50 mm wide x thickness x 25 mm long (2" wide x thickness x 1" long) test piece in paraffin wax to seal the specimen. Then insert a sharp pointed slender rod into the test piece and completely immerse it into a known quantity of water. A known quantity of water is determined by using approximately 400 ml of water in a 400 ml beaker and placing the beaker onto a balance. Completely immerse the test piece into the water within the beaker and record the change in weight to the nearest 0.01g. This weight is the oven dry volume. Figure 4 illustrates an immersed test piece in a 400 ml beaker on a balance. Calculate the specific gravity using the following equation:

$$SG = \left(\frac{OvenDryWeight}{OvenDryVolume} \right)$$

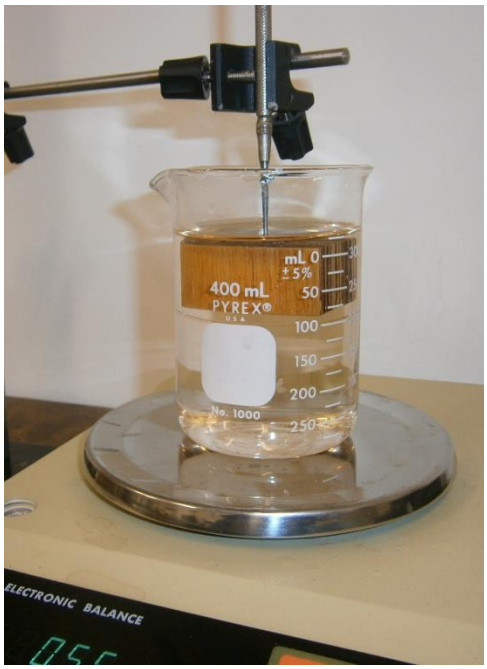


Figure 4 - Immersed Test Piece in a 400 ml Beaker on a Balance

3.1.8 Calculations

- Properties - the following are the calculations used to calculate the mechanical properties for each test specimen:

Shear Force (V): $V = \frac{1}{2} P \max$

Shear Strength (F): $F = \left(\frac{3V}{2bd} \right)$

Modules of Elasticity (MOE): $MOE = \left(\frac{P}{\partial} \right) * \left(\frac{l^3}{4bd^3} \right)$

P max = failure load
P/∂ = slope of linear section of the load-deflection curve
l = test span
b = base or width
d = depth or thickness

3.2 Plywood Floor Panel Bond Durability Test Procedure

Reference: International Wood Products Association – Procurement Standard for Imported Hardwood Plywood, March 1999. (IWPA was also known as the IHPA, International Hardwood Products Association)

3.2.1 Scope

There are three steps to determining adhesive bond durability in all plywood floor panels. The first step is to prepare the specimens for testing. The second step is to expose all specimens to a two-cycle boil test. After the cycles are completed, the 3rd step is to cool the test specimens in water and then subject all specimens to a shear test. For acceptance or non-acceptance of panel adhesive capability, compare failure test load and percent of wood failure in separated bond lines of all specimens to Minimum Requirements.

3.2.2 Cyclic Boil Test procedure

Per the IWPA 4.4 Cyclic-Boil Shear Test and IWPA 4.3 Dry Shear Test

1. **Cutting and preparation of test specimens for exposure to the boiling test.**
    a) At least 1 sample 83mm wide x 355mm long (3-1/4" wide x 14" long) shall be cut from a larger sample. See Figure 1.a).
    b) From the 83mm x 355mm (3-1/4" x 14") samples, two specimens will be cut at 83mm x 178mm long (3-1/4" x 7" long) each. Note that 83mm (3-1/4") is in the long grain direction, and if unable to cut a single 83mm x 355mm sample, the two specimens at 83mm x 178mm can be cut separately but must be from the same larger sample. See Figure 1.b).
    c) One 83mm x 178mm (3-1/4" x 7") specimen will be notched to isolate the center most ply and to open the lathe checks in the direction of pulling during shear testing (forward / tension). Notching is further described in ASTM D 906. See Figure 1.b) and Figure 1.c).
        i. After notching the 83mm x 178mm (3-1/4" x 7"), five specimens will be cut at 83mm x 25.4mm long (1" x 3-1/4" long), with center ply lathe checks in the forward direction.
    d) The other 83mm x 178mm (3-1/4" x 7") specimen will also be notched in the same exact way, except, while looking down at the top surface of the specimen it will be turned 180 degrees (to the left or right) so that the lathe checks will close while pulling during shear testing (reverse / compression). See Figure 1.b) and Figure 1.d).
        i. After notching the 83mm x 178mm (3-1/4" x 7"), five specimens will be cut at 83mm x 25.4mm wide (3-1/4" x 1" wide), with center ply lathe checks in the reverse direction.
    e) In total, there will be 10 specimens to expose to the boil cycle, and 10 results showing breaking force and percent wood failure. See Figure 1.e).

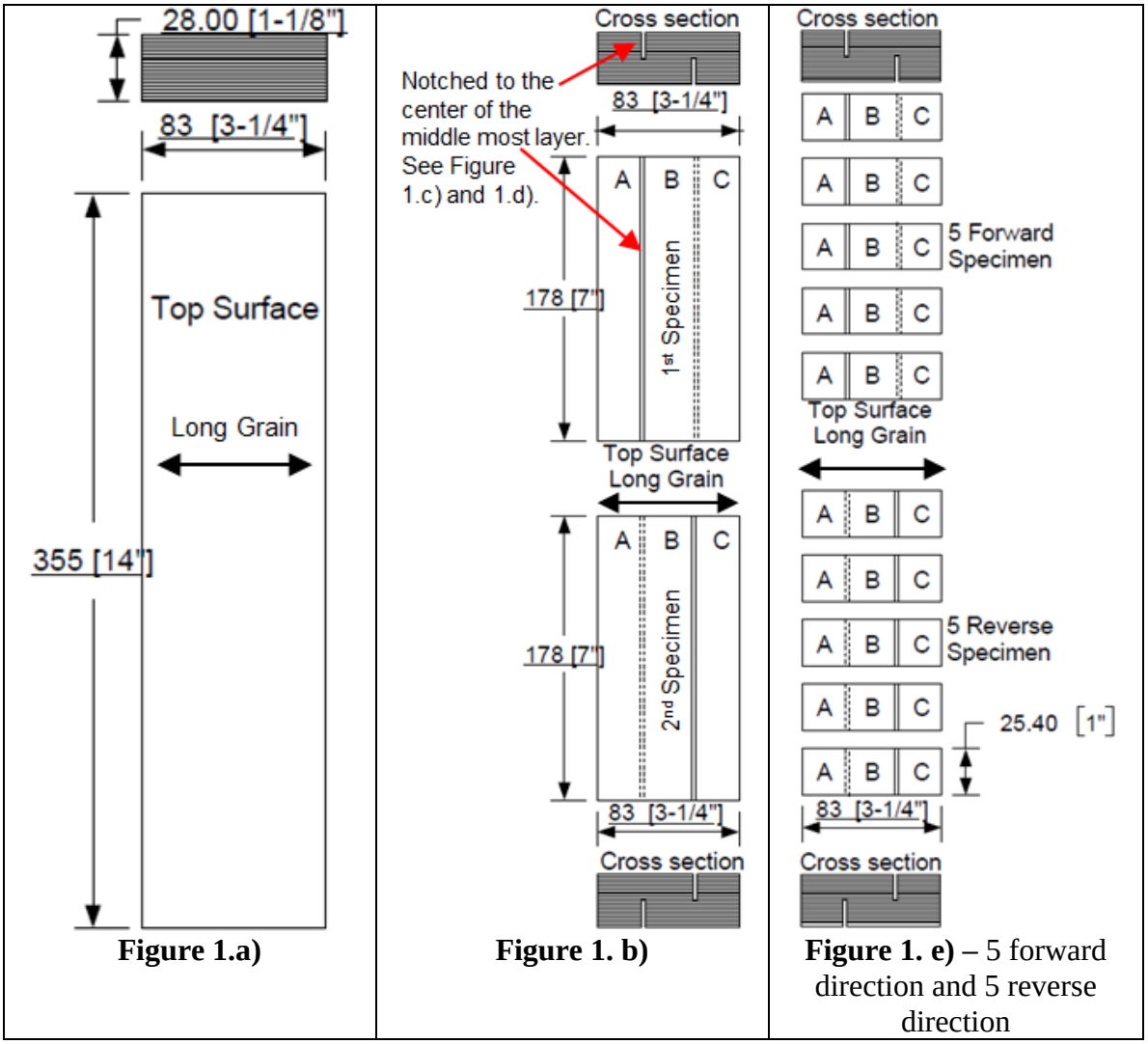


Figure 1.a)

Figure 1. b)

Figure 1. e) – 5 forward direction and 5 reverse direction

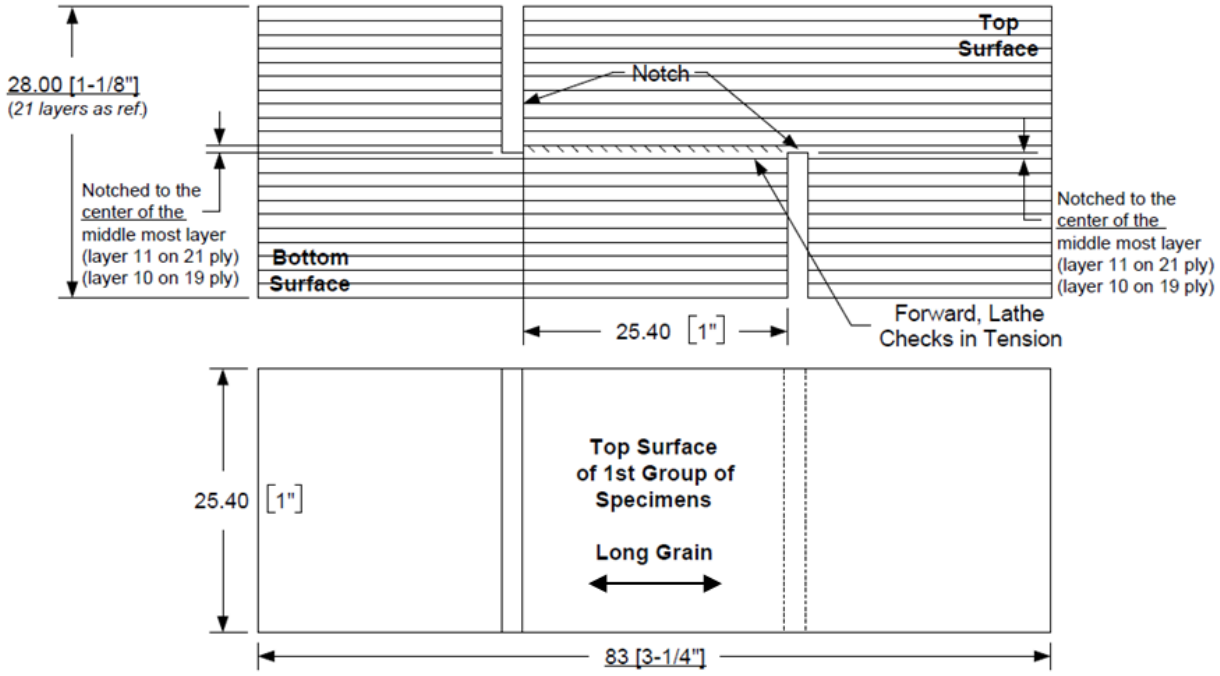


Figure 1. c) and Figure 1. c) i. – 1st Group of Five Specimens.

Each 83mm x 25.4mm (3-1/4" x 1") specimen is notched so that the center ply lathe checks are in the forward direction. Lathe checks will be in tension, during shear test.

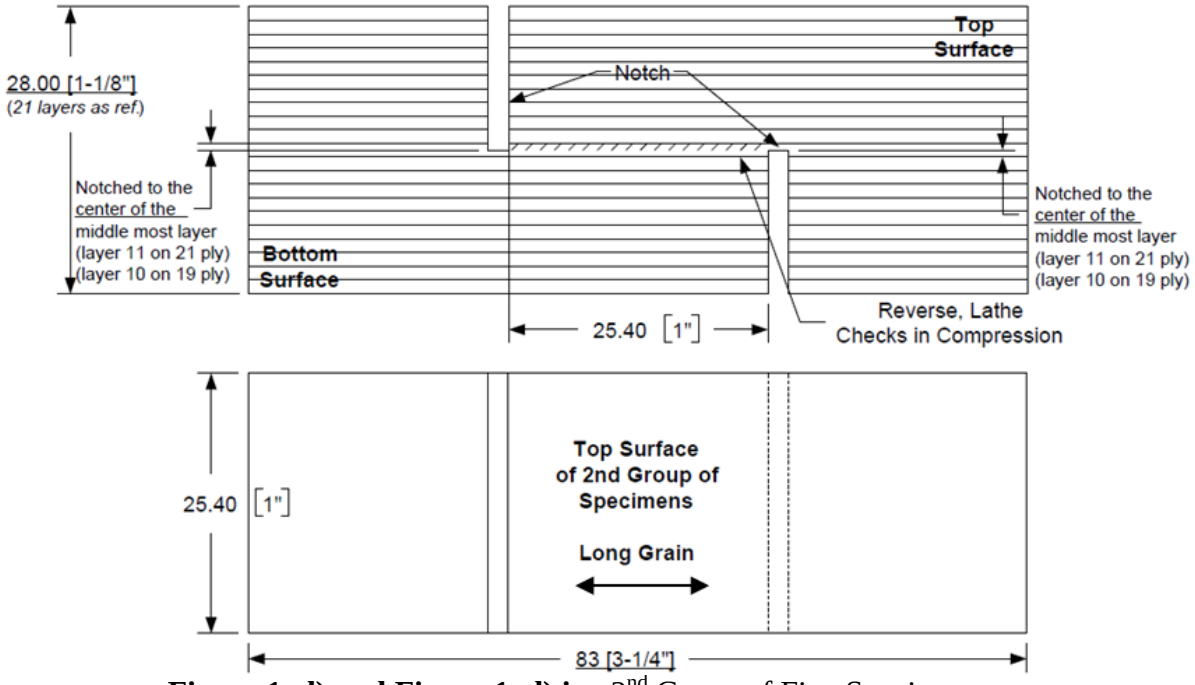


Figure 1. d) and Figure 1. d) i. – 2nd Group of Five Specimens.

Each 83mm x 25.4mm (3-1/4" x 1") specimen is notched so that the center ply lathe checks are in reverse direction. Lathe checks will be in compression, during shear test.

2. **Exposure <u>for all 10 specimens</u> will follow the procedure for the Boiling test as described below. The procedure is also summarized in "IWPA 4.4 Cyclic-Boil Shear Test".**
    a) Boil specimens – 4 hours, about 100ºC (212ºF)
    b) Oven dry specimens for 20 hours, 63 ± 3 ºC (145 ± 5 ºF), sufficient air circulation to lower the moisture content of the specimens to a max of 12% of the oven dry weight.
    c) Boil specimens for an additional 4 hours, about 100ºC (212ºF)
    d) Cool specimen in water, and while wet, perform tension/shear test as described in <u>Section 3</u> below.

3. **After exposure, <u>all 10 test specimens</u> will follow the shear/tension test procedure, as summarized below from "IWPA 4.3 Dry Shear Test".**
    a) After specimen have cooled by being submerged in water, perform shear/tension test while wet.
    b) The ends of each specimen are to be gripped with retaining jaws and pulled apart by applying load at a rate of 2,669 Newtons to 4,448 Newtons (600 lbs to 1,000 lbs) per minute. See <u>Figure 2.b)</u>.
    c) The breaking loads of the 10 specimens are compared to the Minimum Requirements in <u>Table 4</u>.
        i. The broken area will be observed to determine percent wood failure percentage. See <u>Figure 2.c) i</u>.
        ii. The tested area, and subsequent Shear Area is approximately 645 square mm (25.4mm x 25.4mm), or 1 square inch (1" x1"). Shear Stress (kPa or PSI) will be Force (Newtons or Pounds - lbs) ÷ Shear Area (square mm or square inch).

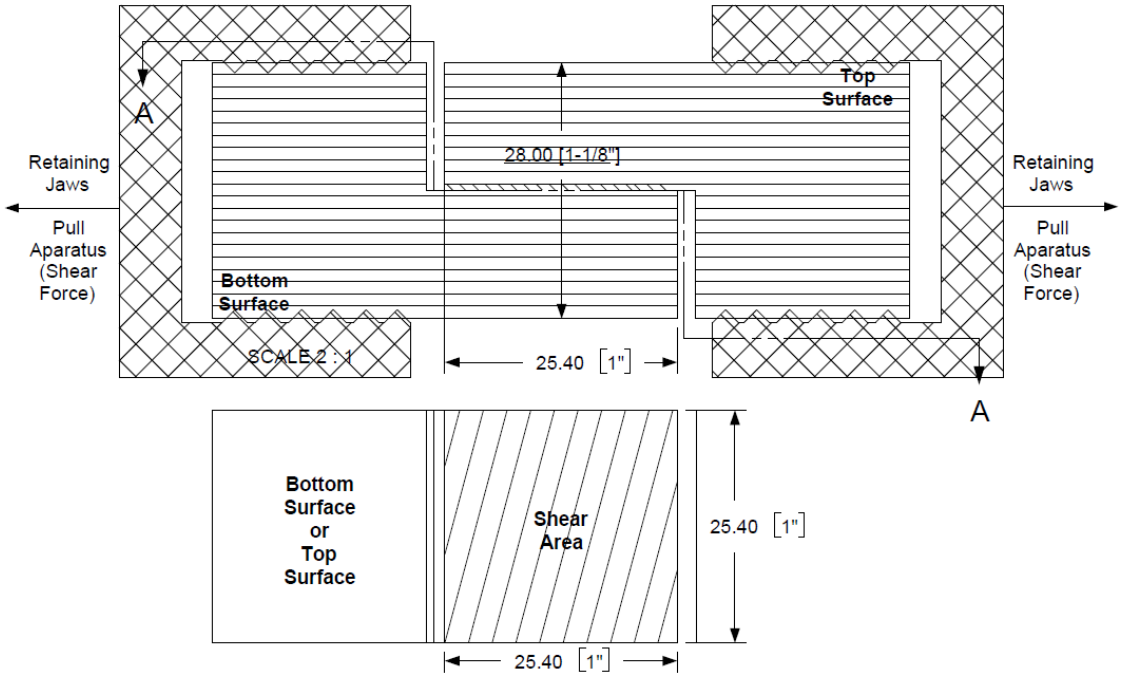


Figure 2. b) - Shear/Tension test set-up, and **Figure 2. c) i** - Shear area for percent (%) wood failure determination

TABLE 4	Wood Failure Requirements for Type 1 Plywood Bond Lines		
Average Failing Load		Minimum Wood Failure	
		Individual Specimen	Test Piece Average
kPa	PSI	Percent	Percent
Under 1724	under 250	25	50
1724-2413	250-350	10	30
Over 2413	Over 350	10	15

3.3 Bamboo and OSB Floor Panel Bond Durability Test Procedure

Reference: ASTM D 5456-10, which refers to APA, PS-10, 6/20/2011, page 34-35, paragraph 7.16. 1 cycle - Moisture cycle test for bond performance (a quality control method to accelerate bond degradation and test adhesive bond strength).

3.3.1 Scope

There are three steps to determine adhesive bond performance and panel strength in Bamboo and OSB floor panels. The first step is short span testing of unexposed specimens. The second step is to expose other specimens to a one cycle vacuum-soak test and then dry the specimens back to their original weight prior to the short span testing. After vacuum-soak exposure, the third step is to subject exposed specimen to the short span bending test described in Section 3.1. For acceptance or non-acceptance of panel strength and adhesive capability, the results of the 1st and 2nd steps are to be compared to the Minimum Requirements and to each other for strength reduction.

3.3.2 Moisture Cycle Test Procedure

3.3.2.1 Dry Test

1. Unexposed short span results must have a minimum breaking load of 6,780 Newtons (1,525 lbs).
   a.) Reference IICL TB 001, Section 3.1 for IICL Short Span Test Procedure.
   b.) At least 2 specimens per sample each 50mm wide x 305mm long (2" wide x 12" long).
   c.) All typical evaluations following short span testing to be done, such as MOE, etc.

3.3.2.2 Moisture Exposure Test

2. Vacuum-Soak Exposure for Bond Performance.

   a) Fabricate, at least 2 specimens from the same panel sample that unexposed specimens were cut from, each 50mm wide x 305mm long grain direction (2" wide x 12" long).

b) Thickness, width and weight will be recorded prior to vacuum exposure.
c) Test specimens shall be placed in racks to ensure free movement of air and water around the specimens, and placed in a vacuum pressure testing vessel.
d) The vacuum pressure vessel is filled with water at a temperature of 66ºC (150ºF). For reference to the vacuum pressure vessel, see Figures 3 and 4.
e) A vacuum is applied to the vessel at 50.6 kPa (15 in. of mercury) for 30 min.
f) The vacuum is released and specimens are to remain soaked in water (at atmospheric pressure) for an additional 30 minutes.
g) The vessel is then drained and specimens are removed and dried in an oven for 15 hours at 82ºC (180ºF). Oven will have fan-forced air circulation of 45 to 50 air changes per minute**.

*** The specimens are to be conditioned by oven drying in order to bring the moisture content back down to within 2% of the original weight recorded in step 2.b), above.*

Figure 3 and 4: Vacuum pressure vessel

3.3.2.2 Minimum Requirements for Moisture Exposure Test

1. Specimens must not delaminate during or after vacuum exposure.
   a.) Following vacuum exposure, specimens will be evaluated for any delamination, cracks, splits, interlayer separation, or swelling.
   b.) No separation shall exist within each layer of material (wood, bamboo, or other material).
2. Thickness and width will be recorded following vacuum exposure to determine how much swelling has occurred, if any. Weight shall also be recorded after exposure.

3. Dimensional change tolerance must not exceed (+1, -1 mm) in any direction.
4. No separation at the glue lines.
5. **After vacuum exposure and oven drying the specimens shall be mechanically tested by following the IICL short span test procedure, with a minimum breaking load of 6,780 Newtons (1,525 lbs), and the breaking load is to be compared to the unexposed specimens for a percent strength reduction not greater than 15%.**
6. Breaking load must be greater than 6,780 Newtons (1,525 lbs)
7. Breaking load strength reduction must be less than 15%.
8. For comparison, it is recommended to short span test at least 2 specimens in the dry unexposed condition and at least 2 separate specimens after the exposed condition, all from the same larger floor panel sample.
9. Also include data for MOE.
10. All typical evaluations following short span testing to be done.

3.4 IICL Floorboard Strength Test (with details added to the latest ISO Floor Strength Test)

3.4.1 Scope of Testing

All batches of production should be tested. The first container of each production batch and one container –RANDOMLY PICKED BY THE BUYER'S REPRESENTATIVE – of every 50 (fifty) units built thereafter should be tested as below. These test units should be moved directly to the testing area after they are off-lined. NO undercoating should be applied until after successful floor testing has been carried out.

Testing should be done in a location such that the buyer's representative can witness the test with minimal interruption of his on-line inspection duties. The testing should be done immediately after pulling the unit from the line so as to minimize the number of units manufactured prior to the test results being determined.

This test procedure does not replace in any way the ISO Floor Strength Test carried out as part of the prototype and batch production tests. It is a FLOORBOARD STRENGTH test only, so it is not necessary to monitor and record base deflection during testing EXCEPT IN THOSE CASES IN WHICH THE RANDOMLY PICKED CONTAINER HAPPENS TO ALSO BE SCHEDULED FOR THE ISO BATCH TEST.

3.4.2 Testing Vehicles

Each floor should be tested using a test vehicle that is consistent with the test vehicle description in **ISO 1496-1, Section 6.9.2, Test No. 8 – Floor Strength**.

3.4.3 Testing Procedure

Step 1: Testing shall be carried out with the above described test vehicle loaded with an axle load of 3,630 kg per wheel (2 wheel load 7,260 kg). Load must be centered over the two 180 mm wide (7.0") wheels evenly.

Step 2: The test vehicle shall be maneuvered SLOWLY **(AT MAX SPEED OF 152 MM PER SECOND or 0.5 FT PER SECOND)**, in such a way that the entire floor area is covered. Care should be taken to avoid impact or other dynamic loads by starting, stopping and rolling the test vehicle gently and slowly.

Step 3: The test vehicle shall be maneuvered over the floor area for a total of 5 (five) cycles. One cycle is considered to be a complete pass into the container from the door to the front panel and from the front panel to the door and out of the container. The wheels of the test vehicle shall follow the same path on the inward and outward passes.

Step 4: The test vehicle should be repositioned outside the container between cycles so as to avoid imposing any dynamic loads on the container floor.

Step 5: At the end of EACH cycle the inspector should, using a hammer, tap the floor in search of hollow sounds, which will indicate delamination between floor panel components. In addition, the inspector should look for other obvious signs of failure such as waviness and/or bulges on the outer plies, and cracks in the outer (usually lower) plies of the tested boards.

Step 6: If tapping after one of the cycles produces a hollow sound but there are no obvious signs such as waviness, bulges, or cracks as mentioned above; the area should be marked for further inspection after all cycles are completed.

Step 7: The inspection procedure in Step 5, above, shall be repeated for each cycle until all five cycles are completed or until a failure is detected in any floor panel. If obvious signs of failure (waives, bulges, or cracks) occur at any time during the test, the container has failed the floor test, and the test should be stopped.

Step 8: At the end of the test (5 cycles), and if no problems are noted during testing, random floor panels should be removed (two for a 20 ft and four for a 40 ft container) for further inspection and determination of the presence of delamination / ply separation between plies. IF THERE IS ANY SUSPICION WHATSOEVER THAT THESE PANELS HAVE FAILED, THE PANELS ARE TO BE SECTIONED FOR FURTHER INSPECTION. In addition, any boards marked in Step 5, above, and any boards showing visible permanent downward deflection should be removed and inspected. THESE PANELS SHOULD BE SECTIONED TO CONFIRM THAT

FAILURE HAS NOT OCCURRED INWARD FROM THE PANEL EDGES. If no problems are found, the undamaged and uncut boards should be reinstalled and the floor test considered successful.

3.4.4 Floor Pass/Fail Criteria

3.4.4.1 Breakage

Any BREAKAGE constitutes failure of the floor tested.

BREAKAGE is defined as follows:

- Any DELAMINATION/PLY SEPARATION resulting from the internal shearing of the veneer or failure of the adhesive including peeling of the surface plies such that the panel no longer acts as a single, composite structure.

NOTE: Delaminations at the edges caused by the abrasive action of the panels rubbing together at panel-to-panel joints is NOT considered breakage.

- Any cross-grain or transverse CRACKS in the plywood exterior veneers.

NOTE: Splits or cracks running parallel to the exterior grain are NOT considered breakage (THIS EXCLUSION IS SUBJECT TO FURTHER CONSIDERATION, AS IT MAY BE NECESSARY TO DIFFERENTIATE BETWEEN MINOR SPLITS AND LARGER SPLITS THAT MAY INDICATE FLOOR BREAKAGE).

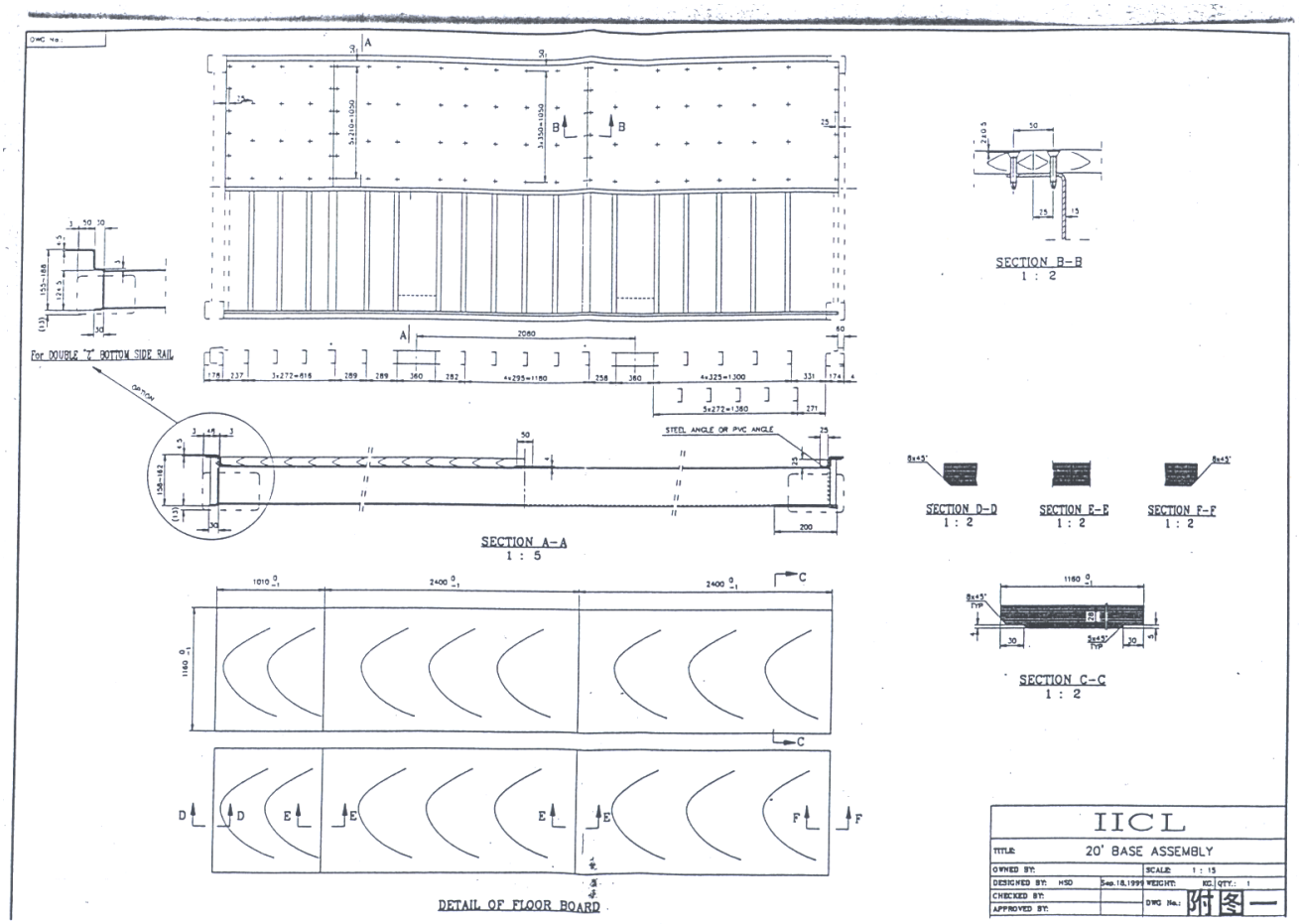
3.4.4.2 Failed Units

- Should breakage be found, a second container from the same batch shall be tested as above.

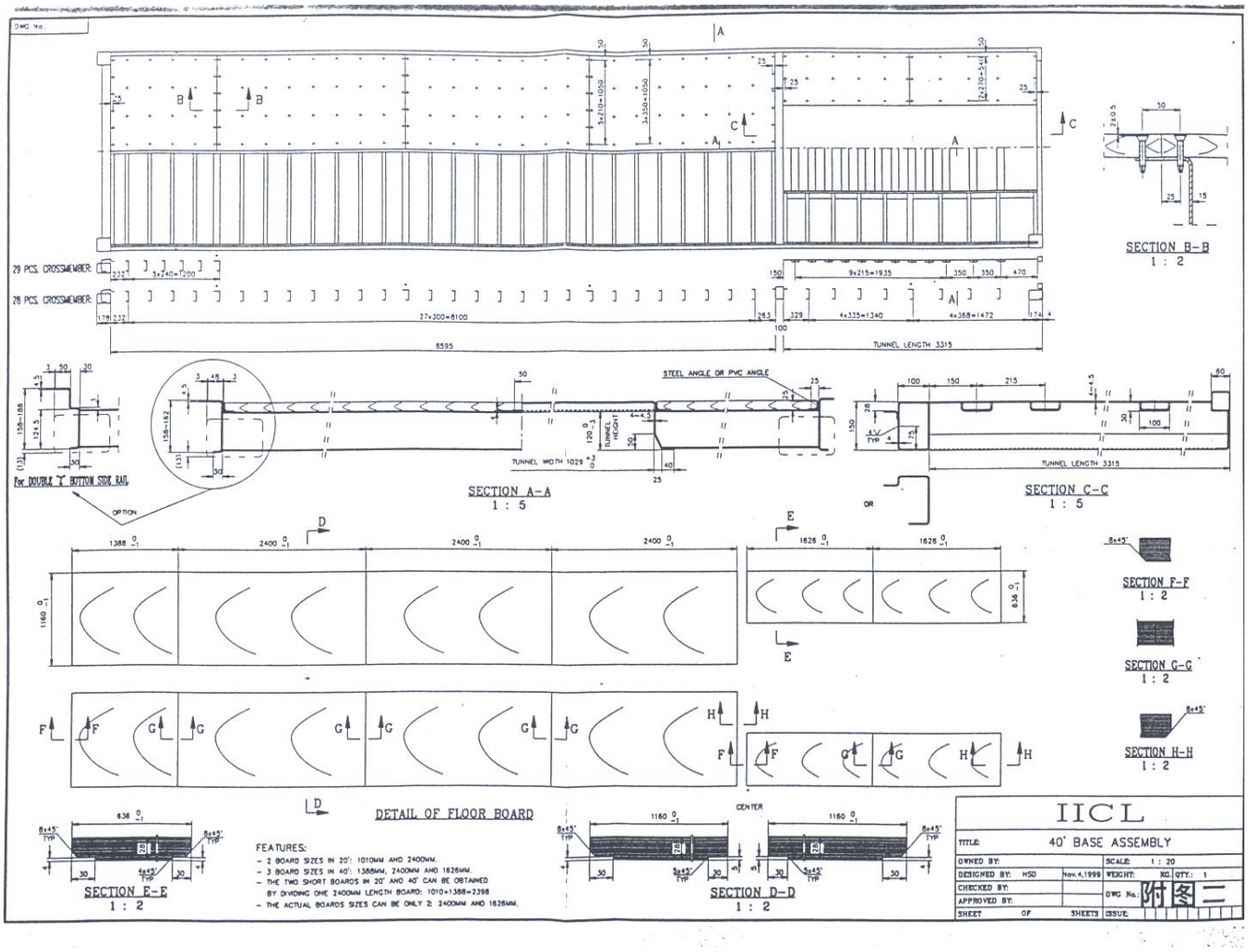
- If the second container passes the test, the batch is considered acceptable, and testing is to return to the one (1) in fifty (50) sampling cycle.

If the second container fails, the container batch is considered to be failed, and the buyer shall be contacted for instructions. AT THE BUYERS OPTION, ADDITIONAL TESTING MAY BE REQUIRED AND TESTING MAY INCLUDE UNITS PRODUCED PRIOR TO OR BETWEEN EARLIER TESTS THAT WERE SATISFACTORILY PASSED.

3.5 IICL 20FT BASE ASSEMBLY



3.6 IICL 40FT BASE ASSEMBLY



3.7 IICL Floor Panel Identification

Below is our project recommendation regarding the implementation of compulsory identification of the floorboard supplier incorporated into the container manufacturing process.

a) Container floorboard suppliers should be identified by the classification society representative, and the floorboard supplier name should be included on the Certificate of Inspection.

b) All container floorboards should he permanently marked by the flooring supplier as follows:

- Flooring supplier's brand should he stamped on the upper face of each board.
- The initials of the flooring supplier should be stamped on the board edge.
- The adhesive spreader and hot press numbers should be stamped on the board edge.
- The month, day, and year that the board was manufactured should be stamped on the board edge.
- Strength rating (see table 1.9 below)

Table 1.9	
T - 7	Only floor boards manufactured to pass ISO** floor strength test at 7.2 tons and above
T - 6	Only floor boards manufactured to pass ISO floor strength test at between 6.0 and 7.2 tons
T - 5	Only floor boards manufactured to pass ISO floor strength test at between 5.0 and 6.0 tons
	** ISO floor test 14:96-1 Sixth Edition 2013-07-01 – 6.9 Test No. 8

c) The container manufacturer's Specification Data Decal that is applied to the interior rear of each container should have an area for a small overlay decal listing the floorboard type and flooring supplier's name. If the Specification Data Decal is not required by an owner, the floor supplier's decal will be applied at the interior rear of the container.

Attachments:

- Attachment (a): Sample of the Certificate of Inspection.
- Attachment (b): Examples of floorboard markings.
- Attachment (c): Sample of Specification Data Decal.
- Attachment (d): Sample of flooring supplier's decal.

Attachment (a)

BUREAU VERITAS

CERT NO. 34323

CERTIFICATE DE CONTROLE / CERTIFICATE OF INSPECTION

No. BVCT 0580191/S

Nom et adresse du Demandeur / *Name and address of Applicant* : NANTONG CIMC-SMOOTH SAIL CONTAINER CO., LTD. LUJINGGANG, NANTONG, P.R.C.

Nom et adresse du Titulaire / *Name and address of Owner* : TRITON CONTAINER INTERNATIONAL LTD. SAN FRANCISCO, CALIFORNIA, U.S.A.

CONTENEURS - CONTAINERS

Type / *Type* : **ISO 1AA** Modele / *Model* : **1AA-084A42G1G(A)**

Numeros de serie de construction / *Serial number of manufacturing* : **NSSC05B 01101 to NSSC05B 01850**

No. d'immatriculation / *Registration numbers* : De/*from* **TTNU 458875** A/*to* **TTNU 459624**

Dates de livraison / *Dates of delivery* : Du/*from* **Feb., 2005** Au/*to* **Feb., 2005**

Nom et adresse du Constructeur / *Name and address of Manufacturer* : **NANTONG CIMC-SMOOTH SAIL CONTAINER CO., LTD. LUJINGGANG, NANTONG, P.R.C.**

Declaration du constructeur / *Manufacturer's statement* – Le soussigne certifie que les conteneurs mentionnes ci-dessus ont ete construits en conformite avec le type de reference / *The undersigned certifies that the here above containers have been manufactured in conformity with the reference type.*

Cachet et signature du constructeur / *Stamp and signature of the manufacturer* : (CHEN JIAN MING)

南通中集順達集裝箱有限公司 CIMC-SMOOTH SAIL CONTAINER CO., LTD. NANTONG

Type de construction de reference / *Reference design type*

- No. BVCT de classification / *BVCT No. for classification*	:	BVCT	0380297/S		
- Masse brute maximale / *Maximum gross weight*	:	30 480	kg	67 200	lbs
- Tare / *Tare weight*	:	3 660	kg	8 070	lbs
- Volume / *Cubic capacity*	:	67.7	m^3		

Conditions d'essais / *Testing conditions*

- Charge admissible de gerbage / *Allowable stacking weight*	:	216 000	kg	476 190	lbs
- Resistance du plancher / *Floor strength test*	:	7 260	kg	16 000	lbs
- Rigidite transversale / *Transverse racking test load*	:	15 240	kg	33 600	lbs

Les conteneurs ci-dessus ont ete controles selon les prescriptions des Reglements applicables et les marquages suivants ont ete apposes / *The here above mentioned containers have been inspected with regard to the applicable rules and have been marked as follows:*

C.S.C (numero / *number*) : **F / BV / 8173 / 03**

U.I.C. (marque / *mark*) : **IC / 87** Ref. Autorite' / *Authority* :

T.I.R. (numero / *number*) : **GB/C 5469 BV/2003**

Marque BV / *BV mark* : **II-TT**

Code ISO / *ISO code* : **42G1** Pays / *Country* – Dimension-type / *Size-type*)

Autres / *Others* : TTNU 458875 - 459224: SST flooring - wood treatment IM/Meganium
TTNU 459225 - 459624: BIC flooring - Wood treatment IM/Taillileum

A / *At* : **SHANG HAI**

Le / *On* : **Mar.1, 2005**

Pour le BUREAU VERITAS, la personne habilite'e (Nom, signature et cachet)
For the BUREAU VERITAS, the person in charge (Name, signature and stamp)

(Michael Wu)

AgME 1626

Attachment (b)

Upper Face of Board

- **Plywood supplier's name**
- **Brand stamped**

Board Edge

- **Plywood supplier's initials**
- Adhesive spreader **number**
- Hot press **number**
- **Manufacture month, date, and year**
- Board **strength rating**

Attachment (c)

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SPECIFICATION DATA

(A) PAINT SYSTEM:

PAINT MFR'S NAME:

HEMPEL–HAI HONG COATINGS CO., LTD.

EXTERIOR COATING:

HEMPADUR ZINC 1536/1983

HEMPADUR PRIMER 1530/2178

HEMPATEX HI–BUILD 4637/6181

INTERIOR COATING:

HEMPADUR ZINC 1536/1983

HEMPADUR HI–BUILD 4520/1115

BASE COATING:

HEMPADUR ZINC 1536/1983

HEMPINOL 1022/1999

(B) DOOR HARDWARE:

SAEJIN SJ-13BF WITH SECURA CAM & KEEPER

(C) DOOR, SIDE, FRONT AND ROOF PANEL, DOOR FRAME, REAR AND FRONT HEADER, REAR AND FRONT SILL, CROSSMEMBER, FORK POCKET TOP PLATE, FORK POCKET SIDE RAIL, REAR AND FRONT CORNER POST:

TOP AND BOTTOM SIDE RAIL,

CORTEN A — Y.P.=35 KG/MM² T.S.=49 KG/MM²

(D) THE OTHER MATERIAL:

SS41 — Y.P.=25 KG/MM² T.S.=41 KG/MM²

(E) Floorboards: Place floor supplier's decal here

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Attachment (d)

Floorboard type: Apitong Plywood

Supplier: P.T. Harjohn Timber

Size to fit Specification Decal

4. DEFINITIONS

4.1 Bamboo: Engineered panel comprised solely of bamboo or a hybrid combination of bamboo and wood veneers where the bamboo is oriented for directional properties along the length of the panel.

4.2 Decay: Decay is deterioration of wood as a result of fungal attack. The typical appearance of decayed wood includes splitting across the grain, soft and punky, stringy, or crumbly. The presence of wood decay can result in significant reductions in strength. Decay must NOT exist in wood to be used for panels, as it has no strength and, under some conditions, may continue to spread into surrounding good wood.

4.3 Decay resistance: The resistance of a wood species or panel treated with a wood preservative to stop/retard wood decay.

4.4 Delamination: A true delamination is when the adhesive bond fails in a panel, and adjacent veneer, plies, or strands are no longer permanently joined to one another. Because panels are often made from the same batches of glue, multi veneer/plies/strands and multi panels often reveal true delamination.

4.5 Density: The weight of a sample divided by its volume. Density is expressed in kilograms per cubic meter (KCM), pounds per cubic foot (PCF), etc.

4.6 High Impact Over Small Area: A high impact can cause another type of failure. If a heavy impact occurs over a small area, it can cause simultaneous multi ply rolling shear failures through the thickness, and also a bending failure of outermost longitudinal plies

4.7 Internal Forces: When any structural member is supported on an approximate 300-350 mm (11.8" – 13.8") span and experiences a vertical load, such as a rolling fork truck wheel, it experiences both vertical and horizontal induced forces. The vertical forces are maximum on the member's top and bottom surface. The top surface is loaded in a compression mode, while the bottom surface is loaded in a tension mode. These forces are zero at the center of the thickness. The horizontal forces are maximum at the center of the member's thickness, and are zero at the top and bottom surfaces. In wood, these horizontal forces create the potential for a sliding motion between the upper and lower portions of the member.

4.8 Internal Forces, Plywood panels in container floor: When a plywood panel is subjected to vertical loads, such as a rolling fork truck wheel, in container flooring that is supported on approx. 300-350 mm spans, the panel experiences both vertical and horizontal internal forces. Traditional Apitong/Keruing panels generally are stronger in resisting the internal vertical forces, and thus fail from horizontal shear overloading. This failure usually results in splits/separations within the interior "middlemost" transverse layers. These failures occur between, or within, a veneer/ply as fibers rolling over each other. This is referred to as a rolling shear failure.

4.9 <u>Internal Forces, Wood Plank in container floor</u>: When a hardwood plank is subjected to vertical loads, such as a rolling fork truck wheel, and is used in container flooring that is supported on approx. 300-350 mm spans, the plank experiences both vertical and horizontal internal forces. Common oak and Apitong/Keruing planks generally are stronger in resisting horizontal internal, shear forces, and thus fail from vertical overloading (in bending), which usually results in splits on their lower exterior surface.

4.10 <u>Marine Grade Plywood</u>: Plywood manufactured to the highest standards and longest service life. Panels of this grade can be permanently exposed to moisture or elevated moisture conditions.

4.11 <u>Moisture Content</u>: The amount of water in wood usually expressed as a percentage of the weight of the oven-dry wood. Moisture content is sensitive to changes in the surrounding environment. As the surrounding relative humidity increase, the wood moisture content will also increase, and as the surrounding relative humidity decreases the wood moisture content will also decrease.

4.12 <u>OSB</u>: Oriented Strand Board (OSB) is an engineered panel typically comprised of a core of wood strands oriented for directional properties along the length of the panel and with wood veneers adhered to the top and bottom of the OSB core.

4.13 <u>Plywood</u>: An engineered structural material consisting of veneer/plies of wood at different thicknesses glued or bonded together with the wood grain of adjacent layers arranged at right angles or parallel to each other. Depending on the desired properties in container plywood panels, up to 3 plies in specific locations all run in the same longitudinal direction, for special increased strength reasons. Also, see lay-up configuration definition below.

4.14 <u>Plywood Layup</u>: Layups are the ply directions of each layer in a panel, and these are transverse (at right angle to panel length) and longitudinal (parallel to panel length). Traverse plies maintain panel dimensional stability (minimize length and width dimensional changes from moisture changes, frequently noted in planks), and allow smaller pieces to be used in these layers to best use varying log trimmings; Longitudinal plies resist bending and shear forces, but must be used full length for attaining panel strength. Lay-up is a part of the "engineered" feature of the panel to meet specific service requirements.

4.15 <u>Rolling Shear Failure</u>: When veneers/plies in a plywood panel are loaded ACROSS/at right angles to the grain, a sufficient load can become more than their natural shear strength. This overload then causes grains to rip free of each other, and begin to roll over each other, in what is known as a rolling shear failure.

4.16 <u>Separation</u>: When a panel fails due to overload, veneers/plies pull apart/separate; in these cases, because horizontal stresses are highest at the center of the panel thickness, the first failure (a rolling shear failure) usually occurs in a transverse layer above or below the core of the panel's thickness. Sometimes secondary failures occur at approx. ½

thicknesses of the remaining thicknesses. After shear failures, extreme loads can also cause splitting/bending failures of outermost longitudinal plies.

Note: Continuous overloading/fork truck travel can result in "rubbing" internal friction forces between adjacent, previously separated veneers/plies. This may result in a smooth appearance at the location of the adhesive bond. This "smoothing" should not be confused with a "true delamination".

4.17 Specific gravity: The ratio of the oven dry weight of wood to an equal volume of water. Specific gravity is a unit-less value. This value is most often used in industry testing procedures for comparative purposes for wood strength and is cited in wood science textbooks. As the specific gravity increases, strength generally increases. As the specific gravity decreases, strength generally decreases. Specific gravity is typically determined with the oven dry weight, or zero moisture content, and oven dry volume of a tested sample.

4.18 Wood/fiber failure: In testing when solid wood is overloaded in bending, it will usually fail/crack through its thickness, similar to a tree branch broken over one's knee.

When panels (i.e. plywood, OSB or Bamboo) are tested according to the test procedures in this bulletin, they generally fail in rolling shear, separating within inner veneers/plies or core. As long as the adhesive bond is good, fibers will remain attached to the adhesive. This is considered wood/fiber failure within a plywood panel.

IICL TB 001 was prepared under the supervision of the IICL Technology Committee.