Germanischer Lloyd

Rules for surveying and testing

of Plywood for Aircraft

Edition

January 1953

Germaniſcher Lloyd

Rules for surveying and testing

# of Plywood for Aircraft

Edition

January 1953

Preface

In 1931, the groups interested in Air Navigation asked Germanischer Lloyd to take up testing of plywood for aircraft into his sphere of action. According to his statutes which determine his activities as those of an institute for the classification of ships and aircraft, G.L. took up this task and, after gathering experiences of his own, established Rules for such testing. From 1931 till now, GL-Surveyors have been testing plywood according to these Rules or to any other specification demanded by the purchaser, in 7 European countries at 22 factories. During this period, more than three and a half million of boards were under test.

As a rule, surveying and testing of plywood is carried out on the basis of contracts between Germanischer Lloyd and manufacturers or dealers, wishing continuous supervision and verification of plywood manufacturing within the factories at home and abroad. Only by way of exception, Germanischer Lloyd also examines finished lots of plywood, if faultless manufacturing and storing have been proved.

Plywood tested by Germanischer Lloyd and provided with his stamps and certificates has become of acknowledged repute on the international market. Like all other G.L.-Rules, those for plywood are permanently adapted to the technical development. This edition is presented as corresponding to the actual state of such technical progress. Photos No.1 - 11, showing plywood-boards of different aspects, are added to explain the text.

Berlin, January 1953

Table of Contents

Edition: January 1953

Rules of Germanischer Lloyd for surveying and testing of Plywood for Aircraft

I. Introduction

The following Rules shall be applied to waterproof and boilingproof plywood boards for aircraft. The Rules detail requirements for two Grades of Plywood, e.g.

1) Grade G.L.I,
2) Grade G.L.II .

Equal strength (including gluing strength) is required for both Grades, the only difference being that the boards of Grade G.L.I can be used as a whole, whereas boards of Grade G.L.II, owing to not permitted defects of the inner and outer plies, may be used divided up only, after the defective parts have been eliminated.

These Rules contain nothing but the requirements for plywood for aircraft proper. They are not applicable regarding further treatment and the assemblage of the boards to other woodwork.

The symmetric assembly of thicknesses must not be disturbed by the surface treatment.

5. Sizes of Boards:

These must correspond to the Order.

The longitudinal dimensions must be stated in cm, the first dimension indicating the grain direction of the face plies.

Example:

Size 120 x 100 cm means:

Grain of face plies following the longitudinal direction of the board.

It is recommandable that Orders are based on approved Standards.

6. Joints:

Unless otherwise specified between buyer and manufacturer, synthetic resin glued boards may contain edge joints in cores and face plies, running parallel to the grain direction, according to the following Rules.

The joints must be absolutely tight fitting; they shall be butt-joints. Joints shall be made by a reliable jointing machine and glued with synthetic resin glue. Paper tapes, metal clips or such likes are not permitted.

The joints shall be made in such a way that they are not lying over each other in the different plies.

The individual strips of face plies shall be assembled in such a way that species and colour of wood are well matched (see Photo No.11).

III. Selection of Test Specimens

For the testing specified in Section V test boards have to be selected, the number of which agrees with the following conditions:

If the Surveyor considers the manufacturing to be highly reliable or if the factory disposes of a suitable plant for automatical supervising, 2 - 3 % of every test lot are sufficient. Otherwise at least 5 % have to be chosen as test boards.

II. Manufacture

In principle, the manufacture shall be supervised by the G.L. Surveyor at the factories; at least it has to be tested there.

1. Species of Timber:

Birch, Beech, Alder, Okumé (Gaboon) or other timbers, if the process of manufacture guarantees the values indicated in Table I .

2. Assembly of Veneers:

Symmetric in relation to the core, regarding grain direction as well as thickness of plies.

The proportions of thickness shall be chosen in such a way that, as far as possible, longitudinal and transverse strengths are alike. The G.L. reserves the right to exclude from testing every board of unsuitable assembly.

Number of plies:

under 2,0 mm	thickness	at least 3-ply,
from 2,0 mm	thickness up to and incl. 6,0 mm	" " 5-ply,
over 6,0 mm	thickness up to and incl.14,0 mm	" " 7-ply;
over 14,0 mm	the number of plies is ..... but none of the plies shall exceed 2,0 mm in thickness.	optional,

See Table I

3. Gluing:

Only types of glue approved by the G.L. are permitted. Such are glues of synthetic resin type: Phenol-resin glues (Tego Film included), Resorcin- and Melamine-resin glues.

Before a new type of glue is admitted, the G.L. requires proofs regarding its faultless application and gluing power, as well as its absolute resistance to watering and boiling.

4. Surface Treatment:

The boards may be unpolished, slightly polished, trimmed or smoothed, resined or unresined.

After this treatment, the surfaces shall still be of sufficient thickness as to guarantee a reliable further treatment.

The symmetric assembly of thicknesses must not be disturbed by the surface treatment.

5. Sizes of Boards:

These must correspond to the Order.

The longitudinal dimensions must be stated in cm, the first dimension indicating the grain direction of the face plies.

Example:

Size 120 x 100 cm means:

Grain of face plies following the longitudinal direction of the board.

It is recommandable that Orders are based on approved Standards.

6. Joints:

Unless otherwise specified between buyer and manufacturer, synthetic resin glued boards may contain edge joints in cores and face plies, running parallel to the grain direction, according to the following Rules.

The joints must be absolutely tight fitting; they shall be butt-joints. Joints shall be made by a reliable jointing machine and glued with synthetic resin glue. Paper tapes, metal clips or such likes are not permitted.

The joints shall be made in such a way that they are not lying over each other in the different plies.

The individual strips of face plies shall be assembled in such a way that species and colour of wood are well matched (see Photo No.11).

III. Selection of Test Specimens

For the testing specified in Section V test boards have to be selected, the number of which agrees with the following conditions:

If the Surveyor considers the manufacturing to be highly reliable or if the factory disposes of a suitable plant for automatical supervising, 2 - 3 % of every test lot are sufficient. Otherwise at least 5 % have to be chosen as test boards.

In case of breakdowns in the factory, or if the production lacks in regularity and reliability, a greater number of boards has to be selected.

The test boards shall be taken from test lots, containing boards of the same species, thickness and manufacturing. Too large homogenous quantities have to be divided into smaller lots.

Each test board will get a special number by the Surveyor, and the test pieces shall be taken from this board and meet the requirements of Section V, 4 and 5 (test specimens see Table II).

Should one or more boards turn out unsatisfactorily when tested, two boards instead of the rejected one shall be chosen for re-testing. If these, too, fail to fulfil the minimum requirements, the whole test lot will be rejected.

If, on the strength of his examinations, the Surveyor gains the impression that the gluing of the boards is unreliable, he is authorized to reject all boards of the test lot in question, or to put them aside for re-testing.

The re-test may be confined to the gluing tests, if those only were unsatisfactory.

Flawless pieces only should be used for test-specimens.

Rejected boards may only be selected for test boards if they have sufficiently large flawless faces from which test pieces can be taken.

IV. Inspection

Grade G.L.I

must comply with the conditions specified in Section II and V .

The boards must be suitable for use as a whole.

Quality:

1) The following defects in material are not permissible:

a) loose and dead knots, gaps in the inner plies;

b) tight knots over 6 mm diameter;

c) for 3-ply boards more than 4 knots in one ply of a 100 × 100 cm board;

d) knots at a distance of less than 200 mm apart;

e) in boards of 5 and more plies, more than 6 knots in one ply and at a distance of less than 150 mm .

For sizes of boards other than the above specified, the number of permissible knots varies according to the surface. Knots at a distance of up to 30 mm from the edge of the board need not be considered.

f) Short-grown wood, cross-grain, coloured appearance and discolorations, dotes, if they obviously reduce strength and flexibility.

Slight signs of dotes and bark-traces may be disregarded.

Short-grown wood and cross-grain mean that the slope of fibers is interrupted; it shows obviously different directions of texture (see Photos No.1 - 7).

g) Scars of knots and splits

(see Photos No.8 - 10).

2) Furthermore, the following faults of manufacture are not permissible:

a) Joints exceeding the limits according to Section II, 6, and patches (fillings).

b) Open joints left without glue and not tightly fitting joints (see Photo No.11).

c) Pleats and splits, checks, cutting-defects and blisters as well as other similar defects susceptible to reduce the strength of the board.

3 infractions, pleats or splits at a distance of less than 30 mm from the edge of the board may be disregarded, if situated on two faces not opposite to each other.

d) Undulating or crooked boards.

e) Spots left without glue, caused for inst. by damage of the film glue, unless they have been covered.

f) Excessive penetrations of glue visible on more than one face of a board.

G r a d e G.L.II

For boards of Grade G.L.II somewhat bigger and other defects than for those of Grade G.L.I are admissible, but these defects must not be distributed over the whole board. A rectangular piece of at least h a l f the size of the board must correspond to the requirements for Grade G.L.I . The remaining part may contain defects which are not admissible for Grade G.L.I, but only to such an extent that it is still possible to use sufficiently large pieces by dividing the board up accordingly.

Moreover, the boards must comply with the requirements specified in Section II and V, i.e. they must show the same quality and strength as Grade G.L.I .

Defective spots and such defects which cause a board to be classified as Grade G.L.II shall be marked, but in such a way that the marks can be easily and quickly removed (recommended carpenters pencil; ordinary chalk, oil-chalk and copying ink-pencil are not permitted).

V. T e s t i n g

1) General condition of the boards:

This is to be determined by external inspection.

To examine the inner condition of the boards they shall be penetrated by light of sufficient intensity in a well-darkened room.

Every board up to such a thickness that it still permits penetration by light, i.e.

fair timber like Birch up to 3,0 mm thickness,
dark timber like Beech, Okumé (Gaboon) up to 1,5 mm thickness,

must be examined in this way.

2) Deviations of thickness:

Deviations of manufacturing, especially of thickness, must comply with the demands of the industrial user. Unless there exist other requirements, the following values for deviations of thickness are admissible:

up to	2,5 mm	± 10 %
over	2,5 mm up to 5,0 mm	± 0,25 mm
over	5,0 mm	± 5 %

See Table I

3) Moisture Content:

Glued boards should have a moisture content between 6 and 12 percent.

In order to measure the moisture content test pieces of 10 x 10 cm have to be cut from the test board and weighed on a sufficiently accurate scale (accuracy at least 0,1 g) The test pieces shall then be dried in an oven at a temperature of 95° up to 105°C until they have lost every humidity and the weight remains constant.

The moisture content in % related to the dry weight will be:

$$\text{Percentage of Moisture} = \frac{W_1 - W_2}{W_2} \cdot 100 ,$$

W_1 representing the weight of the test piece before drying,

W_2 being the weight of the test piece in absolutely dried state.

Example:

W_1	=	24,3 g
W_2	=	22,4 g
difference	=	1,9 g

$$\frac{W_1 - W_2}{W_2} \cdot 100 = \frac{24,3 - 22,4}{22,4} \cdot 100 = \frac{190}{22,4} = 8,5\ \%$$

The exact determination of the dried state is important.

Care should be taken that the test pieces are weighed immediately after they have been removed from the oven, because dry wood eagerly absorbs the moisture of the air. The use of a drying apparatus with scales is recommended.

The Surveyor may only use electrical and mechanical apparatus for measuring after having thoroughly examined the exactness of their indications by drying several test pieces in the oven (kiln-drying test).

4) Tensile Strength of the Wood:

The strengths have to be determined by stretching at least 3 test specimens in longitudinal direction and 3 specimens transverse to the grain direction of each test board by means of a gauged tensile testing machine.

The following minimum strengths are required:

For B i r c h , B e e c h and A l d e r
or timber of similar qualities

longitudinal	to grain direction of face plies	=	700 kg/cm^2
transverse	to grain direction of face plies	=	450 kg/cm^2
longitudinal + transverse	to grain direction of face plies	=	1400 kg/cm^2

For O k u m é (Gaboon) and P o p l a r
or timber of similar qualities

longitudinal	to grain direction of face plies	=	450 kg/cm^2
transverse	to grain direction of face plies	=	300 kg/cm^2
longitudinal + transverse	to grain direction of face plies	=	900 kg/cm^2

Lower values but not exceeding 10 % are permissible for boards over 3 mm thickness.

The average value of the results of the same test board has to be considered as definitive result of the testing.

See Table I

Dimensions of Test Specimens:

For test boards under 4 mm thickness specimens 230 × 25 mm according to Fig.1
For test boards over 4 mm thickness specimens according to Fig.2

See also Table II

Test Specimens for Tensile Strength of the Wood

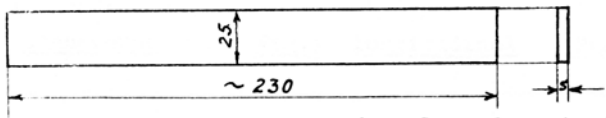


Fig.1 Test specimen for plywood up to 4 mm thickness

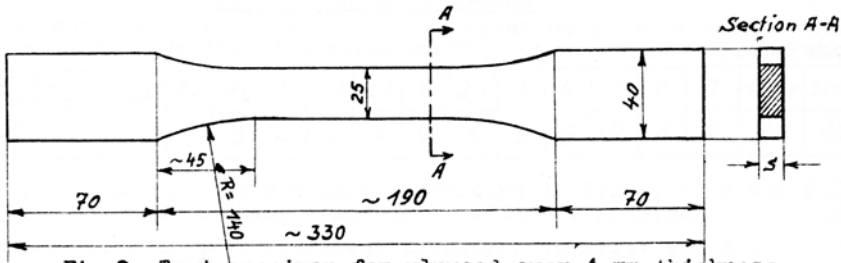


Fig.2 Test specimen for plywood over 4 mm thickness

If the test specimens are taken from a piece of 20 cm width cut from the edge of the board, they may also have the dimensions indicated at Table II .

5) Gluing Strength

The gluing strength has to be determined by shearing in wet state the gluing faces of at least 5 specimens of every test board in a gauged tensile testing machine, furthermore by two boiling tests with specimens of 10 × 10 cm .

Specimens for 3-ply boards see Fig.3
specimens for 5-ply boards see Fig.4 and 7
specimens for 7-ply boards see Fig.5 and 8
specimens for 9-ply boards see Fig.6

Test Specimens for the determination of the gluing strength:

for 3-ply boards

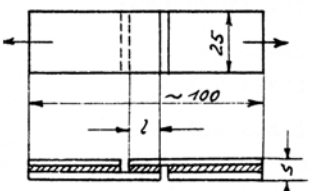


Fig.3 longitudinal

for 5-ply boards

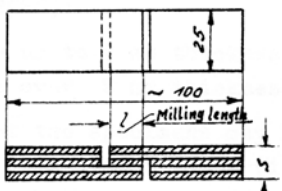


Fig.4 transverse

for 7-ply boards

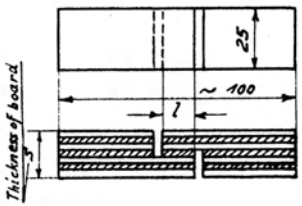


Fig.5 longitudinal

for 9-ply boards

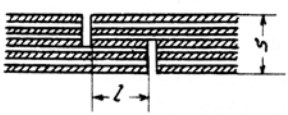


Fig.6 transverse

for 5-ply boards

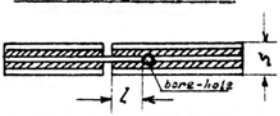


Fig.7 longitudinal

for 7-ply boards

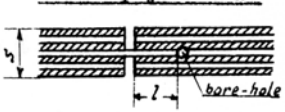


Fig.8 transverse

Standard values for the milling lengths of the gluing specimens

The examined glue line must be so small that no rupture in the wood occurs, and so large that the plies offer good resistance to separation.

Thickness of board s mm	0,6	0,8	1	1,2	1,5	2	2,5	3	4	5	6	8	10-14	16-20
Milling length l mm	3	3	4	4	4	4	5	5	6	7	8	9	10	12

Glue line of test specimens according to Fig.3, 4, 5 and 6 = milling length l × width of specimen,

Glue line of test specimens according to Fig.7 and 8 = 2 × milling length l × width of specimen.

Gluing test specimens of 5-ply and multiply boards with veneers so thin that it is impossible or very difficult to bore them according to Fig.7 and 8, shall be prepared according to Fig.4, 5 and 6 ; the grain direction of the face plies of 5-ply boards must then be transverse, that of 7-ply boards must run parallel to the longitudinal direction of the test specimens. On each surface 3 or 4 plies have to be milled.

Before testing, the specimens must be submerged completely in water for such a period that they are perfectly soaked through.

Standard values for the period of watering at room temperature (15 - 20°C):

for specimens up to 2 mm thickness	24 hours,
for specimens over 2 mm thickness	48 hours.

The soaking of the specimens may be substituted by boiling them for a period of 3 hours (i.e. the specimens must be submerged in boiling water for 3 hours).

Minimum resistance ascertained after saturation in wet condition shall be

$$20 \text{ kg/cm}^2 .$$

Single values may be at the most 10 % less than the above requirements.

In addition, a boiling test of 3 hours has to be carried out twice with pieces of 10 × 10 cm cut from each test board. The test pieces shall be boiled for 3 hours and then dried. They shall then be boiled again, cooled in water, and tested while wet by bending them several times by hand or over a suitable mould and finally tearing them. There shall be no separation of the plies, nor brittleness or disfavorable aspect of the glue line.

If the Surveyor observes any irregularity, he shall increase the number of the tests for which he will use the suspect boards.

Should the boards be glued with phenol resin glue the Surveyor may disregard the boiling tests at his own discretion.

6) Other Tests,

carried out to verify the good quality of the gluing, are left to the discretion of the Surveyor, according to circumstances. Such tests are:

a) Bending Test:

Number of test pieces optional.

A longitudinal test piece, 25 mm wide and sufficiently long, shall be bent with an inclination of 180° once each way over a cylindric mould having a diameter of 100 times the thickness of the board. Direction of the test piece: vertical to the fibers of the face plies. Crackling noises or fracture mean defective gluing or excessive drying of the board.

b) Torsion Test:

Number of test pieces optional.

Edge sections or strips of about 25 - 30 mm width and suitable length shall be twisted round a longitudinal axis until fracture occurs. The breaking spots must be short and show good gluing.

c) Immersion in water of whole boards:

Immediately after pressing, the whole board will be submerged in hot water for at least 2 hours. The Surveyor then examines the board to see whether it shows blisters or faulty gluing.

VI. Marking and Stamping

Each board which corresponds to and has been tested according to the Rules must be marked as follows:

a) by the Manufacturer:

1) Stamp or mark of the manufacturer,
2) Thickness of the board in mm and species of wood,
3) a letter indicating the method of gluing,

e.g. T = Tego Film glued
PH = Phenol liquid resin glued
M = Melamine resin glued
R = Resorcin resin glued

b) by Germanischer Lloyd:

A stamp indicating Grade G.L.I or G.L.II respectively as well as the number of the test lot, week and year of testing.

Example: 2 - 26/53 means
test lot number 2 of the 26th week in 1953.

The stamping carried out by a roller stamp shall run diagonically across the board and must always be applied to the less good face.

Each marking shall be inextinguishable.

Since the tests are carried out only by taking test pieces at random, the Surveyor reserves the right to reject boards already stamped, should they prove to be defective.

The G.L. is entitled to stop the stamping in case of a continual occurence of defects in manufacturing.

Certificates:

Certificates stating the conformity of marked and stamped plywood boards with the present Rules will be added to the furnished boards.

VII. S t o r a g e

Test lots taken in for storing have to be placed in closed rooms, where air and temperature can be suitably regulated. The plywood-boards shall only be put on horizontal scaffoldings at least 30 cm distant from floor and walls in order to eliminate any possible influence of moisture. Oblique placing of the boards must be avoided at all events.

The separate piles must be protected from one-sided moisture by means of stronger covering boards.

Non-observance of these important Rules is apt to make the previous tests invalid.

Rules of Germanischer Lloyd for surveying and testing of Plywood for Aircraft

Table I

Edition: January 1953

Required Tensile Strength and Gluing Strength

Species of Timber	Tensile Strength of the Wood			Gluing Strength
	longitudinal to grain direction of face plies	transverse	longitudinal + transverse	of the wet specimens after 24 or 48 hours' watering or 3 hours' boiling
Birch Beech Alder or timber of similar qualities	700 kg/cm²	450 kg/cm²	1400 kg/cm²	20 kg/cm²
Okumé (Gaboon) Poplar or timber of similar qualities	450 kg/cm²	300 kg/cm²	900 kg/cm²	
	As for boards over 3mm thickness, the values obtained may be less than 10% of those indicated above.			Individual values may be less than 10% of the above value.

Admissible Deviations of Thickness and Number of Plies

Nominal Measure	Admissible Deviations *)		Thickness of Board	Minimum Number of Plies **)
0,6 mm	± 0,06 mm	10%	0,6 mm	3
0,8 "	± 0,08 "		0,8 "	
1 "	± 0,10 "		1 "	
1,2 "	± 0,12 "		1,2 "	
1,5 "	± 0,15 "		1,5 "	
2 "	± 0,20 "		2 "	5
2,5 "	± 0,25 "		2,5 "	
3 "	± 0,25 "		3 "	
4 "	± 0,25 "		4 "	
5 "	± 0,25 "		5 "	
6 "	± 0,30 "	5%	6 "	
8 "	± 0,40 "		8 "	7
10 "	± 0,50 "		10 "	
12 "	± 0,60 "		12 "	
14 "	± 0,70 "		14 "	
16 "	± 0,80 "		16 "	No ply thicker than 2 mm
18 "	± 0,90 "		18 "	
20 "	± 1,00 "		20 "	

*) If possible, deviations shall not reduce the thickness of the boards.

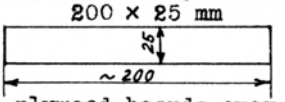
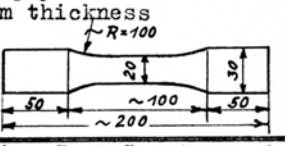
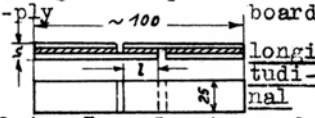
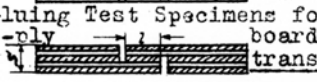
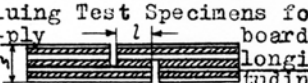
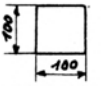
**) If the number of the individual plies happens to be even (4; 6; 8), the fibers of the two innermost plies shall run parallel. These two plies may then be considered as one normal core.

Rules of Germanischer Lloyd for surveying and testing of Plywood for Aircraft

Edition: January 1953

Table II

Number and dimensions of the test specimens which have to be selected from each test board

Species of Test Specimens	Number of Test Specimens: longitudinal to grain direction	Number of Test Specimens: Transverse to grain direction of face plies	Dimensions of Test Specimens mm
Test Specimens for Tensile Strength	3	3	For plywood boards up to 4 mm thickness specimens 200 × 25 mm  For plywood boards over 4 mm thickness 
Test Specimens for Reserve, Bending or Torsion Test	2	2	
S u m	5	5	
Test Specimens for Gluing Strength	5	5	Gluing Test Specimens for 3-ply boards longitudinal  Gluing Test Specimens for 5-ply boards transv.  Gluing Test Specimens for 7-ply boards longitudinal  Shearing of the gluing test specimens after 24 or 48 hours' watering or 3 hours' boiling.
Reserve	2	2	
S u m	7	7	
Boiling Tests	2		Plywood-board ~100×100 mm 
Test f. Moist. Content	1		
S u m	3		

Standard Values for the Milling Lengths of the Gluing Test Specimens

The tested glue line must be so small that no fracture occurs, and so large that the plies will not separate too easily.

Standard Lengths:

Thickness of board = s mm	0,6	0,8	1	1,2	1,5	2	2,5	3	4	5	6	8	10-14	16-20
Milling length = l mm	3	3	4	4	4	4	5	5	6	7	8	9	10	12
Glue line mm, if width of specimens = 25 mm	75	75	100	100	100	100	125	125	150	175	200	225	250	300

Shear-tests shall be carried out with test specimens having a moisture content of 6 - 12 %.

To facilitate the calculations, the deviation of the width as well as of the milling length l of the test specimens for tensile and gluing strength must not exceed ± 0,1 mm

The Surveyor decides from which parts of the test boards the test pieces shall be taken. As a rule, he will have them taken from a strip of about 20 cm width cut from the edge of the board, so that the remaining part is still of use. The remaining parts of the boards must be marked with the numbers of the test specimens and kept until the testing is finished.