Chemical Resistance in Resinous Flooring

What factors are most responsible for the successful installation of a flooring system? The answer at the top of all lists is the *Contractor*. This is undeniably true ("moisture" is the number two answer). The Contractor is responsible for all aspects of the floor installation from preparation, moisture compliance and initial aesthetics. Now let us assume the flooring has been installed properly, once that is done, what happens next? Normal wear and exposure to chemicals are the inevitable fate of the new flooring system and the Contractor can not affect the outcome.

Resin quality is the factor most responsible for long term non-mechanical properties of the flooring system. Many end use applications require sustained cleaning and disinfecting protocols to meet GMP and GLP requirements. Chemical resistance is the feature of resin quality that will govern performance in these potentially abusive environments.

The chemical resistance of flooring resins is very specific. Flooring resins are composed of two primary components, base resin and a hardener. The chemical resistance properties of a particular flooring system are the result of the hardener properties. Formulators do not generate their own hardener product. They simply modify the chemistry of the hardener and corresponding resin component to allow for the proper balance in reactive sites required for proper cross-linking to form the final product. Since the final cross-linking is a product of the hardener, and since formulators use different hardener systems available from hardener manufacturers, the effects of chemicals are not predictable between like named resins from different formulators. Simply put, not all chemical resistant products perform alike. The flooring industry as a rule however, publishes chemical resistance charts with broad implications i.e. "Chemical Resistance Epoxy Resins" tested for a long list of "reagents" including lipstick and beer. The industry uses these charts to report the resistance of a very generic class of resinous coatings i.e. chemical resistant epoxies to a broad range of test chemicals. We too report chemical resistance in this manner however, we caution that you consider it useful only as a general guide. Chemical resistance is very specific to each resin product and should not be judged in broad sweeping generic terms.

Our testing supports this position. For example, there is a remarkable difference between the reaction of a specific resin to reagent grade chemicals as compared to its reaction to commercial cleaners containing the same chemical. This difference is present even when the two are tested under the same conditions and at comparable concentrations of chemical in question. There is also a difference in the level of aggression between commercial cleaners containing comparable concentrations of the same chemical. In such instances, the difference in reactivity to flooring resin is attributed less to the chemical than to the surfactants and other additives incorporated in the commercial cleaners. These ancillary chemicals are designed to enhance the effectiveness of the active reagent by increasing surface wetting among other things.

These ancillary chemicals are obviously absent when testing reagent grade chemicals but are present when using commercial formulations in your facility. When an end user has questions about the performance of a flooring material to phosphoric acid for example, they generally consult a Formulator's chemical resistance chart. Although the chart indicates resistance, field application of the commercial compound may be quite different.

Consequently, we feel it is important to not use chemical resistance charts listing neat compounds for the test reagent as gospel for your specific application. Because of this we test our flooring products against commercial formulations that are part of the end users protocol. By doing so we can more accurately predict the long-term performance of the flooring system.

Designing chemical resistance into a flooring system is always a challenge. Resin formulation is a precarious balance between aesthetic qualities, physical properties and performance characteristics. As one trait is altered, the remaining ones are generally affected. Managing this delicate performance balance in equilibrium while at the same time achieving the desired effects of change is only part of the challenge.

It is difficult to work in the world of quality especially when most people do not. It has been said that doing things right is easier because there is less competition. That is only true if people understand the difference. Epoxies are too often thought of as a commodity item. The commodity mind-set assumes there is little or no difference between two products and that if any difference does exist, it is inconsequential. In some industrial flooring applications, such as warehousing and process manufacturing, the theory of inconsequential differences may be true. The warehouse mentality however does not perform well in Biomedical, Pharmaceutical or other more critical applications.

The challenge is to determine what an end user or an industry really needs from a flooring system.

1. Do we design a floor for today or for tomorrow?
2. If we design for tomorrow, how do we determine what tomorrow looks like?
3. How do we keep end users aware of the potential impact future procedural changes may have on their existing flooring system.
4. How do we include the end user in the ownership of the flooring system?

Our approach has been to become proactive in identifying the chemicals used in an industry, to understand their application and handling, test the commercial formulations on all new and existing resins in our line and to do the testing for meaningful intervals of time. In this manner we can customize a flooring system using specific resins that will withstand the intended abuse with predictable performance results.

Concentration Tested: We test all commercial chemicals in both concentrated form and at recommended use rate dilutions. The rationale for use rate dilutions is obvious, as it is the expected long-term exposure. We include concentrate testing because we understand that in the imperfect world, spills and leaks occur where the chemicals are stored and dispensed.

Test Procedure: Resinous materials are applied at the final film thickness recommended for actual field application. Resins are allowed to cure for 7 days to reach full chemical resistant cure. Test chemicals are applied using soaked cotton balls, which are placed on the surface of the cured resin. The cotton balls are kept wet for the duration of the test period. The cotton balls are removed and the wetted surface is wiped clean for observation at 24, 48, 72 hours and at 7 days. While making each observation, the cotton ball is individually removed, the spot observed and observations recorded, and the cotton re-soaked and immediately replaced. Each exposed area is therefore without test material for a minimum time period.

Observations:

Tests are conducted for the full 7 days unless we observe total film failure prior to that time. If total failure in a given spot is observed, that spot test is stopped. Observations are made on the following categories and recorded for comparison purposes.

1. Staining
2. Pigment Leaching
3. Discoloration
4. Film Swelling
5. Film Softening
6. Loss of Gloss
7. Surface Etching
8. Film Destroyed
9. Other Surface Effects

Some observed results follow.

Figure 1 shows a typical test panel at the beginning of the test and *Figure 2* shows the same panel at the end of the test period.

Figure 1
Chemical Resistant Test Panel

Figure 2
Post Test Panel

The differences are what we would call remarkable. The most obvious effect in *Figure 2* is what most people generically refer to as "staining". Staining occurs most frequently with no effect to the overall performance of the flooring system. It is a blemish that effects the aesthetic acceptability of a floor only. None the less it is an undesirable consequence. Most of what we see as staining is really discoloration, not staining.

True staining is really a discoloration imparted by a dye. The dye penetrates the flooring material and can not be removed by chemical intervention or by scrubbing. An example of staining is the purple stain noticed in *Figure 2*. Another condition commonly referred to as staining is the discoloration noticed in the pigmented (brownish) test resins at the bottom of the same picture. The discoloration noticed there is really pigment leaching. In these cases the chemical attacks the pigment and changes the color; no dye is required. Often in such cased the performance properties of the flooring are not effected, only the aesthetics are effected. A third condition of discoloration is the effect shown by the yellow to brownish spots on the left margin of the test sample. This is a typical discoloration caused by nitric acid and is due to direct chemical attack on the resin. If prolonged exposure were to occur, the coating would deteriorate and completely fail.

Since aesthetics are important to end user satisfaction, we recommend eliminating as many sources of discoloration to the resin as possible. Therefore, we generally recommend using clear resins not pigmented resins so as to eliminate the effects of pigment leaching on aesthetics. True staining can not be completely eliminated although certain resins are more resistant to staining than others.

Figure 3
Stain Comparison - Clear Resin

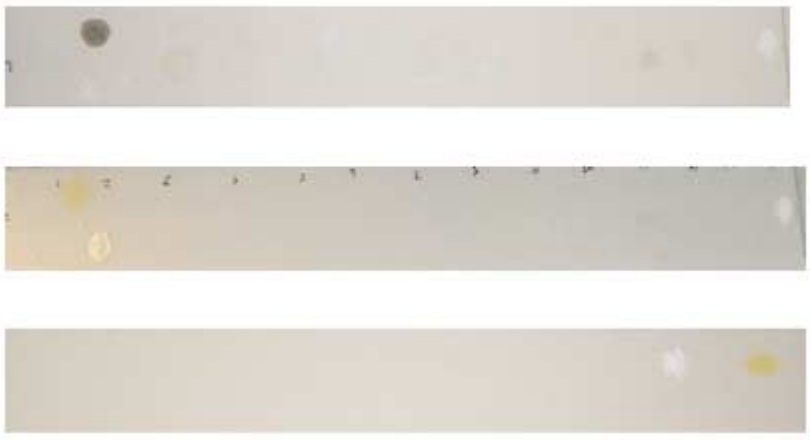


Figure 3 shows three clear resin products with decreasing effects of the purple stain from the top sample to the bottom sample. All test conditions and timing were identical for the three flooring materials. It is the differences in resin quality with respect to chemical resistance that is responsible for the variations in the performance shown.

Figure 4 shows differences between three pigmented resins from three different formulators. Although all three materials stain evenly with the purple dye, there is a difference in the degree of pigment leaching caused by the test chemicals. Since we were unable to obtain matching colors for the test resins, we can not make any conclusions about variations in individual resin quality, nor was that the intent of the test. The comparisons of the pigmented resins with the clear resins tested however do allow the conclusion that clear resins maintain aesthetic value better than pigmented resins.

Figure 4
Effects on Pigmented Resins

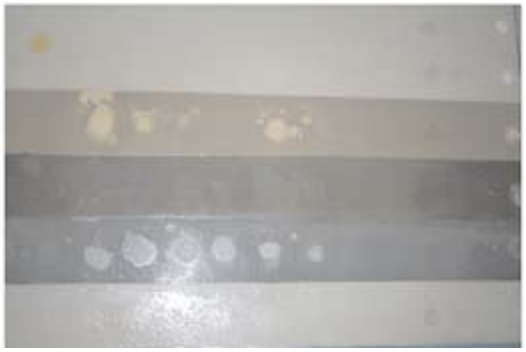


Figure 5 demonstrates film swelling. Film swelling occurs when the resin absorbs the chemical and actually gains volume. Eventually the flooring can have reduced performance properties and deteriorate to the point of failure. Most readings are not as dramatic as the one shown here but are none the less as potentially destructive.

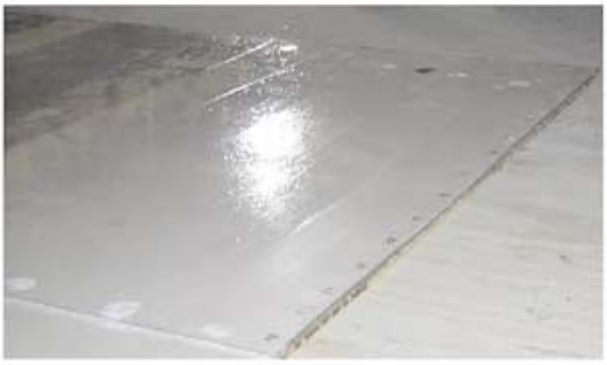
Figure 5
Film Swelling

Figure 6
Pigment Leaching

Film softening has an immediate effect on flooring performance. Softened floors will "cut" with heavy-wheeled traffic and quickly erode to the substrate. The softening can initially occur as a surface effect only or as a result of absorption from film swelling. Softening can be seen in *Figure 6* as evidenced by the scratches on the surface of the gray resin.

Loss of film gloss and surface etching are difficult to show in pictures. If you look closely at the clear resins in *Figure 7* you will notice spots that are dull. In some instances these areas simply have no gloss (minor etching) and have no apparent change in surface texture or smoothness. As this condition progresses, the surface texture is etched and therefore acquires a fine profile much like acid etched glass. The areas shown here fall into both categories. With time both can cause failure if the chemical is strong enough, but both conditions will cause cosmetic blemishes.

Figure 7
Chemical Etching



Total film destruction can be seen in *Figure 7* in the spots that appear white. The white appearance is a result of total erosion of the seal coat exposing the white quartz granules in the flooring sample. The two chemicals tested here that resulted in total failure were glacial acetic acid and methylene chloride, both reagent grade.

The end user is the party most affected by the floor procurement cycle, but who is often in the least influential position regarding the purchase. If resinous flooring were a commodity purchase it would make no difference, but I think we understand that it is not a commodity. It would seem a logical deduction therefore that ownership by the end user in the procurement process would eliminate a host of problems. The question has always been how to accomplish end user involvement and still have a competitive bid process.

We suggest using a comprehensive quality control program and specification development procedure as part of the selection process for new flooring. The program should also be incorporated into the flooring installation protocol in the specifications. The following program has been used successfully on both new construction and renovation projects with remarkable success.

The essence of the protocol is as follows:

1. Competing contractors submit two 4’ x 8’ finish floor samples on plywood backer.
2. The floor systems submitted are those recommended by the Formulator and installing Contractor for the proposed installation.
3. The finish floor samples shall be accompanied by material information including lot numbers of the materials used for the sample (the same as those proposed for the project).
4. End user observes panels for finish characteristics such as gloss, finish texture and general appearance. The panels or portions thereof, can serve as a standard for the final installation.
5. End user performs chemical resistance tests on one panel and tests the second for wear properties using floor buffers, cart or other traffic and/or normal cleaning protocol.
6. The selected system is then installed using the lot numbers initially indicated on the test panel submission.
7. Areas too large for material volumes produced in a single lot number would require testing of each manufactured lot prior to that lot being used on the project.
8. Final approval should be with the **using party.**

Although the protocol is time consuming it accomplishes several critical objectives essential for a successful floor installation. The end user is involved in the final selection. The final flooring selection is based on quality issues and measurable differences not subjective comments. The end user’s personnel test the end use application under near field conditions. There are no surprises later for any party involved. The installing contractor and resin supplier both assume ownership in the project and can not claim ignorance later.

What does this mean to the end user or design professional? Check the specific flooring system you propose to use against the specific chemicals in your facility. Do not rely on charts. Charts can be used to lead you to a resin family that may suit your needs only. Require the flooring professional to provide samples in the quantities required for adequate chemical testing in your facility. This will protect both of you from problems down stream. Do this <u>in advance</u> of awarding any contracts. Once contracts are awarded, subsequent change may be costly.