THE EFFECTS OF VOC REGULATIONS ON APPLICATIONS OF SHIELDING COATING MATERIALS

Understanding the composition and characteristics of shielding products will aid the user in achieving EMI/RFI shielding while complying with environmental regulations.

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The 1980's has been a watershed decade in the discipline of EMI/RFI shielding. All manufacturers of electronic equipment, whether commercial or defense oriented, have been made aware of and understand their responsibility under the law. They must bring about electromagnetic compatibility with respect to their products and the impact of those products on the EM spectrum. Even subcontractors, such as metal and cabinet fabricators, are often made responsible for shielding their cabinets whether or not they know anything about the electronics which will fill these "black boxes." No doubt, this growing awareness has helped to bring about the widespread use of conductive coatings as a readily available solution to shielding problems.

Coatings are generally made of conductive pigments and fillers homogeneously dispersed in an organic resin binder — basically a paint which is applied through spray, dip, or brush-on methods. Plastic enclosures, which are typically non-conductive to start, are coated on the inside surfaces with these materials to provide a conductive, shielding surface. Cabinets and other "boxes" made of metal are often protected with a conductive coating to improve surface conductivity and/or to prevent corrosion of metal surfaces, such as in the case of aluminum or cold-rolled steel.

Many coating materials, although in and of themselves superb solutions to radiated emission problems, have been shown to have a negative impact on the quality of the air we all must breathe. Many levels of government, in response to public concerns about air quality, have promulgated regulations regarding the emission of toxic and/or photochemically-reactive (smog) solvents and fumes which may be given off in the application of these types of coatings. As was the case in the regulation of radiated EM emissions, it has, and will be, through agency regulation that materials are developed which alleviate undesirable chemical emissions.

On the national level, the Environmental Protection Agency is the driving force in policy formulation and enforcement. Microclimes, such as the Southern California air basin, are managed by more local agencies (in Southern California, the South Coast Air Quality Management District — SCAQMD). SCAQMD has implemented regulations which oftentimes are more stringent than EPA's; but, in the past, the EPA has been quick to adopt SCAQMD limits. Therefore, those guidelines covering Southern California are usually imposed on a nationwide level rather quickly. Also, it is wise to keep in mind that regulatory limits are tightened periodically and that attention should be paid to staying current with these limits. In Southern California at present, the volatile organic chemicals (VOC) content of most air-dried coatings (cured below 194 degrees F) are limited to less than 340 grams per liter or to 2.8 lbs./gal. At the moment, regulations do not impose tight restrictions on the VOC content of coating formulations used for EMI/RFI applications. However, tightened limits on the VOC content of coatings with high levels of conductive filler, such as nickel, are expected in the near future.

Consequently several manufacturers have developed, and are continuing to develop, new products with low VOC contents. A VOC content of less than 340 grams per liter for room temperature-cured, sprayable coatings can be very difficult to achieve. Problems arise because of application requirements and because of the very high loading of conductive fillers. Therefore, it would appear that future, achievable regulations may limit the VOC content of conductive coatings products to less than 600 grams/liter. Low levels of organic solvents in sprayable coatings can be achieved by using either highly-soluble resins or resins readily dispersible in water. These two options will produce solutions high in solids.

For these high solids solutions, the types of resins normally used include moisture-cured, 1-component urethanes, 2-component urethanes, and epoxies. These formulations can cure at room temperature or at very low temperatures and will produce excellent films. In developing systems based on these three types of resins, the curing condition and the performance requirements will determine exactly what type is used. For example, 2-component urethanes cure very quickly at room temperature and exhibit excellent physical properties - good tensile strength, high elongations, and good adhesion. However, they do not exhibit the temperature stability and moisture and solvent resistance of epoxies. On the other hand, epoxies tend to be more brittle unless modified. Moisture-cured urethanes also require long cure times because the crosslinking reaction is dependent upon the amount of moisture in the air. Another characteristic of these types of urethanes and epoxies is that in order to achieve good film properties, the resins (i.e., A-component) usually must be in the form of prepolymers. For example, the A-component of a 2-component urethane usually consists of a hydroxy-terminated prepolymer of a polyol and an isocyanate. Final cure is achieved through the reaction of the hydroxyl groups with the isocyanate groups in the B-component. The amount of solvent required to dissolve the urethane prepolymers is considerably less than the amounts needed to dissolve the high molecular weight, fully-polymerized thermoplastic resins. Unfortunately, when a high level of conductive fillers is added, the VOC content may be, as mentioned previously, difficult to keep below 600 grams per liter.

In the water-based formulations, most commercially available systems are composed of fully-polymerized resins dispersed in water with a coalescing solvent. Most of these resins cure by the evaporation of the coalescing solvent. As a result, the solvent and moisture resistance of these coatings may, or may not be, as good as the solvent-based coatings.

The formulae used to calculate the VOC content of any system that contains organic solvents, volatile reactants, or volatile organic by-products are described in ASTM D3960 or in Rule 433.1 of the South Coast Air Quality Management District. As shown in these publications, the following equation can be used to calculate the grams of VOC per liter of coating:

Grams of VOC per liter of coating less water and less exempt compounds =

$$\frac{W_S - W_W - W_{es}}{V_m - V_w - V_{es}}$$

Where:

W_S = weight of volatile compounds not consumed during curing, in grams

W_W = weight of water not consumed during curing, in grams

W_{es} = weight of exempt compounds not consumed during curing, in grams

V_m = volume of the material prior to reaction, in liters

V_w = volume of water not consumed during curing, in liters

V_{es} = volume of exempt compounds not consumed during curing, in liters

For a water based system, if the weight percent of water and the density of the coating are known, the above equation can be expressed as follows:

VOC (minus water) =

$$\frac{(\text{total volatiles}_{(g)} - \text{water}_{(g)})}{(\text{total paint}_{(ml)} - \text{water}_{(ml)})} \times 100$$

$$= \frac{[(100 - N)(D_m)] - [(\%\ H_2O)(D_m)]}{100\ [(D_m)(\%\ H_2O)/D_{H_2O}]} \times 100$$

Where:

N = weight percent non-volatile solids

D_m = density of the coating, g/ml at 25 degrees C

D_{H_2O} = density of water at 25 degrees C

% H_2O = weight percent of water

As this equation indicates, the VOC content of water-based coatings is calculated as though water were not contained in the formulation. For example, in 1 gallon of a nickel-filled water-based system which consists of 50 percent solids, 10 percent coalescing solvent, and 40 percent water, the VOC content is determined as though the 1 gallon were composed of only the solids and solvent at the same ratio. Thus, in the above example, the percentage of solids and solvent in one gallon would be 83 percent and 17 percent, respectively. Again, the density of the solvent resin and filler or coating must be known in order to calculate the VOC content of the gallon.

It is the responsibility of the user of the coatings to make certain that the materials which they use are in compliance with regulations. Often, materials are used which are found to be lacking in various physical or electrical properties, such as adhesion to substrate or electrical conductivity, respectively. Coatings materials which have been commonplace may not be acceptable for use in the future. It is the coatings supplier's responsibility to provide valid information on VOC levels for each product. Some regulations require printing these limits directly on the product label. A wise user will know his supplier and his supplier's product. He must be able to rely on the fact that information supplied is correct, especially since the user-applicator can be held liable for infractions of the emission limits. Now that all electronics manufacturers are aware of their responsibility in maintaining EMC, it is also incumbent upon them to recognize their concomitant responsibility to assure that the materials used to meet radiated EM emissions requirements also meet VOC chemical emission standards. ■