WOODEN PALLET QUALITY CONTROL: A SIMPLE HAND TOOL TO MEASURE NAIL STIFFNESS AND DUCTILITY

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PREFACE

The Information Report Series of the Forest Products Laboratory Ottawa, is used primarily to report the results of limited research, or interim results of studies of long duration which are of current interest to segments of the forest products industry, committees of standards organizations and other special groups. Because some of the results reported are of an interim nature and others have a limited field of interest, not all reports are given general distribution.

SUMMARY

Nail fasteners have been described as the "weak link" in wooden pallet construction. Nail stiffness and ductility, two of the more important properties of pallet nails cannot be derived visually. At the present time, these properties can be determined only by the time-consuming use of relatively expensive and heavy laboratory testing machines. This paper describes a portable, hand-held testing device which, when used with a properly calibrated torque wrench, can quickly be used to determine the stiffness and ductility of pallet nails.

RÉSUMÉ

Le clou est le point faible dans la construction d'une pallette. Deux des plus importantes propriétés du clou sont, la rigidité et la ductilité, celles-ci ne peuvent être distinguées visuellement. Présentement ces propriétés peuvent être déterminées seulement que par équipement de laboratoire relativement lourd et coûteux.

Cette étude décrit un mécanisme, simple et portatif avec un cadran indicateur sur la clef de torsion qui peut être utilisé pour mesurer la rigidité et la ductilité du clou.

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INTRODUCTION

There is a need for an inexpensive, small, portable, and convenient device to determine the stiffness and ductility of wire nails. This need is especially evident in wood pallet construction. Recent studies (2, 3) suggest that a wood pallet's strength, durability, and expected useable life is directly proportional to the stiffness of the pallet nail. It has been shown by Stern (4, 6) that the use of stiffer hardened steel nails will increase a pallet's rigidity, and hence, according to him, a pallet's useable life by as much as 65%.

Most pallet damage results from bending of the fasteners. Approximately 70% of all damage to permanent wood pallets is caused by the failure of the fasteners along the upper leading edges to resist lateral load transmission. It is apparent that in the majority of pallets, the loss of upper leading edgeboards will occur only after the nails have bent and twisted. Lateral leading edge impacts by handling devices are then only resisted by more or less direct nail withdrawal. Therefore, stiffer fasteners will proportionally increase resistance to leading edge damage.

Stiffness and ductility of wire nails can be used as indicators of their brittleness and softness respectively. Soft nails, offering minimal resistance to bending, often cannot be driven satisfactorily and cannot transmit shear loads effectively. Soft nails tend to bend during shear load transmission resulting in either nail head pull-through or nail shank pull-out. Pallet nails should therefore be stiff, but by increasing nail stiffness, one should not sacrifice too much ductility. A brittle nail may break suddenly while being driven, shear-loaded, or impact-loaded.

Fractures on the tension face of a bending nail during lateral load transmission can significantly weaken the strength and durability of the nailed joint.

The ideal pallet nail should, therefore, offer high resistance to bending but at the same time be ductile and not fracture if bent slightly during driving, or lateral shear load transmission, or both. It is therefore desirable to measure the relative stiffness and ductility of wire and wire nails.

Stern (5) states: "The Morgan Impact Bend-Angle Nail Tester (MIBANT) has been considered one of the best tools to evaluate the performance of pallet nails. A single test performed with this tool may provide information on the bending resistance of the nail during lateral load transmission and under certain conditions, its buckling resistance during nail driving".

The MIBANT is essentially a laboratory tool not readily adaptable to field use. A hand tool for measuring nail stiffness and ductility was therefore developed. The purpose of such a tool is not to replace expensive and heavy laboratory testing machines; rather it should serve as a reasonable accurate and portable field tool. It can be readily used as a means of testing wire prior to its being shaped into nails, and wire nails at any stage prior to driving.

Description of Tool

The device, developed to determine the static stiffness and ductility of wire and wire nails, is hand-held and may be used with any suitable commercial torque wrench having a 15 ft-lb capacity, and preferably one having an indicator pointer or "lazy hand". The device (Figure 1) consists of nine parts. The 1-inch knurled tubing handle [4]*, the nylon bushing [2] and the staple-shaped nail holder [5] are press-fitted to the main body of the device [3]. The 5/8-inch arbour [1] having a 3/4-inch head fits through the nylon bushing, and is held in place by a 5/8-inch circlip [6]. The removal device [7], tension spring [8], and small head screw [9] hold the wire or nail in place during the test and provide easy removal of the bent sample. To ensure proper bending of the test nail, the nail holder should be press-fitted to the main body so that the inner surface of the cross member of the nail holder and the inner surface of the plate-like portion of the removal device are equidistant from the main body. The arbour and round legs of the nail holder are of hardened steel to prevent excessive deformation and should be replaced if bent or worn.

This device is intended to determine the stiffness and ductility of 11-gauge wire and 2-1/2 x 0.120-inch wire nails with or without deformation along the shank. For nails of greater or lesser length and diameter, it may be

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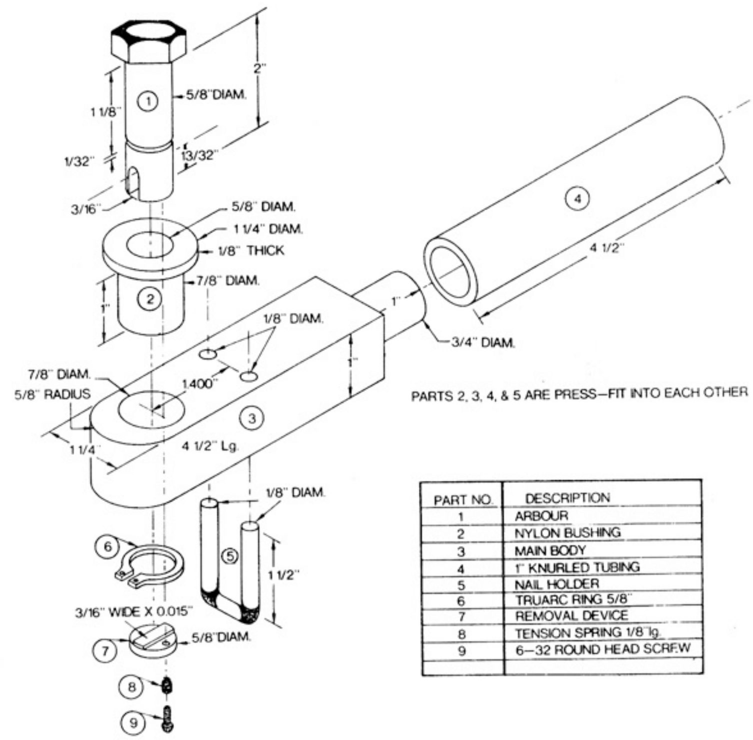
*Numbers in brackets [] refer to Figure 1.



PART NO.	DESCRIPTION
1	ARBOUR
2	NYLON BUSHING
3	MAIN BODY
4	1" KNURLED TUBING
5	NAIL HOLDER
6	TRUARC RING 5/8"
7	REMOVAL DEVICE
8	TENSION SPRING 1/8" lg.
9	6—32 ROUND HEAD SCREW

FIGURE 1.- Nail-testing device. 2-2276

desirable to increase or decrease the span between the nail holder and arbour. The required torque for every angle of bend increases exponentially for any given wire size as the span decreases linearly.

Using the Tool

The stiffness and ductility of any given wire or nail is determined by bending it around the 5/8-inch diameter arbour. Since the device is symmetrical about its long axis, it can be used with equal ease by either a right-handed or left-handed operator. The test sample is placed in the device as shown in Figure 2. The wire or nail does not have to fit snugly into the slot of the arbour to obtain accurate readings and, therefore, the same arbour may be used to test a variety of wire sizes. A properly calibrated torque wrench is then used to bend the sample slowly and smoothly around the arbour (Figure 3). Brittle nails can fracture suddenly when this operation is performed and the device should, therefore, be held so as not to endanger the operator or nearby personnel.

FIGURE 2.- Placement of test sample. 2-2202

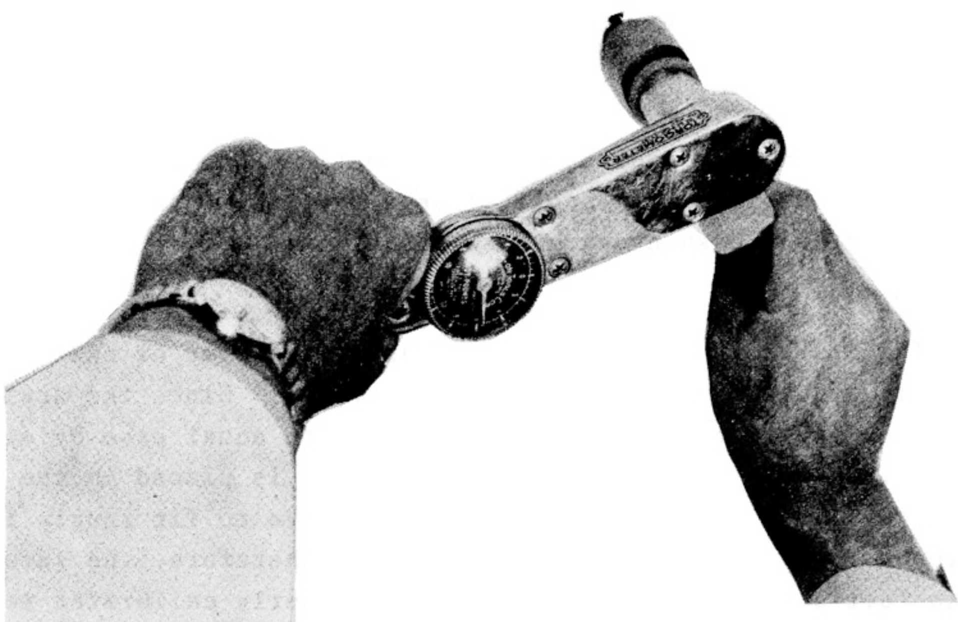


FIGURE 3.- Testing a nail. 2-2203

This method can be used to quantitatively determine the ductility and stiffness of wire or nails since a relative measure of the work required to bend the sample can be observed as a maximum reading on the torque wrench. The relative performance of a wire or nail may be determined by observing the torque required to bend it through a given angle (stiffness), or by bending it until fracture or failure occurs (ductility). The angle of bend may be measured by placing a nail in the device and turning the arbour until resistance is felt. A circular scale revolving about the arbour is then zeroed to a pointer fixed to the arbour. The angle of bend can then be instantaneously measured as the torque is applied. An alternative can be two adjustable stops, one centered at zero and the other centered through the measured angle of rotation. The torque required to bend the wire or nail may be used as a measure of stiffness and the relative ductility may be obtained by measuring the angle at which fracture or failure occurs.

A suggested performance standard (1) for nails requires that a nail be bent through a measured angle. Requirements will be met if a minimum bending torque is obtained and no hairline fractures appear in the nail at the bend. These specifications require that 10 nails must be tested in the EFPL device. The nails must attain a minimum torque of 110 in-lb and no more than 4 of the 10 nails may fracture or crack when bent through a 90-deg angle. Since, during certain conditions, case-hardening may take place during the fabrication of wire nails, it is suggested that nails from a variety of sample lots be tested.

CONCLUSION

This device provides an inexpensive and convenient method of determining two of the more important mechanical properties of wire or wire nails. The test can be performed by anyone at any time and no sophisticated and expensive laboratory testing machines are required. The results of tests performed on this device may be used to determine a nail's stiffness and hence its drivability, and its ability to transmit lateral shear loads.

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