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**Methods of test for pallet joints —**

Part 2:

**Determination of withdrawal and head  
pull-through resistance of pallet nails  
and staples**

*Méthodes d'essai des assemblages de palettes —*

*Partie 2: Détermination de l'arrachage et de la résistance de la tête des  
clous et clous cavaliers de palettes*



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## 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 12777 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12777-2 was prepared by Technical Committee ISO/TC 51, *Pallets for unit load method of materials handling*.

ISO 12777 consists of the following parts, under the general title *Methods of test for pallet joints*:

- *Part 1: Determination of bending resistance of pallet nails, other dowel-type fasteners and staples*
- *Part 2: Determination of withdrawal and head pull-through resistance of pallet nails and staples*
- *Part 3: Determination of pallet joint strength*

## Introduction

In 1988 ISO/TC 51 considered developing standard test methods for pallet joints. It became evident that the lack of International Standards on nail testing meant that fasteners (essential elements of pallet joints) could not be characterized sufficiently to enable worthwhile progress on full joint testing. Although there were existing, or partially developed, nail testing principles, it was considered that, in a practical situation where, for quality control purposes or comparisons of nail quality, reasonably accurate and rapid nail strength data were required, one or both, of the two existing commercial nail testers were better suited to the needs of pallet makers, pallet test laboratories and nail manufacturers. This is now ISO 12777-1.

Preliminary work led the manufacturers of both machines to make design modifications to improve accuracy. An evaluation, carried out with the cooperation of the manufacturers/agents of each nail test machine, demonstrated that the technical requirements for nail test machines/principles were met by both machines. The principles of these test methods are given in ISO 12777-1. They are primarily concerned with pallet joints in shear configuration.

This part of ISO 12777 extends the possibility of characterizing nails with relation to their axial configuration and the methods involve standard laboratory testing equipment. However, these tests are more complex than those in part 1 and are not suitable for routine quality control of pallets or pallet joints. Additionally, the highly significant influence of delayed testing must be considered in all parts of ISO 12777. Values of strength frequently increase even a few days after wood joint assembly and delayed testing may be more relevant to long-term pallet usage.

# Methods of test for pallet joints —

## Part 2:

# Determination of withdrawal and head pull-through resistance of pallet nails and staples

## 1 Scope

This part of ISO 12777 specifies methods of determining the resistance of pallet nails and staples to axial load by specifying test methods for determining:

- a) characteristics and maximum load for axially loaded nailed or stapled joints (wood to wood);
- b) characteristics and maximum load for axially loaded nailed or stapled joints (for wood to wood-based materials and wood to non-wood-based materials, such as plastics).

These test methods apply to joints with all types of nails up to 7 mm in diameter (including plain round shank, square, fluted, twisted, helical and annular threaded) and may also be suitable for other fasteners such as wood staples.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12777. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12777 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 445:1996, *Pallets for material handling — Vocabulary.*

ISO 1133, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics.*

ISO 1183:1987, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

ISO 3130, *Wood — Determination of moisture content for physical and mechanical tests.*

ISO 3131, *Wood — Determination of density for physical and mechanical tests.*

ISO 6891:1983, *Timber structures — Joints made with mechanical fasteners — General principles for the determination of strength and deformation characteristics.*

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

ISO 12777-1, *Methods of test for pallet joints — Part 1: Determination of bending resistance of pallet nails, other dowel-type fasteners and staples.*

### 3 Terms and definitions

For the purposes of this part of ISO 12777, the nail and staple terminology given in ISO 445:1996 and the following terms and definitions apply. Other symbols are shown in Table 1.

**3.1  
nail**  
straight fastener made from round or square stock, usually pointed and headed, designed to be impulse driven

**3.2  
nail shank diameter**  
*d*  
diameter measured over the plain section

**3.3  
staple**  
double right angled or U-shaped round, oval, square or rectangular wire fastener with two legs, usually of the same length and usually pointed, connected by its crown

**3.4  
staple crown**  
connection between the two staple legs

**3.5  
crown width**  
*L*  
distance between the staple legs

**3.6  
staple length**  
*l*  
length of each staple leg, including the point, to the underside of the crown

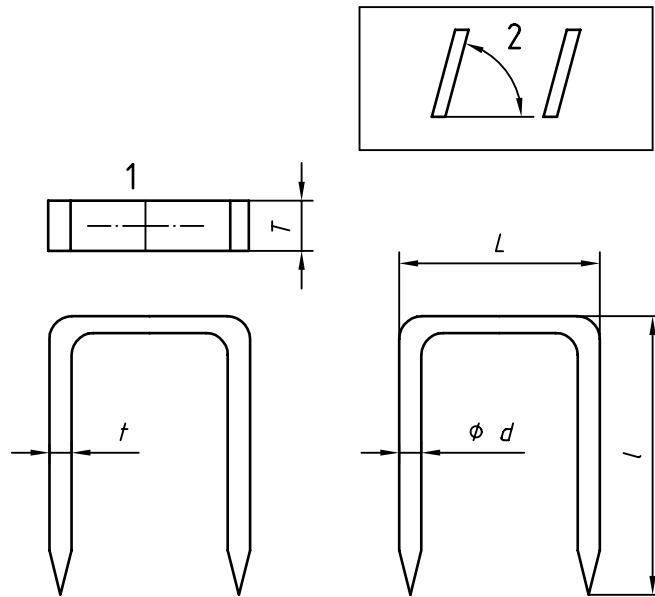
**3.7  
crown angle**  
smallest angle measured between the crown direction and grain direction

**3.8  
crown centre**  
centre of staple crown from which all wood end and edge distances, as well as distances between staples, are measured

**3.10  
staple diameter**  
*d*  
dimension of each staple leg in the round section

**Table 1 — Symbols**

|                        |          |         |
|------------------------|----------|---------|
| Nail head diameter     | <i>D</i> | mm      |
| Head countersink angle | <i>β</i> | degrees |
| Staple width           | <i>T</i> | mm      |
| Staple thickness       | <i>t</i> | mm      |
| Distance between nails | <i>P</i> | mm      |

**Key**

- 1 Crown centre  
2 Crown angle

**Figure 1 — Staples: Definitions and measurements**

## 4 Materials

### 4.1 Non-timber materials

**4.1.1** If the material is not of uniform density or it exhibits grain effects, this shall be recorded and separate tests shall be conducted to measure the effect of such anisotropy.

**4.1.2** Plastics shall have the tensile strength of finished material (MoR), the melt mass-flow rate (MFR) and melt volume flow rate (MVR) recorded in accordance with ISO 1133, and density in accordance with ISO 1183.

### 4.2 Timber

**4.2.1** The timber shall be selected in accordance with ISO 8970.

**4.2.2** For comparative tests on different types of fastener, nails or staples shall be driven into a wood specimen cut from the same plank to ensure a balanced density specimen, or the wood may remain uncut as shown in Figure 2. If further specimens are cut from a different plank, these shall be made up in a similar manner.

**4.2.3** Timber members for the specimens shall be cut so that areas into which the fasteners are embedded are free from knots, local grain disturbance, fissures and wane. Elsewhere the members shall be free from major defects which could lead to premature or unrepresentative failure.

**4.2.4** If there are no special requirements, the timber shall be planed.

**4.2.5** Within a few hours, the moisture content of the timber shall be determined in accordance with ISO 3130, and its density in accordance with ISO 3131.

**4.2.6** The identity of the genus and, where possible, the species shall be confirmed by anatomical examination. If this cannot be done at the time of test, then a sample shall be retained for later examination.

### 4.3 Sheet and manufactured materials

The properties of the materials shall be determined using standard test methods. These properties should include density, moisture content and the physical lay-up of veneers in plywood. In particle-board, the resin percentage and mix of species, chip size, orientation, etc., shall be recorded.

### 4.4 Nails

**4.4.1** The strength in bending shall be determined in accordance with ISO 12777-1.

**4.4.2** Should heads pull off or shanks fracture during withdrawal testing, then, in addition to determination of bending strength, the tensile strength of the unprofiled (plain) shank shall be measured in newtons per square millimetre.

## 5 Test specimens

### 5.1 General

**5.1.1** There shall be a sufficiently large number of test specimens to permit statistical treatment of the results. A sample of 16 should be considered a minimum for each change of variable.

**5.1.2** For the determination of strength values for joints with a series of nails or staples with different diameters, a sufficient number of diameters shall be tested so that interpolation of the results can be made.

**5.1.3** For plastics, assemble at  $20\text{ °C} \pm 4\text{ °C}$ . For wood, the preparation of samples and testing of wood or wood based materials shall take into account the following factors:

- a) assembly of test joints shall be at or above the highest moisture content expected at the time of pallet delivery (first use);
- b) the testing shall take place at the appropriate moisture level selected from one of the following target levels:
  - over 25 % (above fibre saturation point),
  - $20\% \pm 2\%$  (frequent pallet specification level),
  - $15\% \pm 2\%$ ,
  - $12\% \pm 2\%$ .

For certain investigations, other moisture conditions may be appropriate. The condition used shall be stated in the test report.

**5.1.4** Specimens shall not be exposed to non-environmentally controlled test conditions for longer than 2 h before testing.

Specimens may be stored in a non-environmentally controlled test area for up to 24 h provided they are wrapped in polyethylene.

**5.1.5** Two-piece wood specimens with stapled joints (Figure 2) shall be fastened in the same way as regards penetration depth and grain orientation as in the intended commercial practice. For single wood component specimens (Figure 3), if the manufacturing technique permits, the staple crowns shall protrude above the surface, if necessary by assembling with a distance piece and withdrawing the distance piece after manufacture.

**5.1.6** Specimens either wholly or partly comprising wood shall not be tested for at least 16 h after assembly and nailing. The desirability of delayed testing of a second matched set and determination of the increase (or decrease) of strength with passage of time should be considered.



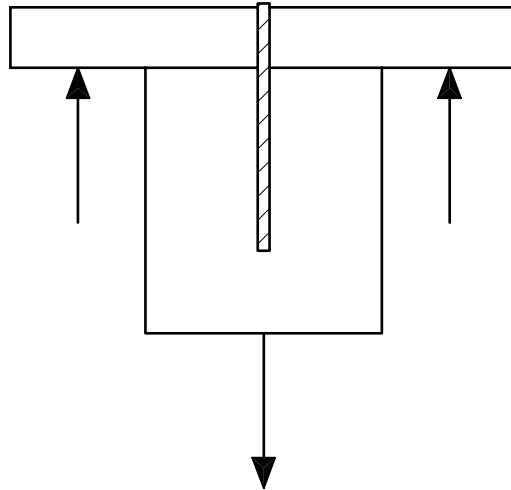
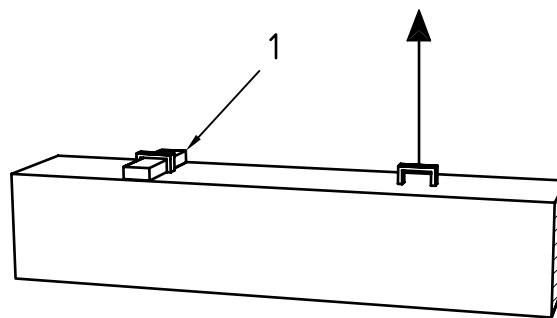


Figure 2 — Staple withdrawal specimen: Double wood component



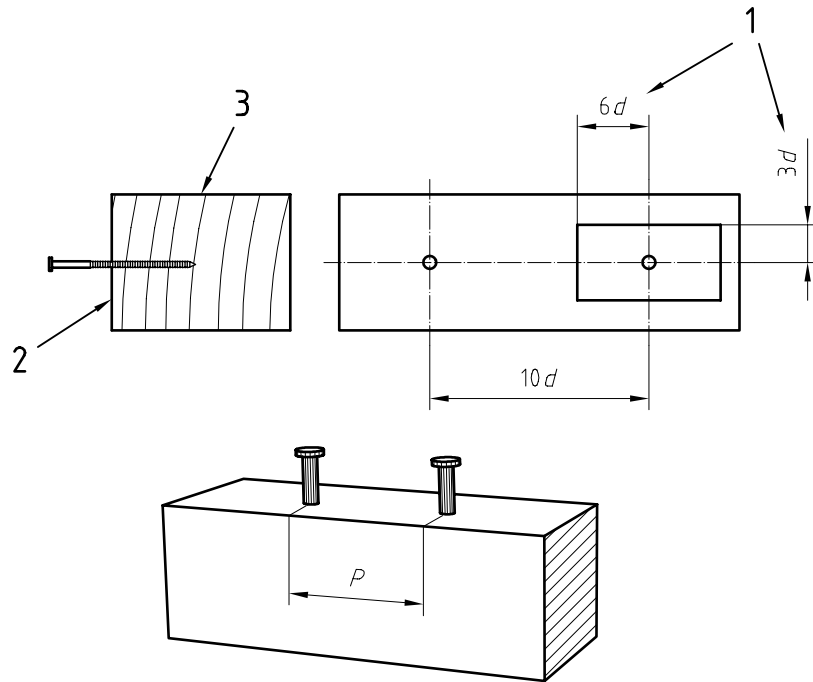
**Key**

1 Distance piece

Figure 3 — Staple withdrawal specimen: Single wood component

## 5.2 Withdrawal tests: Load perpendicular to grain

**5.2.1** The wood timber member shall be cut and planed in such a manner that the nailed face is tangential to the growth rings (Figure 4). Timber shall be cut and planed to produce a face tangential to the growth rings. The fastener shall be inserted into this face. Fasteners inserted tangentially to the growth rings, i.e. at right angles to the specified direction, shall not be used in tests because of the difficulty of determining whether spring (low density) or summer wood (high density) is penetrated and the consequential lack of repeatability of results.



**Key**

- 1 Support limits
- 2 Tangential face
- 3 Radial face

NOTE Loading perpendicular to the grain is the basis of withdrawal strength.

**Figure 4 — Nail withdrawal specimen**

**5.2.2** Test specimens shall be in accordance with Figure 4. The nails shall be hand or power tool driven through a distance piece or other spacing device to accurately achieve a penetration of at least  $8d$  and not more than  $10d$ . The width and depth of the specimen shall be at least the penetration length plus  $5d$ .

**5.2.3** For staples, half of the test shall be performed with crown angles of  $0^\circ$ , and half with crown angles of  $90^\circ$ .

**5.2.4** Supports restraining the wood specimen under test shall not be closer to the centre of the nail or the staple legs than  $6d$  in the fibre direction and  $3d$  perpendicular to the grain. Nails shall be no closer to each other than  $P = 10d$  (see Figure 4).

**5.3 Withdrawal tests: Load parallel to the grain**

**5.3.1** The wood member shall be cut such that the cross-section is perpendicular to the grain (see Figure 5).

**5.3.2** The specimens shall be in accordance with Figure 5. The nails shall be driven to a penetration at least  $8d$  and not more than  $16d$ . The length of the specimens shall be at least the penetration length plus  $5d$ .

**5.3.3** Supports restraining the wood specimens under test shall not be closer than  $3d$  to the centre of the nails or the legs of the staples.

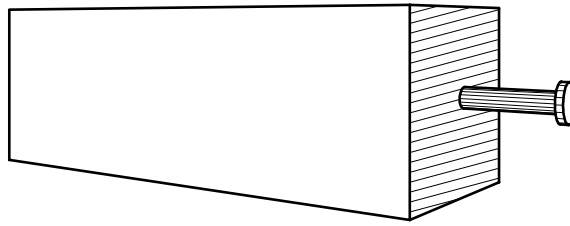


Figure 5 — Withdrawal specimen: Load parallel to grain

## 5.4 Pull-through test

5.4.1 The specimens shall be in accordance with Figure 6.

5.4.2 The specimen thickness  $t$  shall be at least  $5d$  but not less than 12 mm. For sheet materials, the thickness shall be equal to the production thickness of the material.

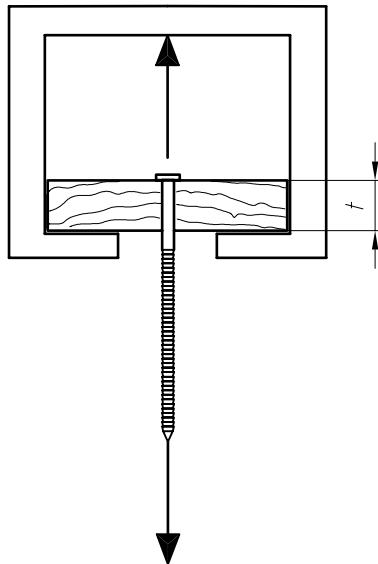


Figure 6 — Pull-through specimen

## 6 Test procedure

### 6.1 Withdrawal testing

6.1.1 The load  $F$  (see Figure 7) shall be applied at a constant rate of  $(25 \pm 5)$  mm/min for a withdrawal of at least 10 mm or until the ultimate load has fallen by at least 10 % from the maximum load.

6.1.2 Load/movement or load/time curves shall be recorded, and the exact nail extraction rate used shall be recorded.

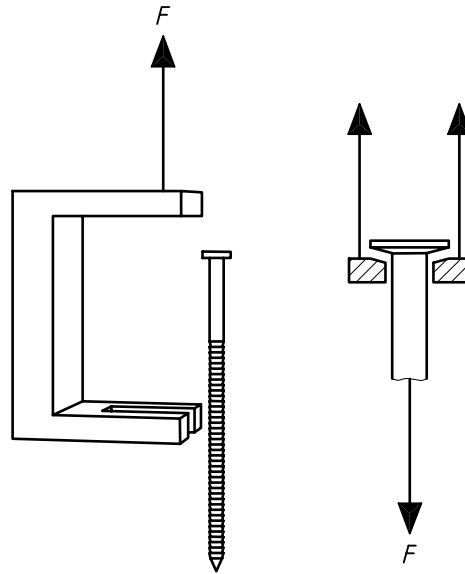


Figure 7 — Nail head claw for withdrawal specimens

**6.2 Pull-through testing**

- 6.2.1 The specimen shall be supported as shown in Figure 6.
- 6.2.2 The load  $F$  shall be applied at a constant rate of  $25 \text{ mm/min} \pm 5 \text{ mm/min}$ .
- 6.2.3 The test shall continue until the nail has embedded a minimum of 5 mm.
- 6.2.4 Record nail head variables  $d$ ,  $D$  and  $\beta$  as shown in Figure 8.
- 6.2.5 Load/displacement curves and the exact pull-through rate shall be recorded.

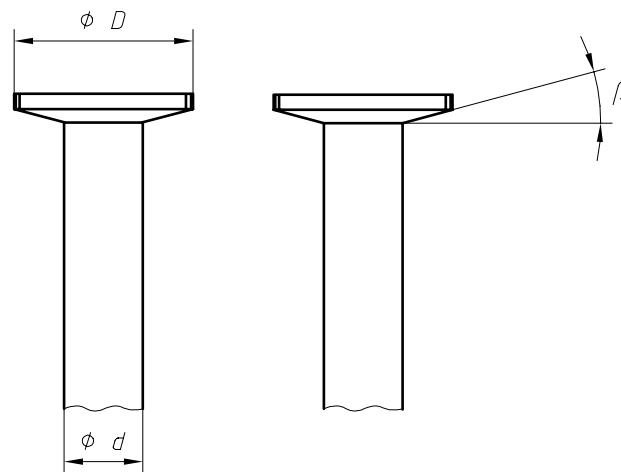


Figure 8 — Variables affecting head pull-through resistance

**7 Test report**

Test results shall be recorded in accordance with clauses 8.5 and 9 of ISO 6891:1983. Additionally, for the purposes of this part of ISO 12777, the following shall also be recorded.

**a) General requirements – All materials**

- record the fastening bending strength measured in accordance with ISO 12777-1;
- record the rate of withdrawal of fastenings during test;
- record the overall dimensions and exact shank profile of nails or staples;
- for pull-through specimens, record the head size and associated angles;
- record the depth of fastener penetration into specimens;
- record the accuracy of the applied loading.

**b) Requirements for wood**

- record the moisture content of wood specimens at assembly, using the electrical resistance method;
- record the moisture content at test using the oven drying method specified in ISO 3130 and the specimen density using the oven drying method specified in ISO 3130;
- record elapsed time period between specimen assembly and testing.

**c) Requirements for plastics**

- record the MoR, MFR, MVR and the density of the plastics used;
- record the temperature at the time of testing.

## Bibliography

- [1] ISO 8611, *General-purpose flat pallets for through transit of goods — Test methods*.
- [2] ISO/TR 11444, *Quality of sawn wood used for the construction of pallets*.
- [3] ISO 12777-3, *Methods of test for pallet joints — Part 3: Determination of pallet joint strength*.



