Which Hardboard Is Best?

by Eric Thomson

This article results from my search for the hardboard most suitable as a painting panel. In 2003 I started a company which supplied gessoed panels to painters in my local Santa Fe community and by mail-order nationally, work which is now carried on by the company True Gesso. For that reason I needed an answer to the question every tempera artist asks at one time or another; “which hardboard is best to paint on?”

In this discussion we will be selecting the best hardboards based on a wide variety of published information. We will also be developing a ‘method’ which can be used by anyone to evaluate a hardboard product. An alternative is to make a selection based on a controlled lab-test of the various hardboards available. Although that is outside the scope of this work, one hopes that such an effort might be made in the future. Richard Davis has published an article in this newsletter [1] exploring the hardboard manufacturing process and I recommend it as general background for this discussion.

First, a quick history. In the U.S., hardboard began with an idea to recycle sawmill waste from mills in the South processing yellow pine. William H. Mason was awarded a patent in 1926 for his work on a process to render sawdust, chips and edging waste into fiber without losing the lignin which binds together cellulosic structures in natural wood. He then worked out ways to turn a slurry of this fiber into a very dense, smooth, homogenous panel by applying both heat and pressure. His product was first made in 1926 by the Mason Fiber Company, later the Masonite Corporation, in Laurel, Mississippi. It was called Presdwood, and later called Duron, but the word “Masonite” has entered the language to refer popularly to all hardboards.

The modern definition of hardboard, written by the American Hardboard Association for ANSI, calls for a “panel manufactured primarily from interfelted lignocellulosic fibers which are consolidated under heat and pressure in a hot-press to a density of 31 lbs./ cubic foot or greater... [2]” It is Mason’s combination of heat and pressure which reconstitutes the lignin in the pulp, forming a ‘glue’ which then re-binds the randomly matted cellulose fibers together in a new, much denser form. This reactivation of the lignin, itself a cellulose-like material, is why classic hardboard is nearly 100% wood; no additional glues are necessary, though many modern makers add them.

Hardboard went on to find countless industrial uses but there is an interesting prologue to this story. There are English patent applications from as early as 1861 which recommend the manufacture of tiles, shingles and bricks using a rendered wood fiber paste similar to Mason’s. These patents mention pressing the paste or slurry into final form, but don’t speak of applying heat. It is not clear whether manufacturing was undertaken with these patents but in 1893 a patent was applied for by J. M. MacIntosh for “improvements in panels, tablets, or slabs for the use of artists or others [3].” They were called the J. M. MacIntosh Patent Compressed Art Panels and were described as made of ordinary wood pulp, pressed between rollers. They were offered in standard sizes, sometimes with a canvas texture and sometimes primed with flake white. They were made available by the James Newman and Co., London, catalog. The panels were described in the MacIntosh patent as made “under pressure considerably greater than that ordinarily used in such manufacture in order that the material may be made very solid and homogeneous” [ibid.]. It therefore seems likely that one of the very first commercial applications of recognizable hardboard was as an artist’s painting panel.

Once Mason introduced his hardboard to the American public, artists this side of the pond likewise found it useful as a painting support. No less an authority than Ralph Mayer claims to have used it since its introduction. In the Artist’s Handbook he recommends it as an “entirely reliable material” for this purpose, “believed to be permanent, (having) passed all tests except the one of actual time...(and) because (such panels are) superior to wood in withstanding accelerated test conditions, we accept them as permanent [4]”. Curiously, a later edition of the Handbook revised after Mayer’s death amends this judgment considerably, but more on that later.

Mayer goes on to distinguish Presdwood (Masonite) from a variety of other types of compact (hard-) boards, laminated boards, pasteboards, cardboards and other construction materials. He recommends only Presdwood for permanent artists’ work, and only one form of Presdwood, the Standard (untempered) variety. This brings us back to our original question, and to modern times when there are a variety of choices available.

The Choices

How many choices are there? A seminal document for the hardboard industry is an article entitled "Hardboard (Masonite) What Is It?" by R. M. Granum and O. B. Eustis [5]. Granum and Eustis were, respectively, the first and the second plant foremen for the Abitibi-Price hardboard plant. The article describes an industry with nearly thirty plants nationally, each producing a slightly but recognizably different product varying with wood-furnish and plant techniques. That's how it was in the 1970's. Perhaps thankfully for our purposes things are different now. The flight of manufacturing off-shore has left a consolidated domestic industry with only a handful of major plants. My research shows most hardboard sold in the U.S. at this time of writing will be from the following sources:

Domestic manufacturers whose product may be found at retail;

• Evanite Fiber
• Georgia-Pacific
• Louisiana-Pacific (formerly Abitibi-Price)
• Masonite International
• Stimson Lumber Company

Foreign product, being brought in by Holland Southwest International;

• An Argentinean hardboard, Holland Southwest #13630, re-branded by others, made of Eucalyptus.
• A Spanish hardboard, Holland Southwest #1268
• A Mexican hardboard, Holland Southwest #1277

How do we choose amongst these products? Our 'method' will be to look at these factors:

1) product integrity
2) production process
3) receptivity to the media
4) strength and dimensional stability
5) chemical stability (archival quality)
6) toxicity

We take these factors one at a time in order.

Product Integrity

Today, some hardboard found at retail will be foreign-sourced since a retailer's standards for hardboard are often price-driven. If the product I find in my local big-box store is Chinese, that may be all I will ever know about it. The obstacles to finding out detailed manufacturing information from foreign plants, making product outside the norms of American industry, may be insuperable. Product integrity here simply means that an ideal board will come from a manufacturer who; 1) rates their board according to objective standards and; 2) openly discloses manufacturing techniques and product ingredients. In gathering my data, this is what I found:

• Evanite; the company provides sparse test data while disclosing adequate detail as to ingredients and manufacture.

• Georgia-Pacific; the company provides clear and adequate test data while manufacturing details were not forthcoming due to inflexible information channels. Still, published information allows a sufficient analysis for our purposes.

• Louisiana-Pacific; the company provides clear and adequate test data and excellent disclosure of details as to ingredients and manufacture.

• Masonite International; this company also provides clear and adequate test data and excellent disclosure of details as to ingredients and manufacture.

• Stimson Lumber; Test-data was unavailable from the company but enough detail information is available for our purposes.

• Argentinean Eucalyptus board: the distributor provides sparse information which is nevertheless adequate for our purposes.

• Spanish board; the distributor provides adequate test data but only a few facts as to ingredients.

• Mexican board; the distributor can provide only the information that the board is untempered and smooth-one-side.

I should comment here that, while published test data is either adequate or it isn't, the disclosure of ingredients and/or plant techniques depends greatly on the person on the other end of the line and how their day is going. An explanation of the typical tests we're looking at can be found on the Holland Southwest web-site [6] , while the actual ANSI standard for hardboard can be found at the AHA site [2]. On the other hand, finding just the right person to tell you what really goes into a particular board can be difficult. The best of this sort of information that I've gotten has been from plant quality-control managers, the worst from distributor's rep's.

As a result of the first factor in the evaluation process, we can bring forward the products from nearly all the sources with varying levels of confidence that we know what goes into them. On the other hand, the Mexican product from Holland Southwest gets left behind since the distributor cannot give us the required detail.

Production Process

The production process determines the hardboard's type, which has a bearing on the choice. There are three basic manufacturing processes, the "wet" process, the "wet-dry" process and the "dry" process (see the Davis or Granum/Eustis articles for discussion). The "wet" process was the original one and is still used by some producers. It leaves the familiar mesh pattern on the back and is termed S1S or 'smooth-one-side'. The "wet-dry" process was developed soon after the "wet" process and was the subject of a patent-infringement lawsuit by Masonite against U. S. Gypsum (Celotex). William H. Mason won, but licensed U. S. Gypsum to produce the first "wet-dry" board, distinguished by having two smooth sides (S2S) without resorting to sanding. The more modern "dry" process is quite different, yields an S2S surface and includes the related range of MDF (medium-density-fiberboard) products. Ironically, it may be closest in type to Mr. MacIntosh's Patent Panels of 1893. A distinguishing feature is that the lignins are not reconstituted as in the 'classic' methods and therefore an additional binder must be added; these days that binder is universally a phenolic resin. Further, I have found phenolic resin (phenol/formaldehyde) to be added to all three types of board, depending on the maker and the end-use.

There are two reasons to prefer avoiding "dry" process boards. First, the use of phenolic resin as a binder has no history in art materials. I know of no studies looking at the aging characteristics of phenolic resin in the context of painting supports and no studies looking at its compatibility with standard painting practices and materials. In the absence of such lab testing it is simply an unknown and for this reason one might avoid it.

Second, phenolic resin is a culprit in the formaldehyde out-gassing of construction materials. This is a potential problem, certainly for chemical-sensitive individuals and possibly for those less sensitive, given how closely an artist will work with the panel. This is the source of the curious comment in the late-edition Artist's Handbook as to "extreme out-gassing properties" of hardboard. Contrary to the implication in the text, only hardboard with added phenolic resins will display marked formaldehyde out-gassing.

As to the surface qualities of the various types, I would lean towards choosing the S2S type. All the standard literature and lore that has built up around priming Masonite repeats the advice that both sides should be treated equally to prevent warpage. This same notion can be found elsewhere, such as in wood-veneering practices. The simple fact of a mesh pattern on one side suggests that a "wet" process board will have slightly uneven tensions front to back, will tend to absorb ambient humidity slightly differently on each side and certainly will absorb different amounts of gesso on one side versus the other. To prime a panel equally on both sides requires an S2S board.

Thus, the surfacing issues narrow the search to "wet-dry" and "dry" process boards. The Evanite board is a "wet" process board and so it is S1S, while also containing added phenolic resin. The Stimson board is likewise S1S and it contains phenolic resins as well as emulsified wax additives. We will forgo these products in looking for an ideal board with two smooth surfaces. But, for the time being, the issue of whether to avoid the phenolic resins that hold together "dry" process board can be set aside; there will be further opportunities to discuss phenol/formaldehyde, especially under the "Toxicity" heading.

Receptivity to the Media

We are concerned strictly with the one medium, true gesso (calcium-carbonate pigment in aqueous rabbitskin glue solution). We are not looking here at whether oil or acrylic primers stick to hardboard. I know of no controlled lab tests comparing adhesion of true gesso to various hardboards, though there will be numerous scattered references in conservator's literature. Mayer suggests a simple test: to chip or pry a gesso layer off the panel and look to see whether it comes off 'clean' or whether it takes a layer of fiber with it. I tested the boards which made it through the rest of our analysis; we will look at those results in our conclusion.

Mayer always recommended using untempered hardboard, but there are examples of the successful use of tempered board for various art purposes, sometimes with the advice to lightly sand the surface or to wash it with solvents. Some modern tempering processes put a thin layer of drying oil on the surfaces of the completed board, either linseed or tung oil, with penetration only to about 1/100th of an inch and with final curing in ovens. It is not surprising, particularly if this surface were roughened, that hide glue might show a reasonable adherence to this completely cured surface.

On the other hand, paraffin wax has been used for tempering and presumably this would interfere with gesso adhesion. Further, the Argentinean board is 'tempered' not by the addition of any modifier but because it is made from Eucalyptus wood which is inherently oily, a characteristic which is captured in the production process. Any woodworker knows that certain woods are the devil to glue because of such inherent resinousness; absent controlled testing we can't know the long term effect of this variable.

The wise choice would seem to be to opt out of the uncertain aspects of tempered boards. It is common sense that a water-borne coating will adhere best to a non-oily, non-waxy, less glassy and slightly more fibrous surface and that therefore we should choose un-tempered hardboard. In doing so, we choose a board which may be less durable in absolute terms and one which is somewhat more hydrophilic. These are compromises we will discuss further below.

Therefore, the "wet-dry" and "dry" process boards which carry through to the next stage of analysis are those products labeled "Untempered" or "Standard" or "Regular" from Georgia/Pacific, Louisiana/Pacific and Masonite, plus the Spanish hardboard, Holland Southwest's #1268. The Argentinean Eucalyptus board is an unknown; although it has no added waxes, oils or resins, the wood itself is so water-resistant that the maker classifies it as 'tempered.' We shall leave this one behind.

Strength and Stability

Durability issues are more straightforward because in this case manufacturers provide test results directly relevant to our questions. For domestic industry, hardboard is classified by minimum tested performance levels. There are five nominal grades: #1 Tempered; #2 Standard; #3 Service-Tempered; #4 Service; #5 Industrialite. The highest strength ratings are achieved by #1 Tempered and tested strength goes down by stages to #5. The test-strength of hardboard is standardized as to modulus of rupture and to tensile strength. Tempering adds significantly to the test-strength of hardboard, but the best untempered board, #2 Standard, falls second overall in test-strength, well ahead of the lower two grades and equal to or better than the secondary grade of tempered board, the #3. So if one prefers to work on untempered board, a product which is rated to meet or exceed the minimum ANSI requirements for #2 Standard board is what is desirable.

The reasons for choosing the strongest possible board are not all self-evident. Good overall strength is obviously desirable, but why exactly? There is a direct correlation between test-strength and density. A denser board has a few desirable aspects. The corners and edges of a painting panel are typically where wear and tear show up as a problem. The late-edition Handbook voices concern about progressive flaking and this is an issue when the edge or corner has been bashed and the internal bond of the fiber has been broken. The denser board will better resist edge and corner damage.

Likewise, a denser board will resist the uptake of ambient humidity and will slow the reaction cycle of expansion and contraction. Indeed, as a general rule, the denser board will show lower figures of linear expansion. A tempered board will be best in this regard but the densest untempered board will be next best. All of this is good for the ground and paint layers, as cracking of the paint surface is induced and propagated by movement.

Last, and again generally, a board that tests strong will resist flexing better and this is likewise good for the ground and paint layer for the same reason of inhibiting movement. This becomes relatively important as the size of the panel increases. As a rule, gesso does not like any movement so increased stiffness of the panel is likely to contribute to the long-term health of the painting surface. For all the reasons we discuss here, I also suggest that the nominal 1/4" version of any given board is preferable to the thinner variants.

So, how do they measure up? The Georgia/Pacific product called Industrapanel has a density of 49 lbs./cu.ft, so it qualifies as hardboard, but the other published data is for 3/8" thickness, which means it does not compare directly to the other boards. It is a “dry” process board and it is held together with urea formaldehyde resins, which generally show higher emissions than phenolics. Its modulus of rupture places it in the lowest category, #5. All this suggests that it is more properly an MDF (medium-density-fiberboard) product. The other Georgia/Pacific board, their Superwood, while testing in the #1 category, is S1S only, plus it also contains phenolic binders. In addition, G/P distributes the Eucalyptus board under their label. So, based on available information, Georgia/Pacific does not produce an ideal board for our uses.

Louisiana/Pacific’s “Premium Standard” hardboard is made of aspen and other hardwoods, with a thin slurry of pure aspen applied to the ‘top’ surface giving it a slight cosmetic edge over the ‘bottom.’ Added ingredients are linseed oil in the amount of 0.72% and ferric sulphate as a hardener in the amount of 0.32%. Its density of 54 lbs./cu.ft. well exceeds the minimum for the standard while its modulus of rupture is 5300 psi, with the standard for #2 board calling for 4500 psi minimum. It is a good candidate.

Masonite’s standard 1/4” Duron also tests comfortably within the #2 category, with a somewhat lower MOR of 4700, and a slightly higher density of 58 lbs./cu.ft. It contains a small amount of tung oil to ‘condition’ the pulp and a small amount of ferric acid as a hardener. Like the LP board it contains no resin binder additives and no moisture inhibitors such as emulsified wax. It is made of assorted “soft hardwoods” like poplar, sweet gum and oak. It is likewise a good candidate.

The Spanish board, at 51 lbs./cu.ft., is slightly less dense than the other two but has a test MOR placing it in the #1 category, even though it is untempered. It has an internal bond rating, another measure of strength, slightly higher than Duron’s. It contains no phenolics but there is no further detail about its ingredients other than that it is made of pine, a wood the Masonite people avoid for its sappiness and short fibers.

Thus, we can bring forward three hardboards to the conclusion of the analysis.

Chemical Stability (Archival Issues)

The boards which have made it this far are ‘simple’ products. It has been possible to avoid, for one reason or another, the more complicated formulations with added resins, waxes, binders and surface oil-treatments. This makes the issue of assessing “archival quality” a little easier. While more complicated formulae would call for lab testing and accelerated aging, we can look at these boards as representing few chemical unknowns. They are 99% wood, or thereabouts. Wood is known to be an acidic material, capable of having a negative effect on some pigments and on paper. There are two reasons tempera paintings on wood panels have survived this. One is that the first layer of rabbitskin glue and the subsequent layers of glue-gesso provide an adequate acid barrier. Second is the ability of the alkaline calcium carbonate itself to buffer and neutralize acid migration from within. These are familiar concepts; linen is sized with rabbitskin glue to isolate it from the acidic action of linseed oil, while museum board is “buffered” against atmospheric acids with calcium carbonate. While final judgment requires true lab testing, it is reassuring that the archival issues in simple hardboard are known issues which are similar or identical to those of a wood panel, something for which we have a lengthy empirical record.

Also under the subject of archival practice, we can observe that there is another good reason to avoid tempered boards. The simplest form of tempering, a surface treatment with tung or linseed oils, has been occasionally approved by technical writers for artist purposes. But hardboard is made of cellulosic fiber, just as is linen and cotton canvas or art papers made of cotton or alphacellulosic fiber. Artists learn early on that painting directly on paper or canvas with oil paint is bad practice due to the rapid disintegration observed from the acidic action of drying oils upon natural fiber. It is a simple logical step to assume the drying oils used in tempering hardboard will have the same embrittling effect over time upon the surface of the board, therefore presenting an archival concern.

Toxicity

By having avoided the boards which are formulated with phenol/formaldehydes and urea/formaldehydes, the very thorny problem of the effects of formaldehyde on health is sidestepped. The Web is full of public-health information on the subject. Here are just a few points. The low end of significant exposure to formaldehyde is difficult to fix; some people can be sensitive to as little as .02 ppm, even though ambient outside air averages can be .03 ppm [7]. Others won’t notice it at much higher levels, although there is a marked sensitizing effect from exposure which can trigger broad immune-system response. Today’s phenolic resins are very popular with the composite board industry because of their ability to cross-link throughout a mass of wood fiber and contribute both strength and water-resistance. They also out-gas much less formaldehyde than some of the most obnoxious products of the 1980’s, some of which used urea-formaldehyde glues. Still, a chemical-sensitive person can readily detect a phenolic-resin board and receive respiratory irritation and allergic effects. My judgment is that the gesso layer probably would not ‘seal’ the board from out-gassing formaldehyde. Therefore, since it's possible to, it may be best for most people to avoid the phenolic-resin-bound hardboards.

Mayer's Test

We may now apply the test Mayer recommends to the boards which have survived the more abstract levels of our analysis. Does gesso stick to them? The Duron and the LP boards behaved nearly identically. In both cases when a layer of gesso was pried up, it took with it a thick and continuous layer of fibers, leaving a shallow crater in the board surface. The mechanical bond was quite sufficient. Inexplicably, the Spanish board was very different. The gesso peeled off nearly clean, taking a mere hint of fiber with it and leaving behind a patch only slightly roughened. The mechanical bond appears much more superficial, even though so many objective factors seemed to align this board with the others. Internal-bond-strength is a measure of how well the fibers will resist separation, yet this board tests similarly to Duron, so the issue seems to be the surface itself. Given we know less about this board than the others it is difficult to speculate where the difference may lie, but one must conclude this board has failed an important test.

Conclusion

Two boards have survived our analysis:

1) Louisiana-Pacific's "Premium, Untempered Hardboard," which is the original Abitibi-Price product now made in the original plant by DPI.

2) Masonite International's untempered or "Regular Duron", made in Danville, Virginia, the original name but much-changed and refined over the years.

Quite probably there are more candidate boards out there than I have found in my search but this discussion has given us a 'method' for evaluating any new option. We have arrived at our choice by deciding whether we can know enough about a particular board, then selecting for a non-tempered S2S surface type, next ensuring that it is a board that tests well for durability and finally making a simple test of the surface's receptivity. For unrelated reasons, we found we did not have to reject a board solely for formaldehyde out-gassing, but we reviewed why we might.

It is interesting to note how different the boards are one from another, despite outward similarity. The standard for hardboard is quite general and can be satisfied many ways. This means that tomorrow someone might make a board with an approach quite different than the ones we've looked at. It also means that a familiar product might well change in some respect that is important for our purposes, and it might not be obvious. When the late-edition Handbook says "The adhesives used during the production of...all types of Masonite...contribute to this chemical reaction (of acidic off-gassing) [8]," it commits an error of generalization. When it says that all board uses a "sizing made of paraffin" it relates, at the least, old information. When it then concludes that hardboard is "impermanent" and to be "condemned by conservators," it may be right about some boards but is wrong in general, as pointed out by the Chief of Conservation at the National Gallery [9].

This serves to highlight the problems artists have in securing the 'right' board. There are only a few boards that are clearly superior, but the distribution realities mean that they may not be available locally. There are definitely some boards about which the Handbook's statements are correct and these are usually the cheaper and may be the more commonly stocked. Hardboard may be ordered from the factory in truckloads or rail-carloads, or from a regional distributor in 1500lb. palletized units. Getting just the right board by the sheet, though, can be tough. Lumberyards in larger cities which specialize in furniture-grade woods or cabinetmaker's supplies are a likely alternative to the more usual sources.

I shall be glad to answer for the reader as best I can any questions arising from this discussion. I can be reached through the email address for the website this article appears on, TrueGesso.com. True Gesso is carrying on the fabrication of true-gesso panels with the materials and methods for which this article was preparatory research.

References

[1] Richard Thomas Davis, 2001. Hardboard- Tempered or Untempered is Not the Only Question. 12th Edition Society Newsletter, Society of Tempera Painters.

[2] ANSI/AHA 1995. American National Standard; Basic Hardboard. http://www.pbmdf.com/Publications and select "Standards" and then select "ANSI- Basic Hardboard".

[3] Alexander Katlan, 1994. Short Communication Early Wood Fiber Panels: Masonite, Hardboard, and Lower-Density Boards. Journal of the American Institute for Conservation, vol. 33.

[4] Ralph Mayer. The Artist's Handbook. 1982 edition, pg. 253.

[5] R. M. Granum and O. B. Eustis. Hardboard (Masonite) What is it? www.panel.com/whatisit.pdf.

[6] www.hollandsw.com

[7] www.cpsc.gov/cpscpub/pubs/725.html

[8] Ralph Mayer, as revised by Steven Sheehan. The Artist's Handbook. 1991 edition, pg. 300.

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