Dealing with Expansion

WOOD BASED PANELS –
How to deal with expansion characteristics

By
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Revised (10/18/04 and 3/7/12) by
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A customer phoned recently and said “We ordered panels 46-15/16” wide. The panels you shipped measure 47”. We can’t fit them into our frames!”

In a case such as this we commonly find our sizing of the panels at point of manufacture was correct. The problem is caused by expansion of the panels between manufacture and point of installation.

We manufacture thin (less than 3/8” thick) components for our customers using hardboard (both wet and dry process variety) or HDF (high density fiberboard). All three substrates contain wood fibers. In fact, they are essentially more “wood” than a tree is. While the details of the actual manufacturing process for each substrate differ somewhat, the finished product consists of wood fibers combined with a minimal amount of resinous binder and then reconstituted in a controlled environment under heat and pressure into sheets of various sizes.

Any wood product will shrink or swell as it gains or loses moisture. Home-dwellers in seasonal climates recognize this phenomenon, called Hygroexpansion, as the difference in fit of wood doors and windows between winter and summer.

It is impossible to confine a wood based panel so as to restrict its expansion. If a panel is closely confined within a welded metal frame, for example, it will expand exactly the same amount as if it were not confined. The expansion will cause bellying or humping of the panel as it grows and could conceivably even break the frame.

Store fixtures and displays often combine metal, wood based, and occasionally plastic components in a single unit. Designers must consider and allow for the difference in expansion of each material. Please consider these aspects:

1) STEEL – Steel will change dimension slightly with change in temperature but within range of its normal exposure it may be considered to hold a fixed dimension.

2) ALUMINUM – For a given change in temperature aluminum will change dimension more than twice as much as steel. The designer must sometimes give this consideration. For example, if a wood based panel is closely confined within an aluminum frame and if this assembly is then shipped in cold weather the frame could shrink enough in transit to warp the panel or crack the frame.

3) PLASTIC – Commonly used plastics have great reaction to temperature change, easily up to 4 times as much as aluminum. Within range of temperatures easily experienced in transit and/or use (0 – 90 deg. F) a 48” length will grow or shrink 3/16”.

4) WOOD PRODUCTS – Wet and dry process hardboard, HDF, particle board, plywood, OSB, etc. show no significant change in dimension with change in temperature. They do, however, change dimension an appreciable amount with change in relative humidity and resultant moisture content.

Engineering Handbooks give the Designer good information on how steel, aluminum, and plastics change dimension with changes in temperature. However, information on how wood based products change dimension with changes in relative humidity is not well known. We surmise this is because variations in wood density, species, resin type and amount, etc. affect this characteristic and preclude listing a general tabulated value. In fact, we see results for panels from different manufacturers that vary enough to preclude their use in our production facilities. The recommendations passed along in this article and the numerical data included in the appendix are for panels from manufacturers of substrates that consistently conform to our rigid Hygroexpansion specifications.

In this article, we hope to give Designers and other interested persons a basic understanding of how wood based panels behave with changes in the humidity of the environment surrounding them.

Most people recognize a "humid" day as one in mid-summer which is "hot and muggy". Few people realize that a cold, crisp day in mid-winter with temperature below freezing is often as "humid" as the "muggy" day in summer. Wood based panels react insignificantly to temperature changes so people are often puzzled why these panels will expand the same when exposed to a sweltering 100 deg. F or a frigid 0 deg. F temperature.

To demonstrate the behavior of wood based panels with change in relative humidity we exposed panels of wet process hardboard, dry process hardboard, and HDF to what we consider the most severe extremes that could be experienced in field exposure. A detailed description of this trial is contained in an appendix to this article. Briefly, results were as follows:

1) With exposure to high relative humidity panels that were manufactured under our normal climatic conditions and cut to 48" expanded approximately 5/32".
2) With complete drying out these same panels then shrank a bit over 3/16". (we dried out the test panels by holding them in an oven for 15 minutes. A similar "drying out" would occur if a van-load of panels were left standing in hot summer sun for a few days where ambient air temperatures inside the trailer could easily reach 160 deg. F.)
3) After drying out, the panels were returned to high relative humidity exposure. In two weeks the panels returned to nearly their original maximum width.
4) When moved to an area of low relative humidity the panels shrank up to 3/32".

After reviewing the results of this trial a designer may ask "Hey, do you mean I have to allow for expansion and contraction of a 48" wide panel of plus or minus 1/8 of an inch?" The answer we'd give is "No". Conditions in this trial were extreme. Consider the billions of square feet of wood based paneling in attractive use throughout the world. If expansion and contraction of 1/8" per 48" occurred commonly this product would be unfit for use.

In our trial we purposefully exposed the specimens to extreme conditions in order to emphasize problems which can arise if precautions aren't taken and reasonable tolerances aren't allowed. **IN OUR EXPERIENCE, A DESIGNER WHO WILL ALLOW TOLERANCE FOR 0.13% EXPANSION OF A WOOD BASED PANEL (1/16'' PER 48'') WILL DEVELOP A PRODUCT WHICH IS 99.5% TROUBLE FREE.**

In actual practice we agree to supply panels cut to a tolerance of plus or minus 1/32" and don't attempt to explain that in order to do this we must try to anticipate how much the panels will change in dimension between our time of cutting and eventual point of use. We commonly set to trim to the lower limit of tolerance, knowing that in most areas we ship to the panels will expand. For shipments into the southwestern U.S. we do, however, set to cut the exact dimension specified.

In summary, the designer must allow for movement between dissimilar materials such as metal, plastic, and wood based components when two or more of them are combined in an assembly. Wood based components will change dimension with changes in relative humidity whereas metal and plastic parts react to temperature changes. Under common conditions an allowance of 0.13% for expansion of the wood based panels will avoid any trouble. However, the designer and the consumer should be aware of extreme conditions which could occur. For example, if a product is stored in an unheated warehouse during cold weather or if it is allowed to stand for a few days in a van or enclosed trailer exposed to hot sunlight. In such cases, large and opposing movements by the dissimilar materials might totally destroy the assembly.

APPENDIX

Following is a description of the experiment charted on Figures 1, 2, and 3. The circled numbers relate to measurements taken on the three different substrates…wet process hardboard, dry process hardboard, and HDF. Points 1, 4, 7, 10, and 13 correspond to wet process hardboard. Points 2, 5, 8, 11, and 14 are associated with dry process hardboard. And points 3, 6, 9, 12, and 15 relate to HDF. The nominal ¼" thick test specimens were cut from "master" panels selected at random from our warehouse inventory (see Figure 4). Temperature in the warehouse during winter months is maintained at about 60 °F.

The six "masters" were run through our conveyorized paint line curing system but were not painted. Here they were exposed to about 50 seconds of high velocity hot air at about 375 °F impinging on the panels at an air speed of about 8,000 fpm. From previous tests we know that each such exposure lowers the actual moisture content of the panel approximately 0.5%. The specimens were exposed twice in quick succession and the resulting moisture content recorded.

Each panel was then immediately cut to an exact 48" x 48" size. This point in time corresponds to the starting point (1, 2, and 3) in Figure 1. Moisture contents of the wet process hardboard, the dry process hardboard, and the HDF specimens were 2.3%, 2.6%, and 2.08% respectively. These panels were then placed in an unheated building.

In the first day the panels expanded nearly an identical 1/16". In the next seven days, the wet process hardboard grew to a maximum of 48.16". The dry process hardboard grew to a maximum of 48.19". And the HDF maxed out at 48.15". Daily average relative humidities for this period ranged from 93% to 68% while temperatures ran from 28 °F to 13 °F. A check of moisture content at the end of this period (4, 5, and 6) showed that the wet process panel was at 6.6%, the dry process at 7.3%, and the HDF at 6.2%.

The panels were then put in our paint-curing oven and held there for 15 minutes at a temperature of 300°F, which was sufficient to remove all moisture from the panels. The panels were weighed to confirm that each was then at 0% moisture content. At this point (7, 8, and 9) the wet process hardboard shrank to a measurement of 47.95", the dry process sample shrank to 47.04", while the HDF ended up at 47.955". It is important to note that similar removal of moisture from our panels can occur in actual practice in some of our customer's "slow bake" painting operations or in a van or enclosed trailer left standing in hot summer sun for several days. (Temperatures have been measured in excess of 160°F in such circumstances.)

The panels were then returned to the unheated storage building. Again, all samples expanded an almost identical 1/16" within

24 hours and then continued growing slowly for about two weeks until they returned to dimensions similar to those prior to drying out. Relative humidities during this period ranged from 93% to 45% while temperatures varied from 37°F to 12°F. At the end of this period (10, 11, and 12) moisture contents were 8.2% for the wet process hardboard, 9% for the dry process, and 7.8% for the HDF.

Immediately after the moisture checks the samples were brought into an office building where the temperature was maintained near 72°F and the relative humidity hovered around 30% (typical levels for heated office or fabricating plants).

Note that this exposure drives home the point that dimensional changes are the result of humidity and corresponding moisture content changes and not temperature changes. For even as the average temperature increased significantly the relative humidity dropped. Yet the panels shrunk. Actually, all three samples quickly shrank around 1/16" and then gradually leveled off at dimensions only slightly greater than their original starting point. At point (13, 14, and 15) the wet process hardboard sample measured 48.067" and its moisture content was 3.7%. The dry process panel was 48.09" with moisture content of 4.1%. The HDF measured 48.065" and had a moisture content of 3.4%.

As an aside it is also worth mentioning that we duplicated this test with panels nearly identical but with standard 9/32" holes perforated in them. We thought perhaps these samples might react quicker to relative humidity changes since the extra exposed areas inside the holes could make it easier for the panel to attain its equilibrium moisture content. However, the data did not bear this out so the numerical results were eliminated from this discussion.

FIGURE 1

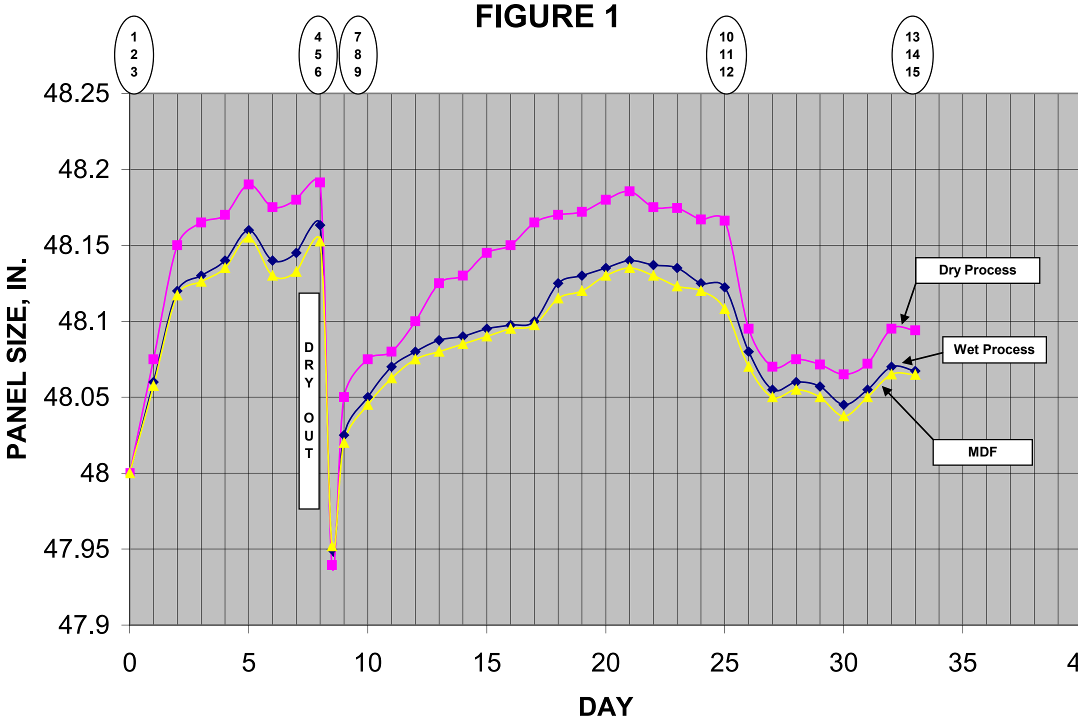

FIGURE 2

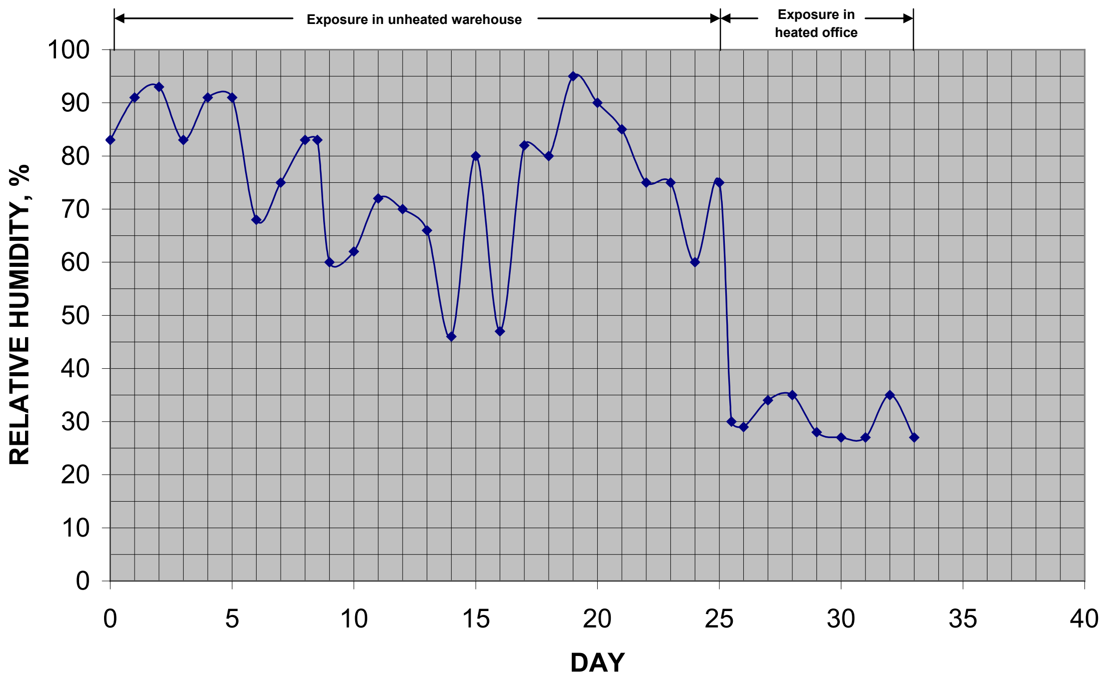

FIGURE 3

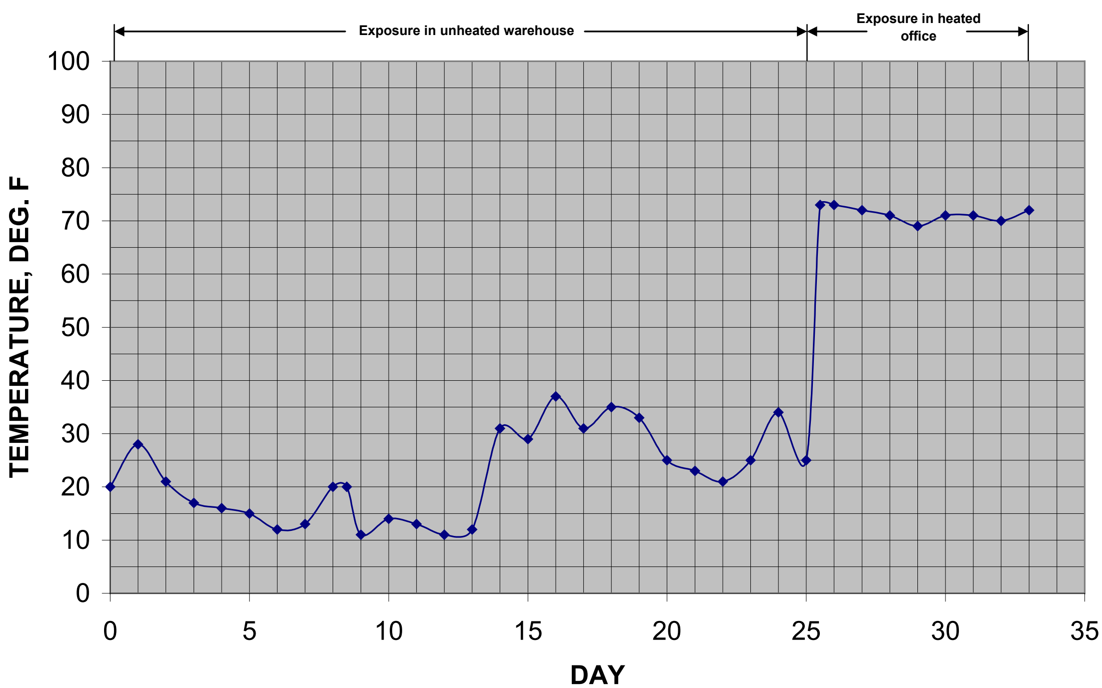

FIGURE 4

Substrate stored in Panel Processing warehouse.

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 Vice President - 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 has patented a proprietary process and associated equipment used in the manufacture of wet process hardboard.