The dictionary definition of compatibility in its broadest sense is the capability of living together harmoniously or getting along well together. When the coating components (including thinner) don’t live together well in the can, with each other, or with the surface, then a failure usually occurs. One thing is certain. The applicator will be one of the first persons blamed for the failure.

This ATB will examine different types of coatings compatibility issues. It will discuss materials compatibility, coatings compatibility, and substrate compatibility. Areas where painting contractors do bear responsibility will be pointed out.

Materials Compatibility

Materials compatibility begins with the formulation of the paint. The formulator must select resins, pigments, solvents, and other constituents that are compatible with each other to manufacture the paint. The coating material should be of uniform consistency when it is mixed. If the coating has liquefied, gelled, or curdled, there most likely is an incompatibility in the paint due to manufacture or age. The paint was either not made properly, was made with out-of-specification constituents, or has exceeded its shelf life. If the paint separates quickly after mixing, the mixed paint is also suspect. Remember, zinc-rich coatings, especially inorganic zincs, will separate on standing because the zinc dust is much denser than the resins, solvents, and other pigments in the paint. So separation is normal and expected. They do require constant agitation during application. Do not use any material that is liquefied, gelled, or curdled, or material that separates after mixing. Contact the coatings manufacturer and have the paint replaced with good material.

Solvents are an important part of the paint formulation. Using the wrong solvent as a thinner for paint can cause the material to separate or congeal. Use only thinners that are recommended by the coatings manufacturer. This is also true for solvents used to clean equipment. Having the paint harden in the spray guns or lines is a big concern if the wrong clean-up solvent is used.

Coatings Compatibility for New Coatings

Coatings compatibility refers to the ability of one coat of paint to stick to another (Fig. 1). Coatings cure by one of four mechanisms: air oxidation, solvent evaporation, multi-component chemical reaction, and hydrolysis (reaction with water). As a generalisation, coatings that cure by the same basic mechanism are usually compatible with each other but not compatible with coatings that cure by a different mechanism. There are exceptions, of course.

Coatings that cure by air oxidation use oxygen in the air combined with drying oils in the paint resin to convert the paint into a solid film. The coating types in this group are oil-based paints, alkyds, silicone alkyds, epoxy esters, and oleoresinous phenolics. The drying oil portion of the paint continues to oxidise (react with oxygen) even after it has cured. This can make the paint film become harder and more brittle as it ages. When it has reached the point where cracking or checking (small cracks that do not penetrate to the coating layer below) occur, it cannot be overcoated—even with itself.

In a normal paint operation where one coat of paint is applied to another in a relatively short period of time, air-oxidising paints are fully compatible. But certain fast-drying primers can quickly reach a point where they will not accept another coat of paint. The use of a fast-drying primer in fabrication shops, followed by application of the field coats weeks or months later, has resulted in many failures due to peeling.

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For about the first six months after they are applied, air-oxidising systems are not compatible (cannot be recoated) with coatings that cure by solvent evaporation or chemical reaction. The strong solvents in these paints will attack the air-oxidising layer, causing it to partially dissolve. Wrinkling, bubbling, and lifting can result. After about six months, they are much more compatible.

Coatings that cure by solvent evaporation do not undergo a chemical reaction in progressing from a liquid to a solid. They are, in essence, a solution of solid resins. Vinyls, acrylics, chlorinated rubbers, asphaltics, coal tars, and bituminous coatings are in this group. Coatings that cure by solvent evaporation remain solvent-sensitive for their entire life. This sensitivity makes them easily recoatable with themselves. However, if these coatings are applied on a hot, humid day, the fast-evaporating solvents may cool the surface sufficiently to cause moisture condensation. A blush will then form on the surface that will interfere with adhesion. The blush must be removed by sanding. Coatings that cure by solvent evaporation should not be recoated with coating types that cure by chemical reaction. The strong solvents will dissolve the coatings, and the curing stresses that occur in chemical-reactive coatings will either pull the coatings apart or pull them off the surface.

Latex coatings can be classified as a special category of coatings that cure by solvent evaporation. A latex is an emulsion of resinous material in water. After application, the water evaporates, and the microscopic emulsion particles come together and coalesce (fuse) rather than react. Common latex coatings are based

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on acrylic and vinyl (polyvinyl acetate) emulsions. Latex coatings do contain a small amount of organic solvents, but not enough to wet surfaces as well as other coating types. They are usually incompatible with recoating by coatings that cure through chemical reaction or solvent evaporation.

Coatings that cure by two-component chemical reaction are normally manufactured as two or more components that are mixed together prior to application. They are converted by a chemical reaction to a hard, smooth film. This chemical reaction is irreversible. The cured film eventually will lose solubility in common paint solvents. Epoxies, coal tar epoxies, and urethanes are the most common coatings in this class.

Coatings formed by chemical reactions can become so hard and smooth that they cannot be softened by solvents in the next coat. These coatings will have both a minimum recoat time and a maximum recoat time. So, although they are compatible when first applied, there is a limited time in which the next coating layer can be applied. Recoat times can be as short as a few hours to as long as a year or more, depending on the coating type and specific formulation.

In addition, certain epoxy hardeners are quite reactive with water. Therefore, applying the coating on a cold, humid day can cause what is called an amine blush (Fig. 2). This is a yellow salt that forms on the surface. The blush will have to be removed for the next layer of coating to adhere. Since it is a salt, it is soluble in water and can be washed off.

The last coating curing mechanism is hydrolysis, or reaction with water. The source of the water is the humidity in the air. The two coating types in this class are inorganic zinc-rich primers and moisture-cure urethanes. The inorganic zinc-rich primers are the slower curing of the two. If another coating layer is put on an inorganic zinc before it has cured sufficiently, the coating may peel. In this case, the primer splits within itself, taking the topcoat with it. A thin layer of primer remains on the surface, with the remainder of the primer on the back surface of the peeling paint chip.

With zinc-rich primers, the surface that will be topcoated is largely zinc metal. Topcoating a zinc-rich primer is similar to painting galvanizing. Inorganic zinc-rich coatings and galvanizing are incompatible with coatings that contain drying oils, particularly the coatings that cure by air oxidation. The coating may stick when it is applied, but within six months to a year, as moisture migrates through the film,
a reaction occurs between the oil and the zinc. This reaction will cause the drying oil coating to peel cleanly from the zinc-rich primer.

Another rule of coating compatibility is that hard coatings should not be applied over soft coatings. Although they may stick together well, the hard coating is inflexible while the soft coating is not. Therefore, movement of the soft coating under stresses such as thermal expansion and contraction will cause the hard coating to crack. So placing an alkyd over an asphaltic coating, for example, can result in cracking of the alkyd under certain conditions (Fig. 3).

The above information mainly generalised coating compatibility. Because two coatings cure by the same mechanism does not assure that they are compatible. Even two coatings of the same generic type made by different manufacturers may not be compatible. It is always good practice when applying a coating system to use only products from one manufacturer and use products that they recommend. In many specifications it will be mandatory. Continued
Coating Materials—Existing Coatings

The general rules presented above hold true when a coating system has started to deteriorate and is going to be spot-cleaned and overcoated. One of the main concerns is that the exact coating materials, particularly the topcoat, may not be completely known. Also, the affects of ageing introduce another variable in achieving a successful coatings project. Perhaps only the generic classification of the topcoat may be known. If it is not known, a coatings laboratory can analyse a sample and identify the generic coating type. But even with this information, differences in manufacturers’ formulations and the current condition of the existing coating will affect compatibility.

It is always recommended, when considering overcoating, that a patch test be performed to assess compatibility (Fig. 4). ASTM D5064, Standard Practice for Conducting a Patch Test to Assess Coating Compatibility, describes how to perform this test (Figs. 5 and 6). You should select test locations that properly characterise the structure to be coated. Consider sheltered vs. unsheltered areas, sun side vs. shade side, and horizontal vs. vertical surfaces, etc.

At least three test patch areas are recommended. Each test patch should be as large as possible. The minimum recommended size is 1 sq m (10 sq ft). Clean the surface with the method that will be used when the structure will be repainted. Then, apply the test coating at the recommended thick-
ness. The preferred application method for the coating should be the same application method planned for when the work is performed. Sometimes this is not practical, such as when spray application will be used but spray equipment is not readily available when the test patch is applied. In this case, it may be necessary to use brush or roller application, although this may cause some error. Inspect the test patch for proper thickness, runs, sags, skips, and holidays, and correct them. Apply a new test patch if defects cannot be corrected.

The test patches should then be allowed to cure. Either a short-term or long-term evaluation should be performed. A long-term evaluation is more reliable. In the short-term evaluation, the coating is allowed to cure for a minimum of 7 days at 32 C (90 F), 10 days at 21 C (70 F) or 14 days at 10 C (50 F). Be on the conservative side in determining the amount of time, i.e., use night-time temperatures because they do not vary as much as temperatures during the day. Examine the entire surface of the test patch for wrinkling, blistering, mudcracking, checking, cracking, peeling, lifting, or disbondment. Then, perform a tape or knife adhesion test. (See the January 2001 ATB.)

A short-term evaluation will only indicate if there is gross incompatibility between the existing coating and the overcoat system. In the long-term evaluation, the test patch is allowed to remain in place as long as possible, spanning seasonal weather changes. The test should span the worst weather season, i.e., winter in cooler climates and summer in warmer climates (Fig. 7). The evaluation technique for the long-term test patches is similar to that used for the short-term patch test.
The advantages of the long-term evaluation are that the overcoating material will develop its full curing stresses, and the most aggressive thermal cycling that the coating will be exposed to in service will also be part of the evaluation. Six months is the preferred time for long-term evaluations. If time does not permit six months, expose the test patch for as long as possible. For example, in northern, cool climates, expose the test patches through the winter. Apply them in the late fall and evaluate them in early spring. Most people might be thinking about finishing work in the fall before winter shutdown, but it also is a good time to plan the work for the next painting season.

**Substrate Compatibility**

Coatings, especially the primer, must be compatible with the substrate to which they are applied. Here are some points about compatibility with the substrate.

Most structural steel is manufactured by the hot rolling process. Hot rolling produces an oxide layer known as mill scale on the surface. Mill scale is smooth and brittle. Most high-performance coatings are incompatible with mill scale (Fig. 8). Abrasive blasting is used to remove the mill scale and roughen the surface to promote adhesion.

Cold-rolled steel is used in the manufacture of such items as appliances, automobile bodies, and office furniture. Cold rolling produces a very dense, smooth surface without any mill scale. Cold-rolled steel can be blast cleaned. Then, its surface is much the same as hot-rolled steel. But a smooth appearance is very important with consumer items, and relatively thin coating layers are applied. Therefore, the normal procedure is to treat the surface with zinc phosphate. A coating of zinc-iron phosphate is formed that has a roughness of about 1 to 10 micrometres (0.04 to 0.5 mils). Then just about any type of coating can be used similar to those used on hot-rolled steel.

Different forms of zinc coatings are used for the corrosion protection of steel. These include galvanizing, metalising and zinc-rich primers. (See the April 2001 ATB for painting of galvanizing.) As discussed earlier, coatings such as oils and alkyds that cure by air oxidation are not...
compatible with zinc. Coatings that cure by chemical reaction or solvent evaporation are the preferred materials to use.

Aluminium is a lightweight structural material that is commonly used because of the corrosion resistance of many of its alloys. The surface of aluminium is smooth and relatively soft. A very active metal, aluminium quickly forms a thin oxide layer that may inhibit coating adhesion. Lightly blasting with a soft abrasive (January 2002 ATB) will remove the oxide layer, slightly roughen the surface, and promote adhesion. Another method used to promote compatibility between aluminium and coatings is the use of phosphate treatments. The treatment forms a crystalline surface that promotes adhesion.

Concrete is an alkaline material. The binder in oil-based coatings, i.e., those that cure by air oxidation, will break down in alkaline environments and should not be used on this substrate. In addition, coatings not compatible with a concrete hardener will peel unless the hardener is removed before coating application (Fig. 9).

Applicators do not design or select coating systems for different substrates. An applicator’s function is to apply the materials in accordance with the specification and the manufacturer’s Product Data Sheet. Make sure that the manufacturer’s Product Data Sheet states that the coating is acceptable for that particular substrate. If the substrate is not covered in the Product Data Sheet, call the technical service department.

Conclusion
Coating compatibility can mean many things. It can relate to the compatibility of the constituents in the formulation, compatibility with other coating layers, compatibility with an existing coating, or compatibility with the substrate. The best way to assure compatibility is to follow the coatings manufacturer’s instructions. Use only the thinners and clean-up solvents that the manufacturer recommends. Do not mix coating layers from different manufacturers. And make sure the substrate being painted is covered in the Product Data Sheet. Patch tests are recommended when overcoating an existing paint system.

A table titled the “Compatibility and Adhesion Properties of Coatings and Paints” can be found in the NACE International publication T-6H-194, Combatting Adhesion Problems When Applying New Onto Existing Finish Coats of Paint (NACE International, Houston, TX) and is also reprinted in Corrosion Prevention by Protective Coatings by Charles G. Munger.