Veneer Checking and Ridging

Over the years, I have read many excellent articles by many knowledgeable professionals in the wood business, which have attempted to explain the wood failure commonly known as veneer checking. For the benefit of those who are not familiar with this problem, veneer checks are cracks, which occur on the surface of veneer panels, veneered table tops, etc. Veneer ridges, which have a similar appearance, are sometimes also loosely referred to as veneer checks. Both veneer checking and veneer ridging will be examined in this article. When veneer checking or ridging occurs, the cracks in the veneer generally result in cracks in the coating on the veneer. Cracks that are the result of veneer checking or ridging typically run parallel to each other and to the grain of the wood. Cracks in a wood coating film that run across the grain or have a mud cracking or crazed type of appearance are the result of other problems, which I will address at a later date. The articles I have read over the years have accurately explained that the root cause of veneer checking and ridging is a substantial change in the moisture content of the veneer panel, which has caused movement of the veneer. Most articles, however, have stopped short of explaining the actual dynamics that are occurring in the veneer panel, that are causing the veneer to ridge or check. In this article, I will attempt to explain these dynamics in the simplest terms.

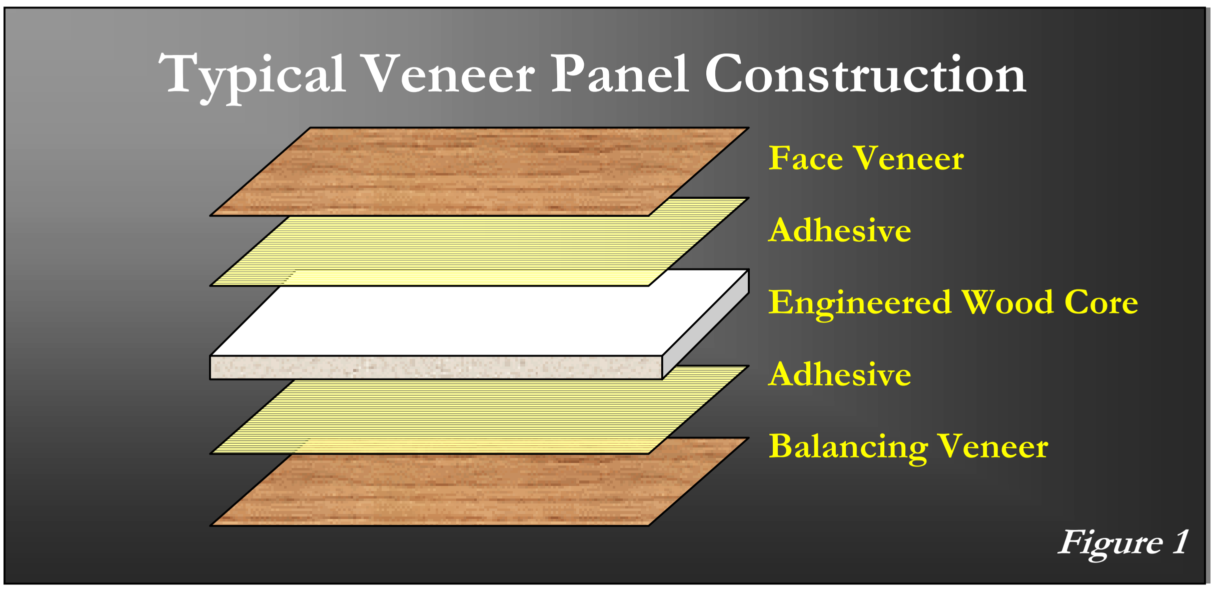
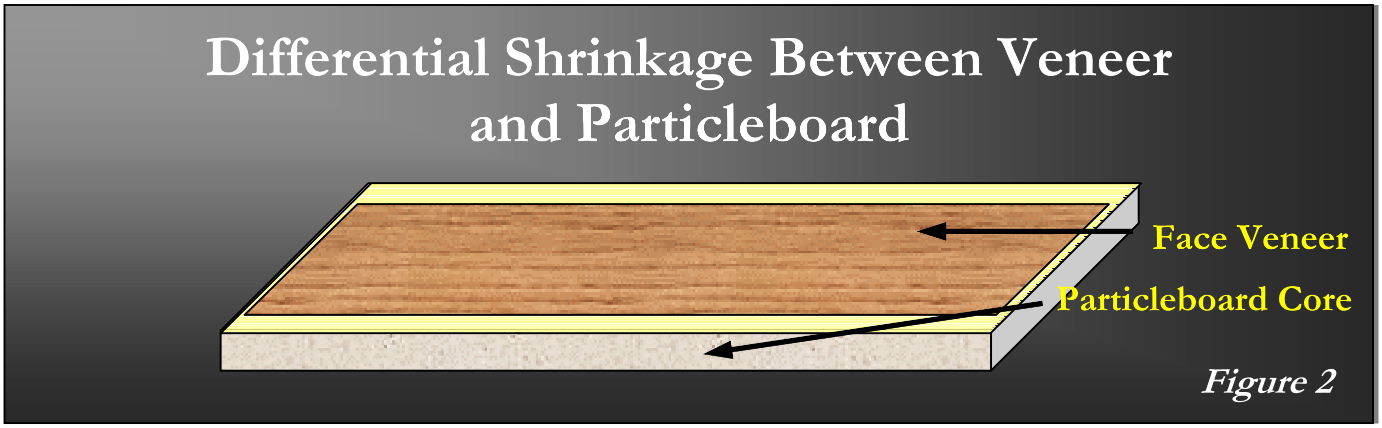


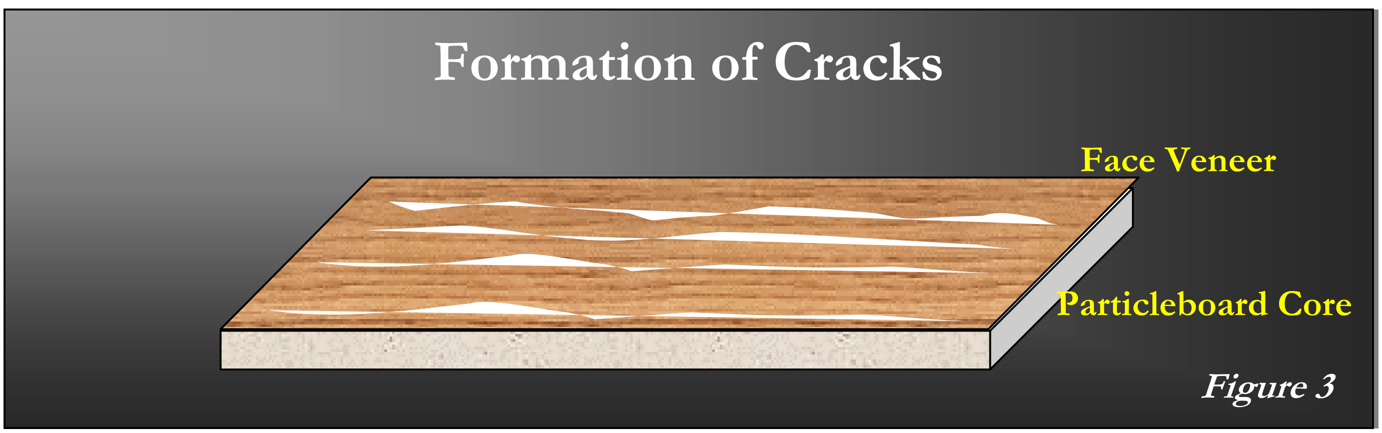
Figure 1

First of all, we should realize that cracks, whether in wood, coating films, rocks, ice, mud, glass, or even the crust of the earth itself, happen as a result of stress. That's the easy part. The more difficult part is determining the cause of the stress and how to prevent it from reaching the point where it causes problems. The type of stress that causes cracking can be the result of several things. For example, bonding two materials together that react differently to changes in temperature and/or moisture content. A second example could be one relatively thick material which, when exposed to a change in temperature and/or moisture content, reacts differently at the surface than at its core. Some materials undergo stress to the point of failure from sudden drastic changes in temperature. An example of this would be placing a hot drinking glass into cold water. In many cases, the glass will crack as a result of the stress created by this sudden change in temperature. Some materials may fail as a result of the stress created by impact, such as a rock being hurled at a plate glass window. The glass window may shatter if the stress created by the impact of the rock is greater than the strength and/or the flexibility of the glass. Cracking is generally about stress versus strength.

The stress, which causes veneer to check or ridge, is the result of bonding two materials together, which react differently to changes in moisture content. If you consider the nature of wood, checking and ridging in veneer panels makes perfect sense and is predictable. A veneer panel (Figure 1) is typically manufactured by gluing a thin slice of natural wood to some type of engineered wood product such as plywood, MDF or particleboard. The problem lies in the way, which the natural wood veneer and the engineered wood substrate react dimensionally to changes in moisture content. Wood, whether engineered or natural will exchange moisture with its environment until it reaches equilibrium with that environment. That is to say, if you place wet wood in a dry environment the wood will loose moisture until it is as dry as the environment it is in. It works the same if you place dry wood in a wet environment. This exchange of moisture is ongoing. Whenever there is a change in the moisture content of the environment, the wood will strive to reach equilibrium. So it is fair to say that wood is always in motion to some extent. It is also important to note that coatings do not completely stop this exchange of moisture, however good quality coatings can slow down this exchange dramatically, thereby minimizing the destructive effects of uncontrolled expansion and contraction due to changes in wood moisture content.



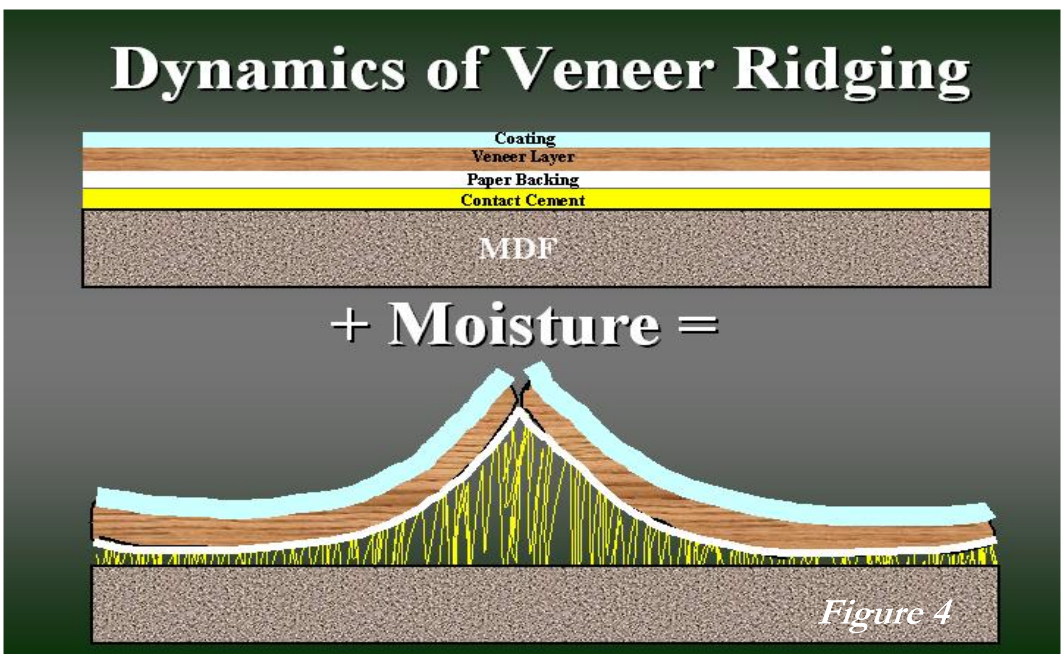
As a veneer panel loses moisture, the veneer shrinks at a greater rate than the engineered wood substrate. If the two were not bonded together, the veneer would become smaller than the substrate



Since the veneer cannot become smaller than the substrate, the stress caused by differential shrinkage is relieved in the form of cracks. As wood contracts the most across the grain, the orientation of the cracks is generally parallel to the grain. The cracks typically occur at weak points in the veneer such as open grain or lathe checks.

Natural wood veneer, having been cut from natural wood reacts the same to changes in moisture content as natural wood. When wood takes on moisture, it expands, primarily across the grain. There is little dimensional change along the length the grain. When wood looses moisture, it contracts in the same manner, across the grain. Engineered wood products such as particleboard and MDF also expand when moisture content increases. However they do so in a different way and at a different rate. Because particleboard and MDF have no specific grain orientation, they expand approximately equally in all directions, and at a lesser rate than natural wood. When moisture content decreases, they contract approximately equally in all directions and at a lesser rate than natural wood. So when a veneer panel is manufactured, as long as the veneer and the engineered wood substrate are seasoned to the same environment, and excessive moisture or drying are not introduced during the manufacturing process, the two bonded components can exist together with little or no interfacial stress, in that particular environment. But what happens when this panel is installed in an environment with excessively low relative humidity due to, perhaps, the use of a gas fired heating system. Upon installation, the veneer and the engineered wood substrate attempt to reach moisture equilibrium with their new environment. Both begin to lose moisture and shrink. The engineered wood substrate shrinks a small amount, approximately equally in all directions. The veneer, however, shrinks at a greater rate, and mostly across the grain. This differential shrinkage between the two bonded components creates stress. If the veneer could, it would actually become physically smaller than the engineered wood substrate (Figure 2), however, since the two are bonded together across the entire surface that is not possible. Instead, the stress of this differential shrinkage is relieved in the form of cracks, which occur in weak spots in the veneer, such as areas of open grain or lathe checks (Figure 3). When the cracks open up in the veneer, the coating covering the veneer surface cracks as well. Because the veneer shrinks the most across the grain, the cracks in the veneer tend to run along the length of the grain. Parallel cracks running along the grain are the typical symptom of veneer checking.

In the case where the veneer panel is installed in an environment with excessively high humidity, upon installation the veneer and the engineered wood substrate again attempt to reach moisture equilibrium with their new environment. Both begin to take on moisture and expand. The engineered wood substrate expands a small amount, approximately equally in all directions. The veneer, however, expands at a greater rate, and mostly across the grain. If the veneer panel in question has been manufactured using a process where the veneer was pressed onto the substrate using a non-flexible glue such as PVA (white wood glue) or a more complex cross-linked or heat-activated glue, the glue line will generally be stronger than the stresses created by the differential expansion, and problems will not typically occur. If, however, a backed veneer, or two-ply veneer skin was applied to the engineered wood substrate using contact cement, exposure to a high humidity environment, or moisture in any form, can be devastating. In this case, we have three components of differing dimensional stability bonded together. We have the veneer, the veneer backing (commonly a paper impregnated with phenolic resin), and we have the engineered wood substrate. All of these components will react somewhat differently to rising moisture content.



The inherent flexibility of contact cement allows ridging of the two-ply veneer skin occur.

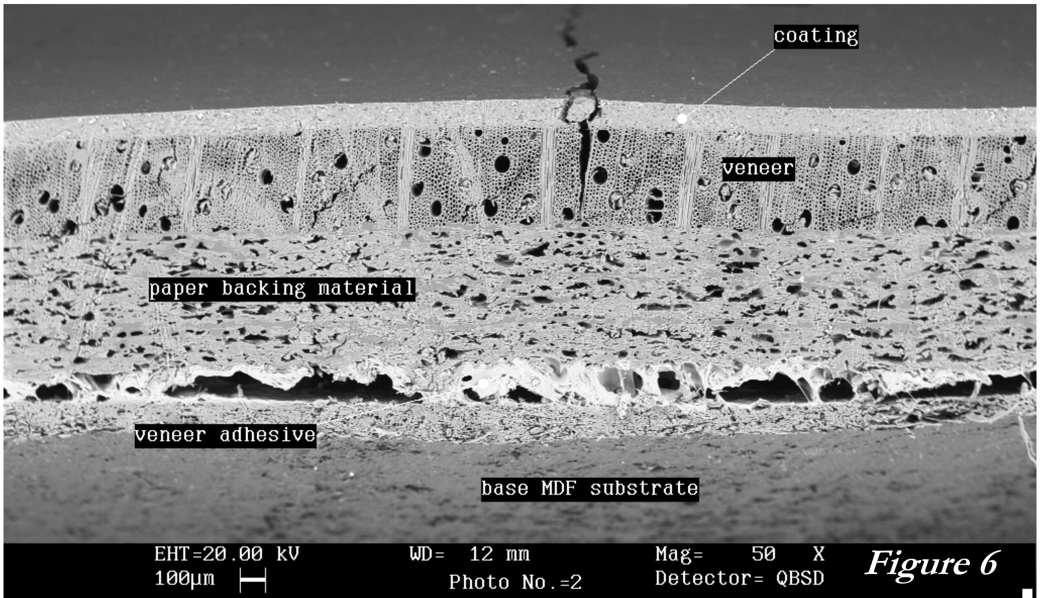
Of greater importance is the fact that the backed veneer, or two-ply veneer skin, is bonded to the engineered wood substrate with contact cement. Contact cement is a flexible adhesive often used to apply decorative laminate. Once dried, contact cement remains flexible throughout its service life. It is this inherent flexibility that can cause problems. When the two-ply veneer skin takes on moisture, the veneer, and to a lesser extent, the paper baking on the veneer, begin to expand. They do so at a greater rate than the engineered wood substrate. When the stress caused by this differential expansion reaches a critical point, the veneer and it backing heave upward into a ridge to relieve the stress of the expansion (figure 4). Again the ridge forms parallel to the grain of the wood because the greatest amount of expansion is across the grain of the wood. As the veneer heaves upward, the pinnacle of the heave splits, and so does the coating covering the veneer. The ridge may recede or shrink back as the moisture content of the panel drops, however, the crack in the coating remains.

It is a common practice for a woodworker to create veneer panels with solid wood edges for a variety of purposes such as large tabletops (figure 5). In cases where the coating on such a panel has cracked as a result of veneer checking or ridging, you will generally observe cracks running parallel to the grain on the veneer portion of the panel, but not extending on to the solid wood portion of the panel. This is further testament that the cracks in the coating are the result of stress cracks in the veneer. The solid wood portion of the panel has been exposed to the same variations in moisture content as the veneer portion, however, instead of cracking, the solid wood has simply expanded and contracted with the changing moisture content, and the coating has expanded and contracted with the wood, without cracking or failure. Coating manufacturers are aware that wood will expand and contract with changes in moisture content, and coatings are formulated to tolerate this dimensional change. Coating are not, however, formulated to bridge open cracks and gaps which occur on the wood once in service. A coating with such elasticity would lack the hardness to be of much value as a protective wood coating

Figure 5

It should be noted that the expansion and contraction of wood is ongoing. This can lead to confusion when a contractor strips the coating off of a panel that has cracked as a result of veneer checking or ridging, and sees no visible signs of checking or ridging on the stripped veneer. In many cases, veneer checking or ridging is the result of a relatively short exposure to an environment of extremely high or low relative humidity. In the case of veneer checking, an example might be a cold spell in the dead of winter. Gas fired heating and cold dry outdoor air result in extremely low indoor relative humidity levels. These dry conditions cause the moisture content of veneered panels to drop, and cracks or veneer checks, as described above, begin to form. As the veneer cracks and checks, so does the coating on top. When the cold spell is over and spring is in the air, indoor relative humidity goes up and so does the moisture content of the veneered panel. As moisture content increases, the cracks and checks in the veneer begin to close up to the point where they are not visible to the naked eye. The cracks in the coating however, remain visible, and, hence the confusion. The same logic applies to veneer ridging. When moisture content drops, the ridges recede, or shrink back, but the cracks in the coating remain.

Although the cracks in the veneer panel are no longer visible to the naked eye, they are clearly seen under the microscope (figure 6). Figure 6 is a cross section of a coated, paper-backed veneer, bonded with contact cement to an MDF substrate. At 50x magnification, you can clearly see the crack in the veneer beneath the crack in the topcoat. Also visible in the veneer are stress cracks, which have not yet resulted in veneer checks. It is interesting to note that the main visible crack in the veneer extends only to the paper backing and not all the way through to the MDF substrate. This is a case of Veneer Checking as opposed to Veneer Ridging. The veneer has suffered a reduction in moisture content, and has shrunk at a greater rate than its own paper backing. This differential shrinkage has resulted in the formation of cracks in the veneer. In this case, the fact that the veneer is glued down with contact cement is incidental, and not related to the failure.



Paper backed veneer glued with contact cement to MDF. Surface crack extends through the coating and veneer to the interface of the veneer and the paper backing. Note the stress cracks in the veneer, which have not yet resulted in surface checks.

It is important to reinforce the difference between **Veneer Checking** and **Veneer Ridging**.

Veneer Checking it the result of a reduction in moisture content of the veneer panel, and subsequent differential shrinkage between the veneer layer and its substrate. This differential shrinkage results in the formation of open cracks in the veneer layer. Veneer Checking can happen on veneer that has been applied with contact cement, or veneer that has been applied using an inflexible glue line and a press.

Veneer Ridging is the result of an increase in moisture content of the veneer panel. As the veneer expands at a greater rate than it's backing and the substrate to which it is applied, the veneer heaves upward. This type of failure is typically only seen on two-ply veneer skins that have been applied using flexible contact cement. The inflexible glue line formed by PVA, cross-linked or heat activated glue is generally strong enough to resist the heaving of the veneer.

There is a school of thought in the wood working community that contact cement, because of its inherent elasticity, is not a great adhesive choice for laying up veneer. Clearly, PVA, cross-linked or heat activated glues, which form hard non-elastic glue lines, are a better choice, but, of course, these types of adhesives require some type of press or clamping system. If applied and dried according to veneer and glue manufacturers instructions, contact cement is a reasonable choice for applying backed veneer products. We just have to be aware that a two-ply veneer skin applied with contact cement is going to be somewhat more susceptible to Veneer Ridging than a similar skin applied with an inflexible glue. Please note that it is never acceptable to apply single ply leaf veneer with contact cement. This type of adhesive can only be used on veneer skins that have some sort of solvent barrier built into the product to prevent dissolution of the glue by the solvent-based coating system.

There are quite a few different types of backed veneers or veneer skins in the market, and naturally, some are better than others at resisting checking and ridging.

Paper-Backed Veneers are generally the most unstable and problematic.

Phenolic-Backed Veneers perform more like a laminate. They have good resistance to ridging however they may still check if the moisture content drops. You can also generally see the phenolic backer when you look at the edge of the veneer.

Wood-Backed Veneers improve dimensional stability by using the principle of opposing grain orientation found in plywood. The face veneer is bonded to a backer veneer with the grain running perpendicular to the face veneer. This type of veneer skin is more dimensionally stable than paper-backed veneer, but not as rigid as phenolic-backed veneer. As such, it may still check and ridge under severe conditions, however, unlike phenolic-backed veneer, you do not see the backer when you look at the edge.

At the end of the day, veneer checking is all about stress vs. strength. If the strength of the adhesive and the strength of the veneer is greater than the stress resulting from changing moisture content, than checking will not occur. In many cases, however, if moisture content reaches extreme highs or lows, the stress will overcome the strength and failure will occur. Gluing wood veneer to an engineered wood substrate is really not much different than laying a hardwood plank floor on a plywood sub floor. When installing a hardwood floor, a contractor will generally deliverer the hardwood planks to the installation site one week or more before he intends to install the floor. The planks will be removed from their packaging and stacked in such a way as to allow air to circulate around them. This process allows the hardwood planks to reach moisture equilibrium with their new environment before being attached to the sub floor. If this process of acclimatization is not carried out before installation, two possible scenarios could occur. The installed hardwood planks could have a higher moisture content than their new environment and they may lose moisture and shrink across the grain, causing cracks to open up between the planks. The second possible scenario is that the installed hardwood planks could have a lower moisture content than their new environment and they may take on moisture and swell causing the planks to buckle or heave upward. Even if the planks are acclimatized to their new environment before being attached to the plywood sub floor, seasonal extremes of indoor relative humidity in the building can cause the planks to expand or contract at a greater rate than the more dimensionally stable plywood sub floor and result in gaps or heaving. The forces that cause hardwood floors to gap and heave are the same forces that cause veneer panels to check and ridge; differential expansion or contraction between two different materials, which are bonded together.

The moral of this story is that wood is a natural raw material with certain properties that are beyond our control. To avoid problems of wood cracking, checking and heaving, it is necessary for the wood worker, the finisher, the warehouser, the shipper, the installer, the homeowner or building manager and anybody else who has care and custody of fine woodwork, to understand these properties and to play by the cardinal rule:

Before constructing a project using natural and/or engineered wood components, all components should be seasoned together, to a moisture content, which closely reflects what the moisture content of the components will be in their end use environment. Once the project is constructed using components, which are at a suitable moisture content, this moisture content must be maintained within a reasonable range, for the life of the constructed piece. That means during construction, finishing, warehousing, shipping, installation and daily use, exposure of the constructed piece to wide variations in relative humidity levels must be avoided. Following these simple steps will help avoid veneer checking and problems:

1. Determine the Average Moisture Content Range for interior wood in your climate. Wood, which will be used in coastal climates where relative humidity is generally high, will have a higher Average Moisture Content than wood to be used in dry arid climates. (the Architectural Woodwork Institute Quality Standards Manual is an excellent source for such information – www.awinet.org)

2. Season all wood and engineered wood components as described above

3. Follow veneer manufacturers instructions for application of veneer to substrate.

4. Maintain a climate in the shop and warehouse similar to that of a properly climate controlled home or office

5. Be careful not to soak or saturate veneers with stains or finishing materials. Initial applications should be conservative until veneer is sealed

6. When shipping is required, attempt to minimize the time wood projects spend in non-climate controlled trucks and vans.

7. Do not install wood projects in new or renovated homes or building where the climate control system is not yet operational.

8. In the end use environment, compensate for seasonal changes in relative humidity by employing humidification and de-humidification equipment.

Clearly, many of these steps would be difficult to follow in the real world, due to time and money constraints, especially for smaller shops. We need to remember, however, that wood cannot distinguish between large, well-equipped woodworking facilities, and smaller, not as well equipped custom shops. Wood is a natural material with certain properties over which we have no control. If we do not understand these properties, or if we choose to ignore these properties in favor of saving time and money, we will likely pay the price in terms of rework, repairs and lost business.

Editors Note – Darrel Young is a Technologist For The ML Campbell Company. With over tens year experience in the coatings industry, Darrel investigates and reports on wood and film failures and is the Developer and Instructor for the ML Campbell Distributor Training Program (a.k.a. Campy University)