Addressing cissing, one type of dewetting, in the April 2015 issue of CoatingsTech made me realize that it had been a long time since I had discussed dewetting in general (not since the November-December 2004 issue). Therefore, I decided to revisit the subject.

Application methods for coatings usually are effective at force wetting of the surface of a substrate or undercoat and spreading a film across it. However, during or shortly after application, there may be a pulling back or retracting of the film. This behavior is called dewetting. Watching the phenomenon occur brings to mind another name, crawling. The paint appears to initially wet the surface, but cannot sustain this contact and pulls back. Dewetting also can produce beads of paint, islands, craters, or pinholes. Figures 1 and 2 show examples of dewetting. Sometimes dewetting on vertical surfaces leads to sagging because the bead or thick area flows under the force of gravity.

The spreading of a liquid, such as paint, on a solid, such as a substrate, is controlled by the surface tensions of the liquid and the solid. The spreading coefficient is defined as

\[ S = \gamma_s - (\gamma_l + \gamma_{ls}) \]

where \( \gamma_s \) and \( \gamma_l \) are the solid and liquid surface tensions, respectively, and \( \gamma_{ls} \) is the interfacial tension between the liquid and solid. There will be a driving force for dewetting if \( S \) is negative, which will occur if the sum of \( \gamma_l \) and \( \gamma_{ls} \) is larger than \( \gamma_s \). The way to keep this from happening is to make sure that the liquid surface tension and the interfacial tension are low. The interfacial tension is difficult to measure, so the usual strategy is to aim at making certain that the liquid surface tension is significantly lower than the solid surface tension. This is not always a simple matter. There are substrates that are contaminated and others that are inherently difficult to wet and must be modified or treated before they can be coated without suffering dewetting.

Some methods are relatively simple, such as improved cleaning methods to remove oil and dirt from metal surfaces and mold release agents from plastics. Others involve complex physical and chemical treatments, such as flame and corona-plasma treatments of plastics and the formation of microcrystalline zinc phosphate coatings on steel. Another technique is the use of specially formulated thin-film adhesion promoters.

The other way to attack the problem is to reduce the surface tension of liquid coatings to make them wet better. Techniques to do this include the use of surfactants and low surface tension solvents. For example, surfactants such as silicones, fluorocarbons, and various wetting agents can be added. However, they must be used at low levels and their effects tested carefully to ensure that they do not cause other problems. Small amounts of low surface tension solvents such as butanols, 2-ethyl hexanol, and VM&P Naphtha also have been used to lower the surface tensions of liquid coatings. The advantage of solvents as additives is that they evaporate on air drying or baking and are not left behind in the coating as are surfactants.

The standard method for characterizing the wettability of surfaces is the measurement of contact angles (see ASTM standards D7334 and D7490), but it requires specialized equipment and is not practical in the field.

There are several simpler wetting/dewetting tests that can be used to characterize substrates for their wettability, including the set of tests found in ASTM D7541. This standard practice describes cotton swab, marking pen, and drawdown techniques that simulate the application of a film. The swab and marking pen techniques are simple and rapid and are particularly useful for testing in the field or on curved, irregular, or porous surfaces where contact angles cannot be measured. The swab test involves applying a series of solvents of known surface tension onto the substrate with cotton swabs and observing whether the strip of solvent stays in place or dewets and crawls. The breakpoint between wetting and dewetting provides what is called the critical surface tension of dewetting. The commercially available marking pens work in the same way. A coating with a surface tension below the dewetting critical surface tension of a substrate is very unlikely to encounter dewetting problems with that substrate. However, if the substrate becomes contaminated, this conclusion may not hold.©