I have published “Coatings Clinic” articles on water sensitivity (February 2007) and permeability (March 2011) of coatings and decided to revisit the area of water–coatings interactions. Exterior coatings and those in bathrooms, kitchens, and many industrial environments see water in the form of liquid water or water vapor. With the big push for energy conservation, new buildings and remodeled older ones are likely to be sealed, which leads to holding in of moisture. Even an older, not very well sealed building (like my house) that runs forced hot air and a humidifier in the winter can suffer from condensation on cooler surfaces.

Depending on the chemistry of the resins and pigments, presence or lack of retained solvent, and the degree of cure of a coating, water may be repelled by the surface of the coating, interact with the surface, enter the bulk, and/or go right through to the substrate. The effects on the coating can take many forms, including softening, wrinkling, spotting, blistering, blushing, haze, leaching or exudation of surfactants and other additives, staining, loss of adhesion (for wet adhesion, see CoatingsTech, March 2015), and poor weather resistance in general.

Softening occurs due to plasticization of the coating by absorbed water. With air-dry coatings, water-soluble solvents that are retained due to low volatility can cause absorption of moisture when the humidity is high. In such a situation, a panel placed on a balance actually will increase in weight with time as it picks up moisture. Severe softening and swelling, particularly of the surface layer, may lead to wrinkling. Water spotting is a defect that usually is due to contaminants in rain or other water that falls on a coating, but spotting is worse and is more likely to be permanent if the coating is softened by water. Blisters occur when there is water-soluble material in or under the coating. If water permeates the coating and dissolves the water-soluble species, it is likely that an osmotic cell will be created that will pull in more water, resulting in a liquid-filled blister. Blushing is a defect in which the surface of a coating becomes white or a lighter color due to absorption of moisture and formation of microvoids. Although haze can be any dulling of a coating surface, in some cases, it may be a form of blushing. Moisture may cause only a thin layer of microvoids at or near the surface of a coating. The resulting appearance will not be white, but the gloss will be low. Haze or whitening also may be due to water-soluble or dispersible materials such as dispersants, rheology modifiers, and surfactants that come to the surface. Some coatings that adhere very well in the dry state have poor wet adhesion due to water that passes through the film and displaces the coating from the layer below. On drying, the coating often regains its adhesion.

Coatings that show unusual sensitivity to water may not be cured properly or may retain amine or a hydrophilic solvent. Other possible causes include off-spec pigment containing a water-soluble salt and components that are water-soluble or swellable. If incomplete cure is the problem, then the bake temperature or bake time may need to be increased or a catalyst may have to be added to achieve sufficient cure. Polar materials such as amines and hydrophilic solvents may be removed by higher or longer bakes, but the coating may need to be reformulated to remove or reduce water-sensitive materials or to replace them with components that are not affected by water. Water-soluble/dispersible dispersants, rheology modifiers, and surfactants are a particular problem because they are needed for properties such as wetting, film formation, color development, and resistance to sag and defects. Yet, unlike solvents, they will not volatilize.

Most moisture tests involve immersing a coated panel in water or placing it in a humidity cabinet. Cycle tests tend to be more severe than continuous wet-only tests, because wet-dry cycles tend to leach more water-soluble materials or promote worse corrosion. After liquid water or vapor contact, films may be tested for a variety of properties. Water pick-up can be measured by weighing the panel before and after exposure to water. Softening can be quantified by measuring the change in hardness that occurs. A thermal mechanical analyzer (TMA) or other indentometer is particularly useful for evaluating hardness before and after water contact. If there is difficulty in identifying the water-soluble materials causing problems, the water used in the tests can be analyzed to see what has been extracted from the coating.

It is a good idea to do both immersion and humidity testing, because some coatings resist liquid water much better than they do humidity, whereas others tend to respond more to immersion. Resistance to water soak may be due to rapid swelling at the surface that prevents further penetration by water. Humidity, even condensing humidity, often is more completely absorbed by the coating. Other tests can be useful. For example, water sensitivity of interior latex paints often is tested in terms of scrub resistance. Outdoor exposure also can point up water problems, although it is not always possible to separate water effects from other processes.