INTERNATIONAL STANDARD

ISO 12122-5

First edition
2018-11

Timber structures — Determination of characteristic values —

Part 5: Mechanical connections

Structures en bois — Détermination des valeurs caractéristiques — Partie 5: Assemblages

Reference number
ISO 12122-5:2018(E)

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 165, *Timber structures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the ISO 12122 series can be found on the ISO website.

Introduction

This document sets out a framework for establishing characteristic values from test results on a sample drawn from a clearly defined reference population of connections. The characteristic value is an estimate of the property of the reference population with a consistent level of confidence prescribed in this document.

This document is intended to be used in conjunction with ISO 12122-1.

This document permits the evaluation of characteristic values from testing on connections made with commercial components.

In some cases, characteristic values determined in accordance with this document may be modified to become a design value.

Timber structures — Determination of characteristic values —

Part 5: Mechanical connections

1 Scope

This document gives methods of determination of characteristic values for a defined population of mechanical connections between timber components, calculated from full scale test values.

It presents methods for the determination of:

a) slip modulus of mechanical connections;

b) characteristic strength of connections subjected to either monotonic or cyclic loads.

Glued connections are excluded from the scope of this document.

NOTE 1 It is assumed that the failure mode is the same for all specimens in the sample.

NOTE 2 When a small number of test results is available, ISO 12122-6 is used for the determination of the mean and the 5th percentile values.

NOTE 3 Informative commentary to the clauses of this document can be found in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6891, *Timber structures — Joints made with mechanical fasteners — General principles for the determination of strength and deformation characteristics*

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 16670, *Timber structures — Joints made with mechanical fasteners — Quasi-static reversed-cyclic test method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
mechanical connection
assembly of one or more timber components connected directly together or connected together with components made from other materials

Note 1 to entry: Other materials include steel dowels, bolts, nails, screws, shear connectors and plates.

3.2
test load
peak load achieved for each test specimen for both monotonic and cyclic tests

3.3
ultimate displacement
displacement associated with the maximum load or peak load or ultimate load, F_{max}, determined in accordance with ISO 16670

4 Symbols

F_{est} estimated maximum load, in newtons

F_{max} maximum load or peak load or ultimate load, in newtons

v_y yield displacement (determined only if a clear yield point can be established)

5 Reference population

In addition to the requirements for definition of the reference population in ISO 12122-1, the following attributes of connections shall be described:

a) the material of the connecting components;

b) the dimensions of the connecting components;

c) the method of assembly;

d) the dimensions of the assembly, in particular end distances, edge distances and connector spacings;

e) the species and density range of timber used in the connections;

f) the presence or exclusion of specified features (e.g. knots or finger joints) in or near the connection;

g) the moisture exposure conditions (before and after specimen preparation);

h) the moisture conditions when the specimen is installed and tested (e.g. installed dry and tested dry, installed wet and tested wet, installed dry and tested wet, installed wet and tested dry).

NOTE Where the densities of timber components comply with ISO 8970, this can be declared as part of the reference population.

6 Sampling

6.1 Sampling method

The sampling method shall comply with the performance objective of sampling defined in ISO 12122-1.

Representation of each of the variants in the sample shall approximate the representation of the same variants in the reference population.

Where the reference population includes a range of end distances, edge distances and connector spacings, the sampling method shall ensure that the range of densities is covered in each variation of dimensions.

NOTE A major variation is the range in individual properties of the timber components that make up the connection.

6.2 Sample size

The sample size shall comply with the requirements of ISO 12122-1 and shall take into account the coefficient of variation expected for the timber components in the reference population.

NOTE ISO 12122-1 gives some guidance on selecting the sample size.

7 Sample conditioning

The sample storage and testing environment shall reflect conditioning in accordance with the definition of the reference population as indicated in ISO 12122-1.

For specimens that are constructed by forcing the connecting component into the timber (e.g. nails and toothed plates), a minimum period of seven days shall elapse between assembly and testing of the test specimens to allow for fibre relaxation.

NOTE 1 A case can be made for an allowance of shorter conditioning periods if all timber components are dry at the time of fabrication and testing.

For reference populations in which the connections are constructed in a wet state but are dry during service, appropriate conditioning shall be required for the test specimens to simulate these conditions.

NOTE 2 Such conditioning requires an appropriate time delay between connection construction and testing to ensure that the service condition is replicated (this can be days or weeks).

8 Test data

8.1 General

This document uses data obtained from testing undertaken to relevant testing standards for mechanical connections. Test loading of connections is undertaken either in a linear form (i.e. load versus displacement) or an angular form (i.e. moment versus rotation). For the purposes of this document, moment and rotation may be substituted for load and displacement respectively.

8.2 Test method

8.2.1 Monotonic loading of connections

The test data shall be obtained from:

a) tests that follow the principles of ISO 6891;

b) tests in accordance with the ISO document relevant to the connection; or

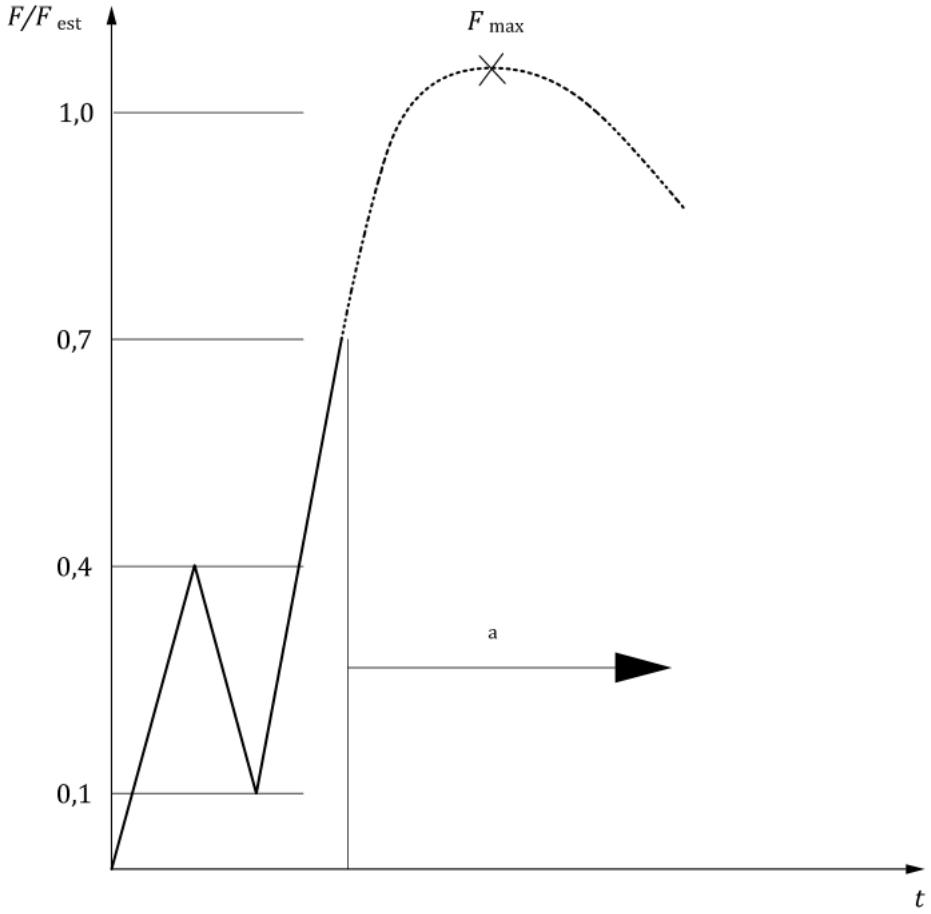
c) a standard test method appropriate for the reference population provided equivalency factors with the relevant ISO document can be established.

The selection of test variables shall be appropriate to the objectives of the testing, and can require some adjustments specified in 8.3.

NOTE 1 Test methods involve many variables that affect results including loading configuration and rates, specimen positioning and measurement methods.

The peak load for each test specimen in a monotonic test, F_{max}, shall be recorded (see Figure 1).

NOTE 2 If a clear yield point can be obtained, then the yield can also be recorded.



Key

F/F_{est}	load divided by estimated maximum load
F_{max}	specimen peak load, expressed in newtons
t	time
a	Displacement controlled.

Figure 1 — Monotonic test sequence

8.2.2 Cyclic loading of connections

The test data shall be obtained from:

a) tests that follow the principles of ISO 16670;

b) tests in accordance with the ISO document relevant to the connection; or

c) a standard test method appropriate for the reference population provided equivalency factors with the relevant ISO document can be established.

8.3 Test data compatible with product description

Where the characteristic value is applicable to a standard configuration and size or moisture content of the connection components, adjustments to the test data can be required. Any adjustment shall be in accordance with ISO 12122-1 and shall be detailed in the report.

8.4 Failure modes

The failure modes obtained in the tests shall be recorded.

The data shall only be included in the analysis if it comes from a test in which the failure mode appropriate to the property was obtained.

NOTE The same test method can produce different failure modes on different products. The characteristic value can be under-estimated or over-estimated by tests that produce failure modes that are completely different to ones that the test method was intended to produce.

9 Evaluation of characteristic values for structural properties

9.1 Structural properties

For connections, the determination of the characteristic values for the structural properties shall be in accordance with 9.2, 9.3 and 9.4.

The properties shown in Table 1 shall be calculated from the test data.

Table 1 — Characteristic values to be calculated

Characteristic value	Mean	5th percentile	95th percentile
Stiffness	✓[a]	✓	✓
Yield load[b]	✓	✓	
Max load or ultimate load		✓[a]	✓
Ultimate displacement	✓[a]		
Yield displacement[b]	✓	✓	

[a] Mandatory characteristic to be calculated.

[b] To be reported only if a clear yield point is established.

The characteristic value based on the 95th percentile value is the upper single-sided 75 % confidence limit on a 95th percentile property and can be found by fitting data to a distribution using Formula (1).

$$X_{0,95;0,75} = X_{0,95}\left(1 - \frac{k_{0,95;0,75}\,V}{\sqrt{n}}\right) \tag{1}$$

where

$X_{0,95;0,75}$ is the 95th percentile value with 75 % confidence;

$X_{0,95}$ is the 95th percentile of the test data from a fitted distribution;

$k_{0,95;0,75}$ is a multiplier to give the 95th percentile value with 75 % confidence and defined in Formula (2);

V is the coefficient of variation of the test data found by dividing the standard deviation of the test data by the average of the test data;

n is the number of test values.

$$k_{0,95;0,75} = -k_{0,05;0,75} \tag{2}$$

where $k_{0,05;0,75}$ is a multiplier to give the 5th percentile value with 75 % confidence, and defined in ISO 12122-1:2014, A.2.3.

9.2 Characteristic initial stiffness of the connection (monotonic loading)

The characteristic stiffness used for serviceability shall be evaluated in accordance with ISO 12122-1 using the mean value, taken as the average of the test values. In the case of its use in the ultimate limit state, it shall be evaluated in accordance with ISO 12122-1 using the 5th percentile value determined from the test results.

9.3 Characteristic stiffness of the connection (cyclic loading)

The average of the stiffness for both directions of loading may be used when the asymmetric performance of the connection is within 20 % of the lower stiffness value. If the difference is beyond 20 %, the stiffnesses for the two directions and the evaluations shall be considered separately.

NOTE Connections can exhibit an asymmetric performance, particularly if the physical construction of the joint is asymmetric.

9.4 Characteristic capacity of the connection

9.4.1 Characteristic capacity

The 75 % lower single-sided confidence limit of the test 5th percentile values of the test loads shall be evaluated.

NOTE Suitable methods for evaluating the 5th percentile value of the test data and estimating the 75 % lower single-sided confidence limit are presented in ISO 12122-1.

9.4.2 Test load in monotonic tests

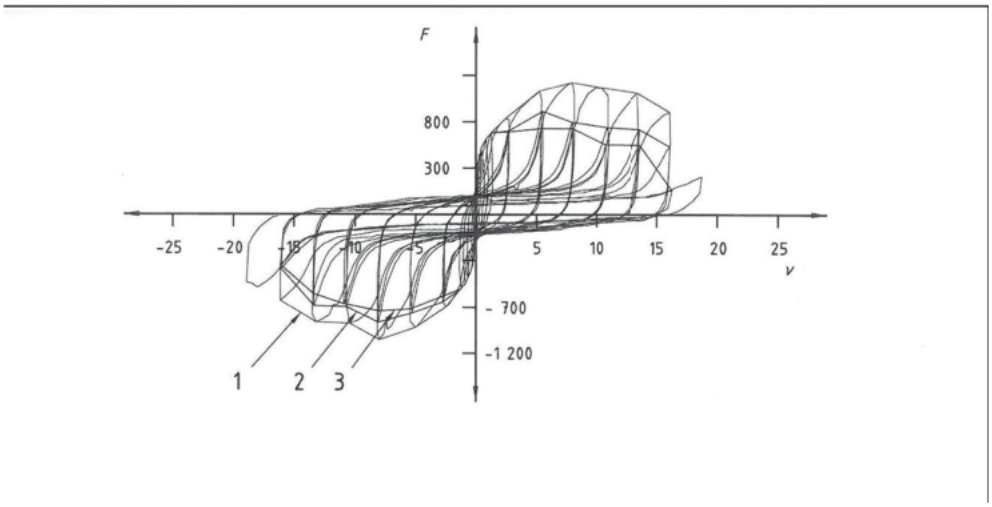
The test load, F_{max}, in each test shall be the maximum load obtained in the test.

When the yield load has been evaluated in the test, then the characteristic yield load for the connection can be calculated.

9.4.3 Test load in cyclic load tests

The test loads for each test shall be determined from the backbone curves for all of the first, second and third cycles in the test (Figure 2).

If the structural response in one direction is different from the other direction, then the characteristic loads shall be reported separately for each direction.



Key

F load, expressed in newtons

v displacement, expressed in mm

1 first envelope curve

2 second envelope curve

3 third envelope curve

Figure 2 — Envelope curves traced from hysteretic data

10 Report

The report shall comply with the requirements of ISO 12122-1.

a) specification of the source, species, density and relevant strength properties of the timber members, and the sampling and conditioning methods;

b) the sampling method shall indicate a response to each of the identified attributes of the reference population listed in compliance with ISO 12122-1:2014, Clause 5 or otherwise important to the description of the reference population;

c) specification and sampling of the fasteners including dimensions, and surface coating;

d) a description of the fabrication details (e.g., elapsed time between the fabrication and test, predrilling of holes, and tolerances);

e) a description of the joint geometry (e.g., dimensions of the joint members, number of fasteners, arrangement and spacing, details of the gaps between members) and the loading configuration;

f) a test matrix showing the number of replicates for each test group;

g) a description of the test apparatus and a diagram of the test set-up with location of measuring devices, tolerances and any restraints;

h) the rate of specimen loading;

i) a statement of any deviations from this document;

j) a report of the sampling speed for data collection;

k) a description of the failure modes;

l) a description of the cyclic displacement schedule including the displacement rate (for cyclic tests);

m) a plot of the hysteresis data (load-displacement or moment-rotation data), and tabulated envelope curves, maximum loads, ultimate displacement, moisture content of the wood at the time of fabrication and test, density and failure modes (for cyclic tests).

Annex A
(informative)

Commentary

A.1 Commentary on scope

This document presents methods for determining characteristic values for connections between timber elements. It is to be read in conjunction with ISO 12122-1.

The document presents a uniform methodology for the evaluation of characteristic values that are consistent with the characteristic values found for other structural timber products.

The document does not establish methods for the determination of design values. These may be determined based on characteristic values from test data, but for connections will also incorporate appropriate safety factors to account for any or all of the following factors:

— Expected changes in timber properties over a long period. These changes can be due to variations in timber resource quality, production methods or adhesives;

— The complexity of the reference population. For example, where the reference population has a large number of producers who draw their resource over a large area, then it is possible that the sampling does not effectively reflect all possible combinations of resource quality and production methods. In this way, it is possible that the sample is not truly representative, and a safety factor may be applied to allow for that;

— Variations in fabrication of the connections. These variations can include the presence or frequency of timber characteristics (e.g. knots or finger joints) in the vicinity of the connection; or

— Anticipated variations in quality control across the reference population in the future.

Characteristic values presented in this document relate only to the determination of characteristic values from the results of tests on full-scale connections. The ISO 12122 series has this common basis. However, in many cases, the characteristic properties for connections are found from calculation using models that relate the properties of individual fasteners to the properties of the assembled connection. The scope of this document does not cover these methods.

A.2 Commentary on normative references

No commentary.

A.3 Commentary on terms and definitions

No commentary (see ISO 12122-1).

A.4 Commentary on symbols

No commentary (see ISO 12122-1).

A.5 Commentary on reference population

Characteristic values can be taken to represent the properties of the connections from which the sample was taken. The reference population is the definition of the parent population to which the

characteristic properties are said to apply. ISO 12122-1 presents some general requirements for definition of the reference population, but some other features are known to influence the structural properties of connections:

— The properties of the wood that is the basis of the connection may affect the properties of the final connection. This means that the definition of the reference population should include all possible sources of wood for the product. This also requires sampling across the full range of raw material sources to ensure that the test sample is truly representative of the reference population. In some cases, the timber elements may be standardized (for example, complying with ISO 8970) and, in these cases, this is an essential part of the definition of the reference population;

— Where the timber at the time of fabrication has a different moisture condition to its moisture content in service, this implies fabrication and testing at different moisture contents. The moisture contents at fabrication and at test become important parameters in the definition of the reference population;

— Limitations on the features in the timber permitted at or near the connection can also influence connection capacity. These limitations (e.g. knot sizes and positions or finger joints) shall be declared as part of the definition of the reference population. Where a reference population can be drawn from timber that has a range of permitted features, they should all be represented in the test sample;

— End and edge distances, fastener spacings are critical in the strength of mechanical connections. Specification of the limits on these dimensions is an important consideration in defining the reference population; and

— The characteristics of the metal components in the connection shall be fully specified. This includes the grade of the metal, surface coatings and physical dimensions.

ISO 12122-1 refers to the period over which the product was manufactured. In some climates, the time of year can affect the properties of the raw materials or fabrication processes in use.

The lists in both ISO 12122-1 and ISO 12122-5 are examples, but the intent of Clause 5 is that anything in the fabrication of the product that can affect the structural properties shall be included in the description.

A.6 Commentary on sampling

Where the reference population of the connections includes a number of different manufacturers or processes, care should be taken to ensure that all variations in raw material, and fabrication methods are included in the representative sample.

The list of features to be described in the reference population (from ISO 12122-1:2014, A.5, and A.5) can be used to derive a sampling program that includes all of the variations in the reference population. In particular, where a number of variations are included in the reference population, care should be taken in sampling to ensure that the variations are not correlated. For example, if a range of edge distances is included, and a range of timber densities, then it is important to ensure that each variation in edge distance has the full range of timber densities.

Guidance on sample size can be found in ISO 12122-1.

A.7 Commentary on sample conditioning

For many connections in which the fastener is driven into the timber, a settling period is required. This period allows for creep deformations around the fastener after it is initially driven and more accurately represent the condition of the connection in service.

Samples must be stored so that the moisture content remains within the requirements for the reference population. Where connections are fabricated in timber with high moisture content, but the timber

is allowed to dry in service, then the conditioning needs to be suitable to have achieved the service conditions prior to testing.

Otherwise, the requirements of ISO 12122-1 apply.

A.8 Commentary on testing

A.8.1 Commentary on test method

ISO 6891 and ISO 16670 present test methods for most timber connections. In other cases, properties can be tested in accordance with other recognized timber tests (international and national standards where equivalency with ISO test methods has been established).

A.8.2 Commentary on test data compatible with product description

The tests are conducted on full size connections. However, adjustment of the test data to a reference size, moisture content or temperature can be required. Where this is performed, it shall comply with the requirements of ISO 12122-1.

Where pooling of data on different sizes takes place, the data needs to be corrected to the standard size. In order to do this, the guidelines on pooling in ISO 12122-1 should be carefully followed.

A.8.3 Commentary on failure modes

Where tests are aimed at a particular structural property, but a different failure mode has occurred, then the intended property may be under-estimated by the test data.

An example is when tests for ductile failure strength can be performed, but brittle plug failures can be produced. In this case, the calculated strength from the test is a lower bound on the true ductile strength of the product. Different geometries can be required to eliminate the brittle plug failures.

A.9 Commentary on evaluation of characteristic values for structural properties

A.9.1 Commentary on structural properties

The structural properties to be determined are presented in Table 1. Some properties are simply determined (such as mean stiffness). Others do not have clearly defined definitions or there is a variation in the manner in which the property is established between countries (such as the yield load). This document allows for the determination of characteristic values for these properties only if there is a clearly established yield point.

In some cases, an estimation of the higher range stiffness and strength can be required. The characteristic value based on the 95th percentile gives this information. The upper single-sided 75 % confidence limit on a 95th percentile property is a characteristic value representing 75 % confidence that 95 % of the population is expected to have a property lower than this characteristic value. The value can be found using similar techniques to the other characteristic values:

1) A distribution (either normal or log-normal) is fitted through the test data. The 95th percentile value of the fitted distribution is found.

2) The coefficient of variation of the raw test data is found as the ratio of the standard deviation to the mean of the data.

3) ISO 12122-1 lists values of $k_{0,05;0,75}$ which are a function of the number of test data, n. The appropriate value is found.

4) Formula (2) is used to evaluate $k_{0,95;0,75}$ from $k_{0,05;0,75}$.

5) This value is used to evaluate the characteristic value based on the 95th percentile of the test data using Formula (1).

A.9.2 Commentary on characteristic initial stiffness (monotonic loading)

No commentary (see ISO 12122-1).

A.9.3 Commentary on characteristic stiffness (cyclic loading)

No commentary. (see ISO 12122-1).

A.9.4 Commentary on characteristic values of capacity

No commentary (see ISO 12122-1).

A.10 Commentary on report

No commentary (see ISO 12122-1).

Bibliography

[1] ISO 8969, *Timber structures — Testing of punched metal plate fasteners and joints*

[2] ISO 8970, *Timber structures — Testing of joints made with mechanical fasteners — Requirements for wood density*

[3] ISO 10984-1, *Timber structures — Dowel-type fasteners — Part 1: Determination of yield moment*

[4] ISO 10984-2, *Timber structures — Dowel-type fasteners — Part 2: Determination of embedding strength*

[5] ISO 13061-2, *Physical and mechanical properties of wood — Test methods for small clear wood specimens — Part 2: Determination of density for physical and mechanical tests*

ICS 91.080.20

Price based on 13 pages