Panel Processing
An Employee-Owned Company

hook-hanging strength

PERFORATED WOOD BASED PANELS – (Pegboard)

Factors affecting Hook-Hanging Strength

By
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Revised (03/12/12) by
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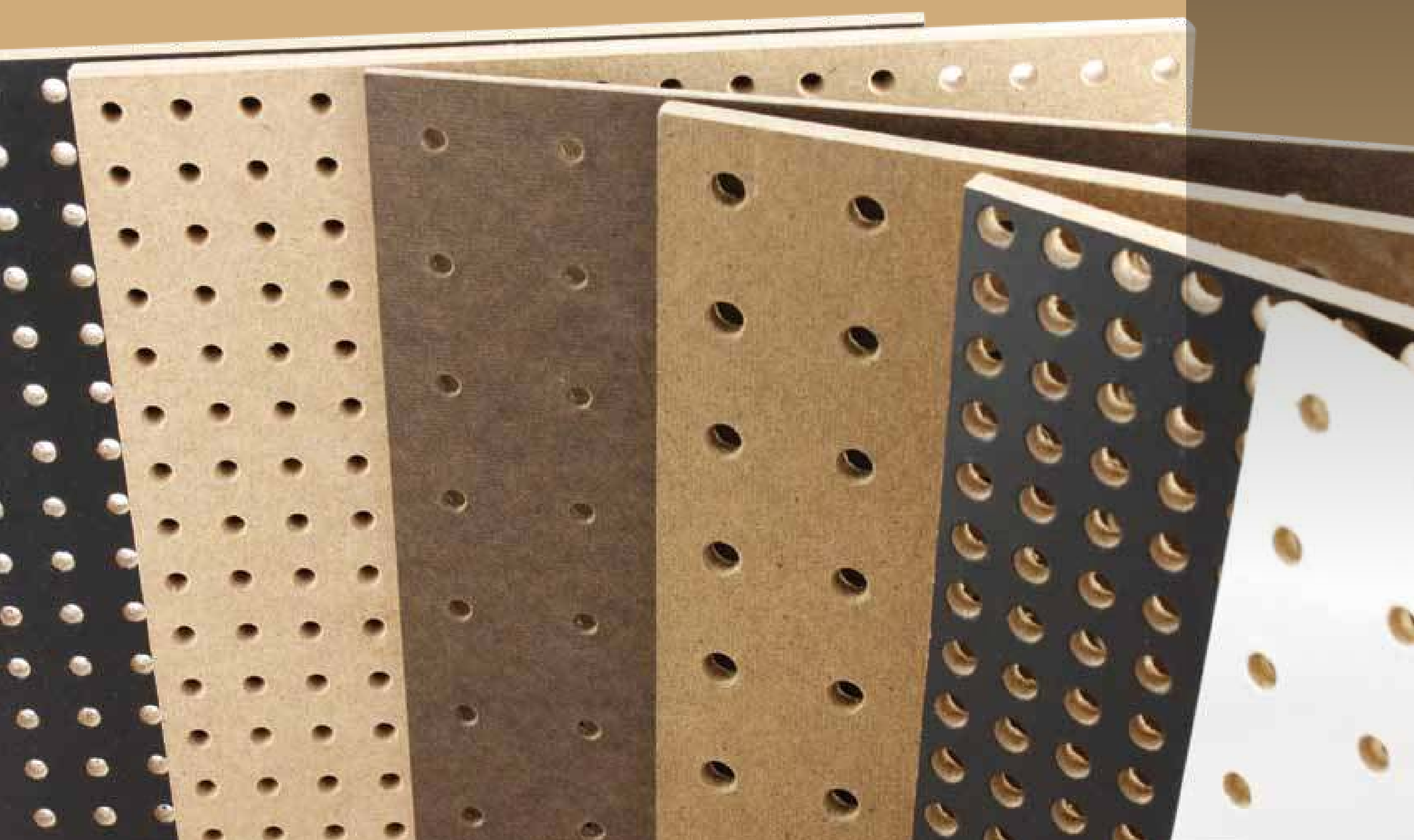


The attractiveness of a store fixture installation is sometimes marred by pegboard with paint chipped away from the edges of the perforations and/or elongated, wallowed out holes. In extreme cases pegboard may become further disfigured when overloaded hooks tear pieces out of the panels. As a supplier of pegboard, we share the concerns of the store owner, the store fixture manufacturer, and the pegboard hook manufacturer; we all want fixtures which give good service and remain attractive for at least ten years.

Why would a pegboard installation give unsatisfactory service? Was the pegboard strength substandard? Were the hooks poorly designed? Did the fixture frame not provide adequate support? Was the fixture loaded beyond reasonable capacity in the store?

In an effort to answer some of these questions we designed a series of tests to determine the behavior of various combinations of pegboard and hook types under severe loading conditions.

METHOD FOR TESTING PANELS AND HOOKS FOR OCCASIONAL PROBLEMS

We researched and selected several types of hooks for evaluation, targeting commercially available hooks advertised to carry medium to heavy loads. Then we built the test apparatus shown in Figure 1 to simulate a common type of store fixture installation. The frame provided 48” high vertical (¼”wide x ¼”) deep channel supports with an overall inside horizontal clearance of 47-1/16”. This is the typical expansion allowance for a 47” wide store fixture panel. Accordingly we cut our test panels to 47” wide by 48” high.

FIGURE 1

Four types of wood based panels that we typically supply were chosen for testing. We refer to them as (1) High-strength 5.5 mm (1/4” nominal) High Density Fiberboard (HDF), (2) High-strength 4.8 mm (3/16” nominal) HDF, (3) High-strength ¼” smooth two sides (S2S) Hardboard, and (4) High-strength 3/16” S2S Hardboard. All of these panels meet or exceed our pegboard substrate specification for a minimum Density of 50 lb/ft^3 and a minimum Modulus of Rupture of 5000 psi (as determined by ASTM 1037-99 Part B). These panels were then installed in our test fixture, equipped with various hooks and subjected to steadily increasing loads applied at the end of the hook until either the pegboard or the hook failed.

HOOK DESIGN IS USUALLY MORE IMPORTANT THAN PEGBOARD STRENGTH!

A dissertation of the hooks tested, the testing procedure used, and the test results appears later in this article. Briefly, however, test results indicated that many common types of pegboard hooks will perform almost equally well installed in any of the four types of panels tested. Apparently manufacturers of these hooks design them so that they yield before they cause tear-out and thus permanently disfigure the pegboard.

We found that pegboard strength does not become a significant factor until the loading becomes very heavy (more than 40 pounds at the end of a 6" long hook). Very few hooks are designed to carry these kinds of loads. Most are designed to carry medium loads (15 to 20 pounds).

We also found that hook design has an important bearing on the performance of the pegboard. Under the same loading, some hooks will deface the pegboard whereas others will not. As a supplier of pegboard we prefer a hook design which causes the hook to yield before it scars or breaks the board. Also, in consideration of safety, we prefer a hook which yields through bending of prong and/or tangs rather than by sudden breaking which could allow displayed product to fall on a bystander.

Hook loading is typically referred to as "X pounds at the end of a 6" long hook". That's because two factors determine the stress placed on the pegboard panel…the weight and the distance that weight is hanging from the face of the panel. A 10 pound load at the end of a 12" long hook is equivalent to a 20 pound load at the end of a 6" long hook….they are both calculated as 10 "ft-lbs". We will use this nomenclature throughout the rest of this discussion. As a point of interest, since many of our customers spread their products uniformly over the length of the hook prong, we should add that the engineering formula to determine the loading in this application is also very simple…1/2 x Load x Prong Length. In other words, 20 pounds of product uniformly distributed over the same 12" hook mentioned earlier is 10 ft-lbs.

TERMINOLOGY USED IN DESCRIPTION OF HOOKS TESTED

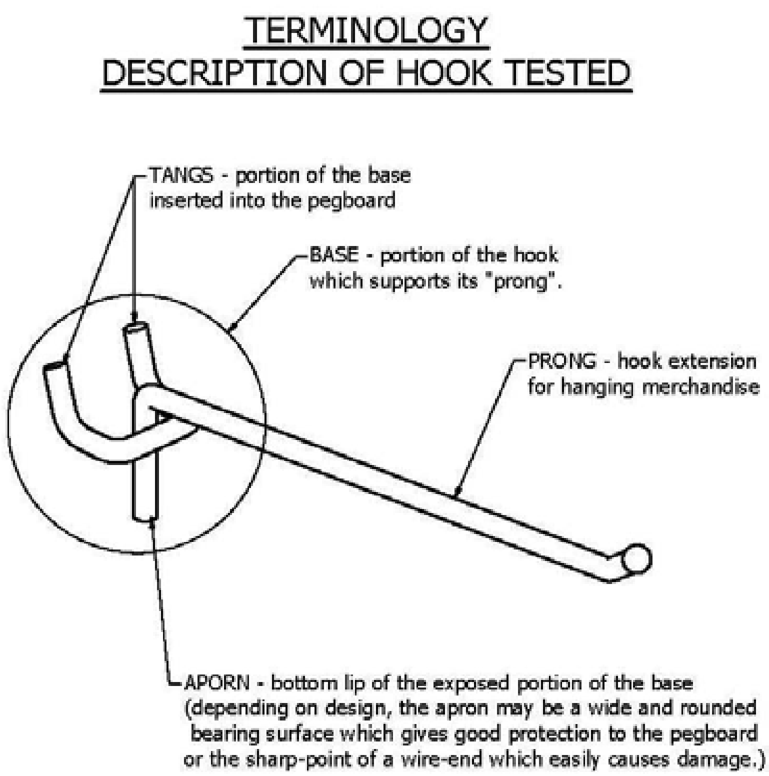


FIGURE 2

We should also define some terminology used to describe various hook types. Essentially, the terms "tang, apron, base, and prong" can be used to depict any and all hooks commercially available. Figure 2 shows a typical hook with these features noted for demonstration purposes. Figure 3, included as reference page at the end of this pamphlet, shows the types of hooks tested and describes them in the fore mentioned terms. Please note that only if terms such as "heavy duty" and "super heavy duty" are mentioned in the hook manufacturer's literature do we include them in our descriptions.

A BRIEF DISCUSSION OF ANY STRENGTH vs. RIGIDITY CONSIDERATIONS

Please note that as part of our investigation and prior to any actual hook hanging testing we performed simple transverse strength (bending strength/deflection) tests of the four substrates reported on herein as well as a couple less desirable panels with lower densities and MORs than our previously mentioned minimums. Some of our suppliers and competitors have claimed that such products could perform adequately in "most" applications because of the added flexibility ("Bend before you break" theory). We thought perhaps we could identify a combination of a higher transverse strength with slightly lower MOR and density that would perform adequately if the test panel were somehow supported better with additional "capture" in the fixture. As a baseline test for determining if these panels should be subjected to our more time consuming complete battery of tests we selected hook #4 (a general purpose hook that is found universally in use by our customers) and loaded it to 12.6 ft-lbs (a point known with this hook to cause permanent hook deformation without damaging our normal high strength panels). We were unable to find any panels with an MOR under 5000 psi and corresponding 50lb/ft^3 density, regardless of transverse strength, that passed this initial test. Consequently, these panels are not included in this dissertation.

ADDITIONAL DETAILS OF TESTING METHODOLOGY AND HOOK TYPES

We slid our 47" x 48" sample panels into the top of our ¼" x ¼" channels until the bottom of the panel simply rested on a piece of flat iron. While the top edge of the panel is not captured a piece of flat iron does connect the two channel uprights to ensure that the entire structure is very rigid…much more so than the typical store fixture found in the stores that use our products. This eliminates any flexing issues associated with bad fixture design and yields more consistent results. We placed two identical test hooks in each panel. The "test" hook was placed as close to the center of the panel as possible while the "base line" (or never loaded) hook was placed at the same elevation as the test hook but a couple inches away laterally at approximately eye level. At the end of the test hook we attached a rope which, after going through a pulley system, was attached to one end of a 0-30 pound spring scale equipped with both a "Max Load" indicator and a "Zero Offset" adjustment. The other end of this scale was then attached by a short section of rope to a manual winch with a very high turn down ratio (50:1). After zeroing the scale to compensate for the weight of the pulleys and connectors, we very slowly began turning the winch to add "weight" to the end of the hook until either the hook bent or the board failed. As soon as we noted little or no change in the scale reading with the slow turning of the winch handle, we stopped winding, recorded the scale reading, and unwound the winch. We then would move the test hook into a new set of peg holes at the same elevation but on the opposite side of the base line hook for visual comparison. If we noted permanent deformation of the hook (whether due to the prong, apron, or tangs bending, the board was declared as passing and the weight recorded. If we didn't note any deformation we examined the board front and back for any signs of cracking. If cracks were found we declared the board as failed and again recorded the load. If no permanent hook deformation or board cracking was found we reinstalled the bare test hook in the original set of holes, turned the winch very slowly up to the previous setting, paused slightly, and then began turning the winch extremely slowly while watching the scale. Invariably, the scale reading would start increasing again and the very next time it stopped we were able to detect either hook or board failure. This higher scale reading was then recorded. If at any time, we noted both permanent hook deformation and board cracking we still called it a passing board, again recorded the weight, and noted that the board just barely passed.

Each result reported here is the average of at least two tests performed in "fresh" holes in the same panel. If close agreement between tests was not evident, a third test was run. And if results still diverged, a new panel and new hook were tested. This was only necessary once and was traced to an off specification test hook. It should also be noted that no hook (regardless of results) was used for more than one test.

HOOKS GENERALLY FAILED BEFORE THE PEGBOARD (DESIRABLE SINCE HOOKS ARE EASIER TO REPLACE).

Please refer to Figure 5 at the end of this article for the actual test results presented in bar chart form. Table I (immediately preceding the bar chart) presents the same information with an expanded description of the specifics of each failure (hook, board, or both). In the interest of providing a more familiar picture of various loading levels associated with these failures we have also included a picture of a typical "heavy duty" application in a customer's store (Figure 3). This loading is in the range of 15 -20 ft.-lbs. Two-thirds of the hooks tested would have failed under this loading. It should also be mentioned that the maximum loading used in our testing (34 ft.-lbs.) was double this amount.

FIGURE 3

Our conclusions regarding the performance of the three types of pegboard and twelve kinds of hooks are as follows:

Hook Type #1 – We found this type of hook to be "very kind" to pegboard panels. The plastic tangs break before damage can be caused to the board. The downward slope of the prong indicates hook overload well before the tangs break. However, loading this hook to its breaking point could become dangerous because the prong is catapulted from the base when the tangs break.

Hook Type #2 – We were surprised by the large load this hook was able to support before deforming. The panels bowed noticeably more leading up to this load and the 4.8 mm HDF eventually broke out. Users of this hook should monitor loading carefully in 4.8 mm HDF and assure they have adequate "capture" of the panel in their fixture before heavily loading these hooks in all other panels.

Hook Types #3 and #4 – Because we have seen instances where the "can opener" action of the sharp wire-end on the apron of this design has cut through pegboard panels from some of our competitors we purposely tested both a medium duty and a heavy duty hook of this commonly used type. The heavier hook (#4) did leave a noticeable imprint on the surface of all four panels (more so on the HDF) when the hook finally deformed which indicated we were nearing a board failure condition. Since our major concern is the protection and long service life of the panels we supply, we recommend that this type of hook be limited to a maximum wire diameter of 0.203" to provide a safe margin of error.

SOME HOOKS ARE "VERY KIND" TO THE PEGBOARD…OTHERS HAVE A "CAN OPENER" EFFECT.

Hook Type #5 – This is another hook that is kind to a pegboard panel. The tangs straighten out before overloading causes damage to the pegboard.

Hook Type #6 – This hook, though designed and recommended for use only with pegboard of full ¼" thickness, accepted a surprisingly large load, even with the 3/16" thick panel. Failure came from the tangs pulling through the pegboard holes, causing bad disfigurement and paint chipping in the bottom of the holes in all four panels. Heavy loading of this hook must be regarded as potentially dangerous due to the possibility of sudden pull out.

Hook Type #7 – This well designed "implement-holder" type hook proved strong enough to carry our maximum load tested (34 ft.-lbs.) on all panels. Most store managers would consider this excessive as it equates to 68 pounds distributed evenly over the length of a twelve inch long hook. Panel bowing was again excessive.

Hook Type #8 – Again we find a hook kind to pegboard. The weldment of the prong to the base seems to be intentionally designed so that it will break before damage occurs to the panels. Though the load this hook is designed to support is quite low we must again point out the hazard of sudden dropping from an overloaded hook.

Hook Type #9 – We dislike the design of this hook as the 3/8" prong diameter encourages overloading of a pegboard panel. The substantial apron stiffens up the entire assembly and transfers damaging loads to the two tangs which begin to bend at the same time the face of the panel begins to crack. These tangs could easily straighten out completely with only a slight additional load and suddenly drop that load at the same time the pegboard fails.

Hook Type #10 – Hinging on the base of this hook permits horizontal entry of the prong on installation. The three tangs and good support of its apron allow it to carry a very heavy load. Board surface cracking did occur on HDF panels.

Hook Type #11 – Here we have another "can-opener" type design on the order of Hook Types #3 and #4. Again we recommend that a hook of this design be limited to a wire diameter of 0.203" to ensure that the prong bends prior to the sharp apron cutting in to the face of the panel.

HOOK DESIGN IS OF OVER-RIDING IMPORTANCE…SIMPLE TESTS SHOW ADEQUACY OF PEGBOARD

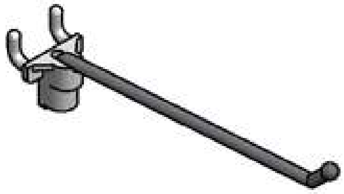
We started this test program with no idea that we would find either pegboard strength or hook design primarily responsible for the occasional failures which affect the attractiveness and functionality of pegboard installations. However, we now believe that our tests have presented strong evidence that careful selection of hook type is of over- riding importance in preserving a good looking and highly functional installation.

This observation confirms a conclusion arrived at by the Engineering Department of a large department store chain following several years of study. They concluded that it was impractical to develop specifications for pegboard which would insure its trouble free performance unless the quality and design of the hooks being used were also specified. In fact, they abandoned writing a specification for the pegboard panels and instead devoted a separate section of their manual to specifying acceptable hook types to be used in their fixtures.

These comments aren't intended to imply that quality of pegboard should be held blameless in case of a failure. There are suppliers who will substitute pegboard made from an inferior substrate with lower MORs and densities. These panels will be problematic and short in useful life except in the lightest of loading applications. We have grown to be the largest supplier of pegboard panels in the world by assuming that our panels will eventually see medium to heavy duty loads some time in their useful life. We do occasionally have a customer with a special application requiring loading heavier than what we have included in our testing. We usually can help them by sourcing a special order extra high strength panel or counsel them on hook and/or fixture design.

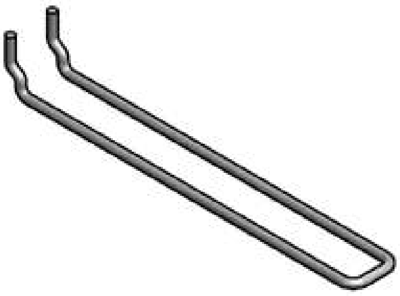
1

Type: General purpose, "heavy duty"
Prong: Single; 6" x .225"
Tangs: 2-.215" round plastic
Apron: Flat, 1/2" wide straight tip



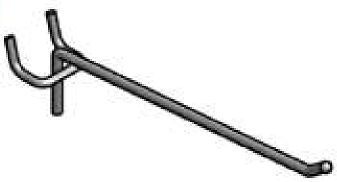
2

Type: General purpose,
Prong: Loop; 8" x .187"
Tangs: 2-.187" round wire
Apron: .187" round wire shape to form a "heel"



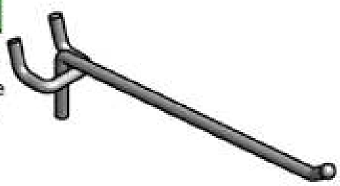
3

Type: General purpose,
Prong: Single; 6" x .177"
Tangs: 2-.149" round wire
Apron: .177" round wire, sharp lip



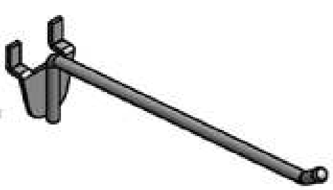
4

Type: General purpose,
Prong: Single; 6" x .212"
Tangs: 2-.212" round wire
Apron: .212" round wire, sharp lip



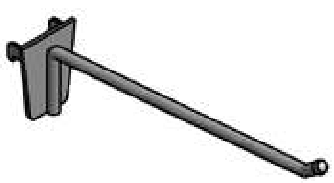
5

Type: General purpose,
Prong: Single; 8" x .217"
Tangs: 2-.080" x .240" wide
Apron: Flat, plate formed to 3/8" radius at lip



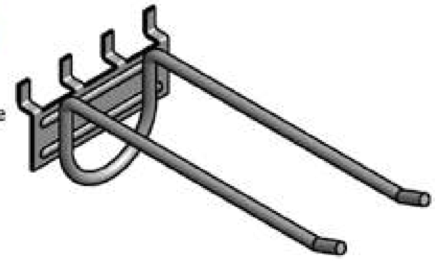
6

Type: General purpose, "heavy duty"
Prong: Single; 6" x .217"
Tangs: 2-.120" x 217"
Apron: Flat plate, 3/4" wide stright lip



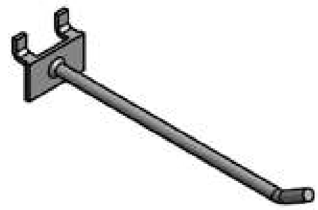
7

Type: Implement holder, "heavy duty"
Prong: Double; 6" x .225"
Tangs: 4-.085" x .190" wide
Apron: Flat, 1-3/16" wide straight tip



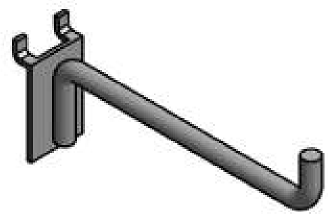
8

Type: General purpose,
Prong: Single; 6" x .225"
Tangs: 2-.090" x .235" wide
Apron: Flat plate, 1-1/8" straight tip



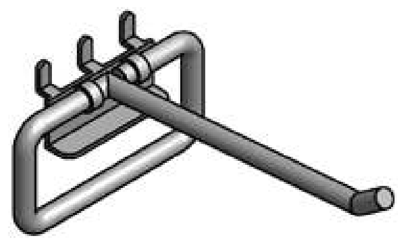
9

Type: General purpose, "super heavy duty"
Prong: Single; 6" x .375"
Tangs: 2-.085" x .190" wide
Apron: Flat plate, 1-3/16" straight tip



10

Type: General purpose, "super heavy duty"
Prong: Single; 6" x .375"
Tangs: 3-.085" x .190" wide
Apron: Flat plate, 1-3/16"



11

Type: General purpose,
Prong: Single; 6" x .085"
Tangs: 2-.085" x .230" wide
Apron: .225" round wire, sharp lip

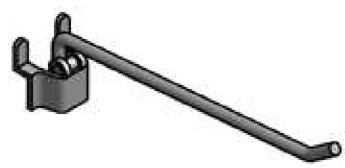


FIGURE 4

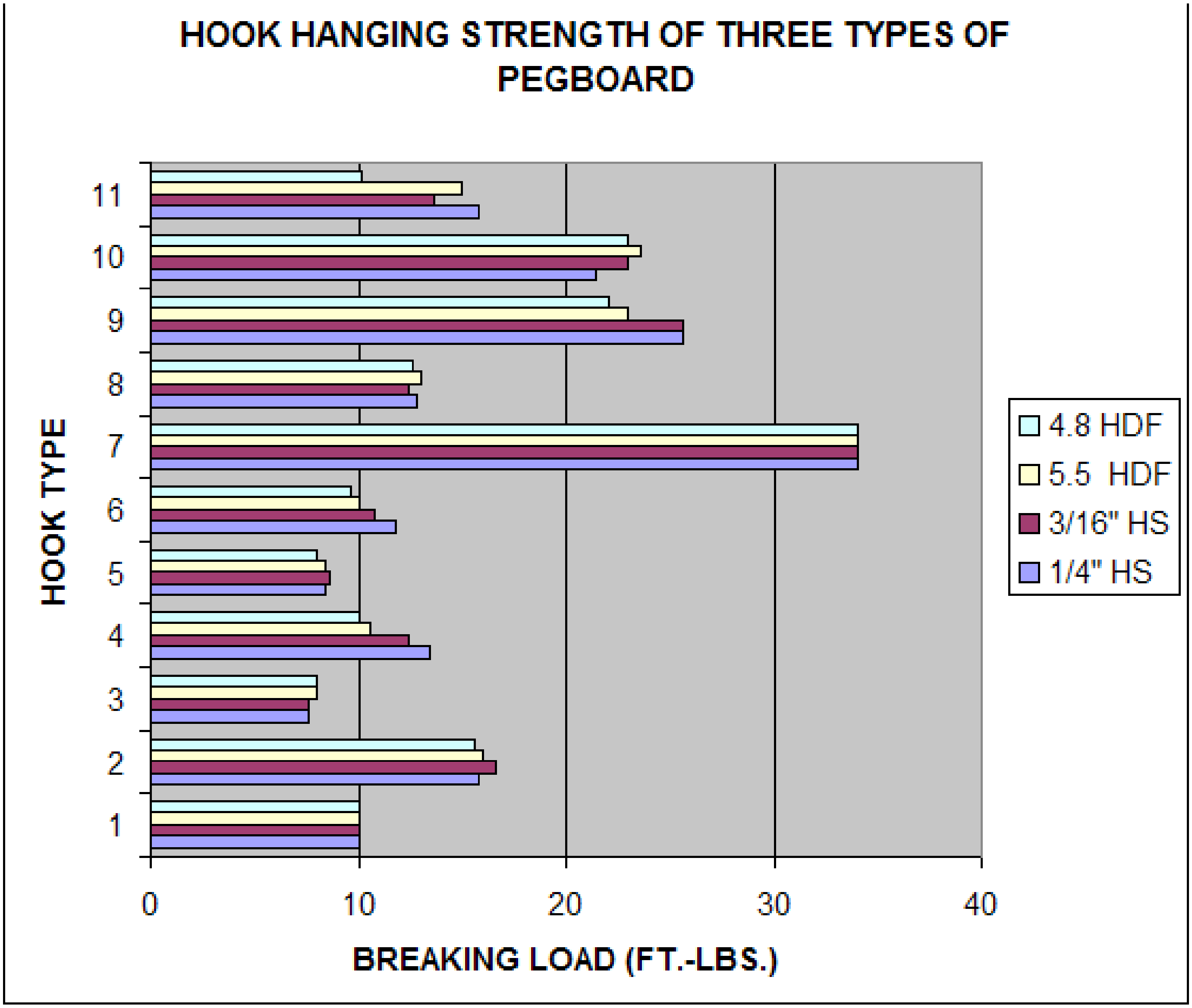

HOOK HANGING STRENGTH OF THREE TYPES OF PEGBOARD
HOOK TYPE
11
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
BREAKING LOAD (FT.-LBS.)
4.8 HDF
5.5 HDF
3/16" HS
1/4" HS

FIGURE 5

TABLE I: TEST RESULTS ON HOOK HANGKING STRENTH OF FOUR COMMON TYPES OF SUBSTRATES			
HOOK TYPE	SUBSTRATE TYPE	BREAKING LOAD FT.-LBS.	DESCRIPTION OF FAILURE
1	4.8 M/HDF	10	Plastic tangs broke
	5.5 M/HDF	10	Plastic tangs broke
	3/16" HS	10	Plastic tangs broke
	1/4" HS	10	Plastic tangs broke
2	4.8 M/HDF	15.6	Board cracked, hook prongs bent
	5.5 M/HDF	16	Hook prongs bent
	3/16" HS	16.6	Hook prongs bent
	1/4" HS	15.8	Hook prongs bent
3	4.8 M/HDF	8	Hook prong bent
	5.5 M/HDF	8	Hook prong bent
	3/16" HS	7.6	Hook prong bent
	1/4" HS	7.6	Hook prong bent
4	4.8 M/HDF	10	Apron cut into panel, prong bent slightly
	5.5 M/HDF	10.6	Apron cut into panel, prong bent slightly
	3/16" HS	12.4	Apron cut into panel, prong bent slightly
	1/4" HS	13.4	Apron cut into panel, prong bent slightly
5	4.8 M/HDF	8	Tangs straightened out
	5.5 M/HDF	8.4	Tangs straightened out
	3/16" HS	8.6	Tangs straightened out
	1/4" HS	8.4	Tangs straightened out
6	4.8 M/HDF	9.6	Tangs pulled through bottom of pegs
	5.5 M/HDF	10	Tangs pulled through bottom of pegs
	3/16" HS	10.8	Tangs pulled through bottom of pegs
	1/4" HS	11.8	Tangs pulled through bottom of pegs
7	4.8 M/HDF	34	No Failure @ Max.Load
	5.5 M/HDF	34	No Failure @ Max.Load
	3/16" HS	34	No Failure @ Max.Load
	1/4" HS	34	No Failure @ Max.Load
8	4.8 M/HDF	12.6	Weldment of prong to base failed
	5.5 M/HDF	13	Weldment of prong to base failed
	3/16" HS	12.4	Weldment of prong to base failed
	1/4" HS	12.8	Weldment of prong to base failed
9	4.8 M/HDF	22	Board cracked, tangs bent
	5.5 M/HDF	23	Board cracked, tangs bent
	3/16" HS	25.6	Board cracked, tangs bent
	1/4" HS	25.6	Board cracked, tangs bent
10	4.8 M/HDF	23	Hook prong bent, board cracked
	5.5 M/HDF	23.6	Hook prong bent, board cracked
	3/16" HS	23	Hook prong bent
	1/4" HS	21.4	Hook prong bent
11	4.8 M/HDF	10.2	Hook prong bent, apron tore into board
	5.5 M/HDF	15	Hook prong bent, tangs bent
	3/16" HS	13.6	Hook prong bent, tangs bent
	1/4" HS	15.8	Hook prong bent, tangs bent

TABLE 1

ABOUT THE AUTHORS

R. M. Granum was the founder and Chairman of the Board of Panel Processing, Inc., a fabricator and finisher of wood based components for industrial use. At the time of his death in 2003 he had amassed nearly 50 years of experience in the hard board and wood based panel industry. He'd held positions in research, production, and top level management prior to founding Panel Processing, Inc. Mr. Granum was widely recognized as one of the nations leading experts on the various types of hardboard and other thin wood based substrates manufactured in the United States and Canada.

O. B. Eustis was involved in building products manufacture, research, and development work for 45 years holding mostly executive positions at both the corporate and plant levels of major hardboard manufacturers until his retirement in the late 1970's. From that time until his death in 1986 he served as a consultant to various manufacturers, fabricators, and end users in the wood products industry.

T. L. VanMassenhove, PE is the Vice-President of Engineering for Panel Processing, Inc. He is a registered Professional Engineer and has worked in the hardboard, pulp and paper, and wood products industry for over 39 years at both the plant and corporate level. Mr. VanMassenhove mentored under both Mr. Granum and Mr. Eustis at various points throughout his career and is co-holder of a United States patent for a proprietary process and associated equipment used in the manufacture of wet process hardboard.

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