UNDERSTANDING VOLATILE ORGANIC COMPOUNDS REGULATIONS IN THE COMMERCIAL ROOFING INDUSTRY

by

Dwayne Wacenske

RCI 25th International Convention & Trade Show
Orlando, Florida

INTRODUCTION

There have been many changes in the regulations governing materials used in the low-slope commercial roofing industry in recent years. The regulations set maximum allowable amounts of volatile organic compounds (VOCs) that products may contain. Complicating matters further is the fact that these rules and regulations are being enacted at the state level and sometimes even locally, making it very difficult for the overall roofing community to understand their obligations and responsibilities. Typically, these regulations apply to the users, sellers and manufacturers of these products. However, some jurisdictions also include the specifier of the product.

Many of the products used in roofing systems, such as adhesives, sealants, primers and coatings, contain organic solvents. These solvents may or may not be an exempt VOC for the purposes of calculating the VOC content, depending on the jurisdiction. Thus, it is difficult to determine the VOC content of a product if the status of a solvent varies by location.

Another factor is that 12 Northeastern and Mid-Atlantic states and the District of Columbia have joined to form the Ozone Transport Commission (OTC). This organization was formed to coordinate the member states' efforts to reduce ground-level ozone in the region. While the members have agreed in principle to what constitutes a VOC and the permissible VOC content of products, not all of the states have actually enacted the regulations. Others have enacted laws with different enforcement periods.

The goal of this paper is to clarify these rules and regulations as well as the implementation of them. A discussion on the strategies employed to meet these requirements also is included.

DISCLAIMER

Unless otherwise specifically stated, the information presented in this paper is based on publicly available information and is accurate as of the date it was written. The information contained in this paper should not be considered legal advice and you should

not act or refrain from acting on the basis of any content included in this paper without seeking advice from local authorities or a qualified legal professional.

WHY REGULATE VOCS?

To understand why VOCs are regulated, it is important first to understand the relationship between VOCs, ozone and smog.

Smog is a brownish haze that pollutes the air in urban areas. Many people have difficulty breathing when the air is polluted with smog. Visibility also is adversely affected by smog.

The primary component of smog is ozone. While the two terms often are used interchangeably for general use, smog is more complex. Smog is primarily made up of ground-level ozone combined with other gases and particulate matter.

Within the Earth's atmosphere, ozone is present in two layers – the troposphere and stratosphere. About 10 percent of the atmospheric ozone occurs in the troposphere, which is the layer closest to the Earth's surface, and is considered ground-level or "bad" ozone. Ground-level ozone is an air pollutant that is harmful to breathe, damages crops, trees and other vegetation, and is the main ingredient of urban smog. The troposphere extends up from the ground about six miles, where it meets the stratosphere (e.g., the ozone layer). The remaining 90 percent of ozone occurs naturally in the stratosphere, an area that stretches about 30 miles up from the top of the troposphere. This "good" ozone shields the Earth from the sun's harmful ultraviolet (UV) radiation.

Ground-level ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NO_X) and VOCs in the presence of sunlight.

$$\textbf{VOC + } NO_X \textbf{ + Heat + Sunlight} \rightarrow \textbf{ Ozone}$$

The VOCs that are of concern for the environment are those that are photochemically reactive. VOCs that are determined to have negligible photochemical reactivity may be exempt from being included in VOC content calculations because these chemicals do not lead to the formation of ground-level ozone.

SOLVENTS

The main source of both NO_X and VOCs is automobile exhaust emissions. However, the second largest source of VOCs is solvents. Figure 1 shows the quantity of VOC emissions from various sources in 2002 as reported by the EPA[1].

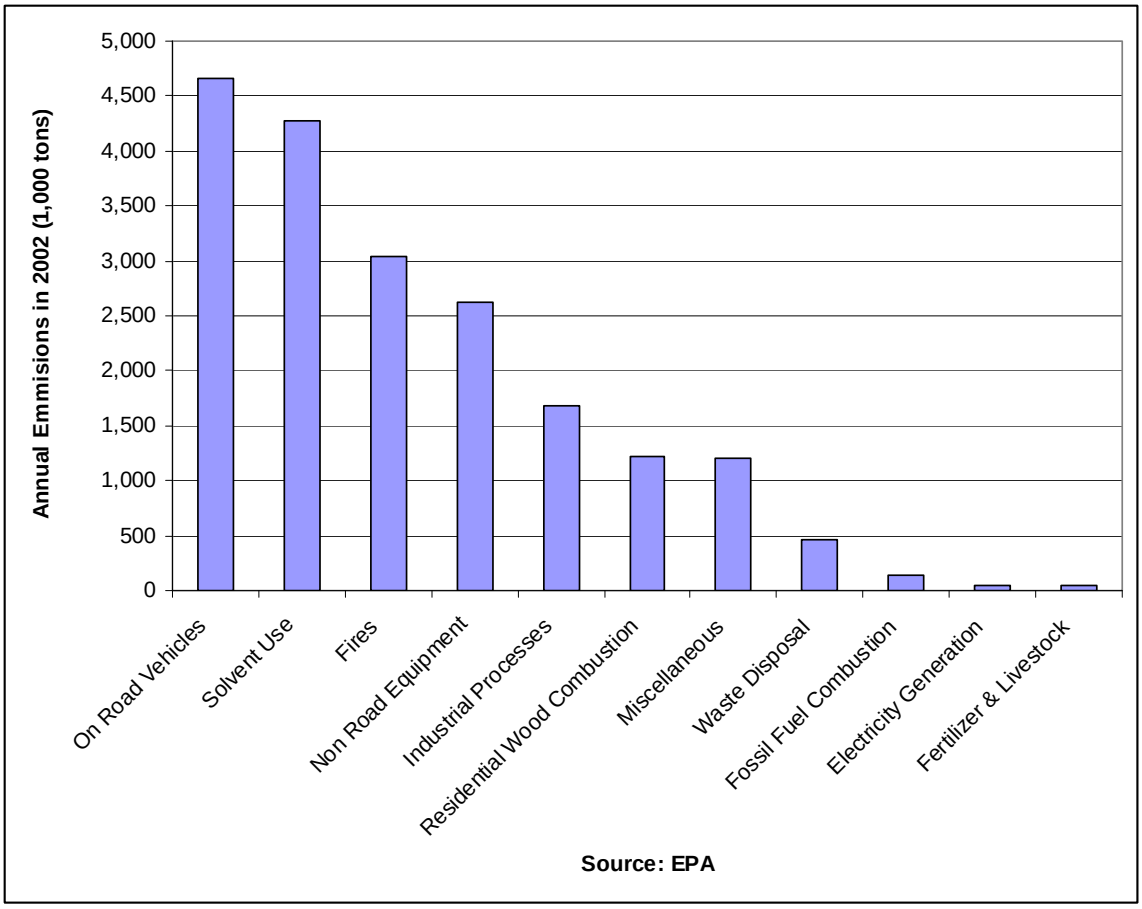

Figure 1 - National VOC Emissions by Source Sector in 2002

We are all well aware of the efforts to reduce automobile emissions. Less obvious are the efforts to reduce VOC emissions from solvents. Solvents are used in many industrial processes and in many consumer and commercial products. Since 1998, the EPA has regulated the VOC content of many of these products including automobile refinish coatings, consumer products, architectural coatings, aerosol coatings and portable fuel containers[2]. Among the consumer products that are regulated are many household cleaners and personal care products.

The roofing industry uses many products that contain solvents, including coatings, adhesives and sealants. Solvents are used to dissolve polymers or bitumen to make the material easier to apply. The solvent then evaporates, leaving the polymer behind. However, the quantity of solvents used in the commercial roofing industry is very small compared to all other sources.

REGULATING VOCS TO REDUCE GROUND-LEVEL OZONE

The Federal Clean Air Act Amendments of 1990 (CCA) require the U.S. Environmental Protection Agency (EPA), states and cities to implement programs to further reduce

emissions of ozone precursors from sources such as cars, fuels, industrial facilities, power plants, and consumer/commercial products.

Although the commercial roofing industry supports the overall efforts to improve air quality by reducing VOC emissions, recent state regulatory developments may have a significant adverse effect on many widely used products, roof application methods and, ultimately, total installed costs.

Currently, there are no direct federal regulations concerning the VOC content of adhesives and sealants. The CAA authorized the EPA to establish the National Ambient Air Quality Standards (NAAQS). The CAA also establishes provisions defining when and how the federal government can impose sanctions on areas of the country that have not met certain conditions. As such, areas that do not meet the NAAQS are designated as *nonattainment* areas. These areas must submit air quality plans, known as State Implementation Plans (SIPs), showing how they will attain the standards. It is within these SIPs that states may propose stringent regulations, such as limiting the VOC content of various products, which may include adhesives and sealants.

Typically, the regulations limiting the VOC content of adhesives and sealants apply to people who use, sell or manufacture these products. However, some jurisdictions have also included persons who "solicit, require the use or specify the application" of adhesives and sealants[3].

CALIFORNIA'S AIR DISTRICTS

The first regulation concerning adhesives and sealants was adopted by the South Coast Air Quality Management District (SCAQMD) in the state of California in 1989. Rule 1168 regulates the VOC content of adhesive and sealants. Of concern to the roofing industry are two categories of materials, single-ply roof membrane adhesives and single-ply roof membrane sealants. The VOC content limits for these two materials are 250 and 450 grams per liter respectively[4].

The SCAQMD is one of 35 air districts in California. Another 12 of the California air districts have adopted rules similar to the SCAQMD rule. The remaining 22 air districts do not have rules governing adhesives at this time.

Unfortunately, there are differences in the rules of the 13 air quality districts. The SCAQMD and some other California air districts currently do not exempt the solvent tertiary butyl acetate (TBAc) from VOC content calculations. In 2004, the EPA revised the definition of VOC to exclude TBAc. The EPA made this revision on the basis that TBAc is "negligibly reactive" and that using TBAc as a substitute solvent "will help decrease ground-level ozone formation."[5] TBAc has been found to be a very good replacement solvent for some commonly used solvents that are considered VOCs. Thus materials that maybe compliant with regulations in one air district may not be compliant in another.

THE OZONE TRANSPORT COMMISSION

More recently, the Ozone Transport Commission (OTC) created a model rule to regulate the VOC content of adhesives and sealants. The OTC is a multi-state organization created under the CAA. It is responsible for advising the EPA on transport issues and for developing and implementing regional solutions to the ground-level ozone problem in the Northeast and Mid-Atlantic regions. Ground-level ozone and other pollutants can travel long distances by wind currents, creating air quality problems far from the source of the pollution. This migration of pollutants is known as transport and has lead to the regionalization of air quality matters. The OTC consists of the eleven Northeastern states, Pennsylvania and the District of Columbia.

The OTC developed a "model rule" to reduce ozone levels in the region[6]. However, the member states may opt to promulgate rules based on the model rule or they may modify the model rule to fit the needs of their state. Some states have not adopted yet any rules regarding the VOC content of adhesives and sealants.

An important consideration for the OTC states is that the climate in the northeastern United States is quite different from southern California. To comply with the regulations in California, many manufacturers developed water-based materials. The climate in California allowed these materials to be used yearlong in most of the state. However, using water-based materials in some OTC states will severely limit the roofing season, as these materials do not perform well in cold climates or when temperatures drop below 40 °F.

The EPDM Roofing Association (ERA) has worked with several state environmental agencies to make them aware of the consequences of these new regulations on the roofing industry. In response, some states have decided to phase in the regulations for the roofing applications over a few years. This has provided manufacturers with additional time to develop products to meet these unique requirements.

In most of the OTC states, the regulations for the VOC content of single-ply roofing adhesives, primers and sealants will be in effect during the months of June through August of 2009; May through September of 2010 and 2011; and after January 1, 2012. During these months, adhesives, primers and sealants that are used with single-ply roofing membranes must comply with the VOC content limits.

Table 1 summarizes the regulations in the OTC states at the time of this writing. Since several states have not acted on this issue yet, it is recommended that the reader consult the environmental agency that has jurisdiction over the project to ensure that products used on a project comply with the current local regulations.

COMPLIANCE STRATEGIES

In order to comply with VOC content regulations, manufacturers must reduce or eliminate solvents that contribute to the VOC content. Some solvents are not photochemically reactive and are exempt from VOC measurements. In some cases, these exempt solvents can be used as a substitute for some of the VOC solvents. However, for

many polymer systems, simple replacement is not an option. Rather, complete reformulation of the product is needed.

Some of the solvents that the EPA excludes from its definition of VOC are acetone, parachlorobenzotrifluoride (PCBTF), and TBAc. The use of these solvents will reduce the calculated VOC content of the mixture, but there will be consequences. Typically, the cost of these solvents is much higher than traditional solvents. The working and drying time also can be adversely affected.

Another option is to replace the solvent-based products with water-based products. Some polymer systems are water-soluble and thus have zero or very little VOC content. Unfortunately, water freezes at a much higher temperature than most other solvents. Therefore, water-based coatings and adhesives cannot be applied when the ambient temperature is near freezing. Many of these adhesives and coatings will be irreparably damaged if they are allowed to freeze before installation. Therefore, water-based adhesive must be stored at temperatures greater than 60 °F. Manufacturers usually recommend that the adhesives be brought to room temperature before and during application.

Moreover, at low temperatures, it can take an inordinate amount of time for these adhesives or coatings to dry. Water has many shortcomings as a solvent for adhesive, sealants and coatings that are to be used outdoors.

For some applications, there may be the option to eliminate solvents completely. Examples include 100% solids systems, such as polyurethane sealants and adhesives, and epoxy coatings.

BONDING ADHESIVES

The products most affected by the VOC regulations are bonding adhesives. Bonding adhesives are extensively used in the commercial roofing industry to adhere single-ply roofing membranes and flashings to the roof deck, insulation or other substrates. Bonding adhesives are a critical part of fully adhered, single-ply roofing systems.

These adhesives usually use *contact adhesive* technology. Contact adhesives provide very strong initial and long-term bonds with high shear resistance. This is needed in order for the roofing membrane to resist wind uplift forces. Contact adhesives require the adhesive to be applied to both surfaces. The adhesive is then allowed to dry before the two surfaces are mated.

There are two key components of any contact adhesive, the polymer matrix and the solvent system.

The polymer matrix determines the final performance characteristics of the adhesive system. The polymer must meet some very demanding requirements. It must be able to provide excellent strength, yet remain flexible. It must be durable and exhibit this high level of performance for decades. It must be temperature resistant, it must remain flexible at very low temperatures, and it must be stable at temperatures up to 200 °F. In addition,

it must be fire resistant to prevent spread of flame and to meet stringent building code requirements.

The solvent system determines many of the application characteristics of the adhesive, for example viscosity, the ability to be spread or sprayed and its drying properties.

Drying time is a critical requirement of bonding adhesives. The adhesive must dry in a reasonable period. Ideally, the drying time would be equal to the application time. Excessive drying time will lead to loss of productivity on the rooftop.

SOLVENT-BASED BONDING ADHESIVES

Most solvent-based bonding adhesives in use today use polychloroprene rubber (PCR), such as DuPont's Neoprene, as the polymer matrix. This synthetic rubber provides excellent properties for a roofing adhesive. It is very stable over the entire service temperature range experienced on a commercial, low-slope roof. It also possesses excellent physical properties and good fire resistance.

Unfortunately, PCR is a difficult polymer to dissolve. Typically, xylene, toluene or a combination of the two are used as the main solvents for PCR. Acetone (a VOC exempt solvent) can only be used in PCR adhesive at low levels. Acetone has a relatively low flash point (1.4 °F), which may cause water to condense on the surface of the adhesive as the acetone evaporates causing the surface to cool. This is sometimes referred to as *blushing* and can lead to poor bonding when the two surfaces are mated.

Manufacturers have been able to reformulate bonding adhesives using exempt solvents such as PCBTF or TBAc. However, there are trade-offs with these solvents. The drying time can be considerably longer, reducing productivity. There have been some user complaints concerning the odor of some exempt solvents. PCBTF may cause swelling of EPDM membranes, resulting in solvent blisters or areas that are not adhered properly. In addition, both of these exempt solvents are relatively scarce and therefore, considerably more expensive than the more readily available xylene and toluene.

WATER-BASED BONDING ADHESIVES

Water-based bonding adhesives have been available for single-ply roofing applications for several years. Latex acrylic technology is used as the polymer matrix in most water-based bonding adhesives. These acrylic polymers are heat-resistant, flexible, and strong.

As mentioned above, the use of water-based bonding adhesives is limited by the ambient temperature. Most manufacturers recommend that these adhesives only be used when the temperature is 40 °F and rising. Additionally, the adhesive must be maintained at temperatures above 40 °F for 48 hours after application in order for the adhesive to cure fully. In many areas of the country, this will limit the use of these materials to six months out of the year.

Although water is a very inexpensive solvent, many water-based materials are relatively expensive compared to a traditional solvent-based material. Water-based bonding

adhesives may be 1½ to 2 times more expensive than a solvent-based adhesive. Some of this expense may be offset by increased coverage rates.

The drying time of water-based adhesives is highly dependent on the ambient conditions. Temperature, humidity, wind speed and cloud cover will all affect the drying time. Also critical is that the drying time needs to be consistent. Water-based adhesives may dry quickly in sunny areas, yet remain wet in shaded areas. Typically, the drying time of solvent-based adhesives is much less sensitive to the ambient conditions than water-based adhesives.

POLYURETHANE ADHESIVES

There are some polyurethane adhesives used in the commercial roofing industry that contain no VOCs. These adhesives typically require the use of a fleece backing on the membrane. The backing is needed because the polyurethane adhesives usually do not bond well directly to the single-ply membranes.

ADHESIVE PRIMERS

Adhesive primers are needed in many single-ply roofing systems to prepare a surface (single-ply membrane, metal, insulation, etc.) to receive an adhesive or adhesive tape.

Primers are either included under the definition of an adhesive or given their own category in the rules and regulations for VOC content and are typically limited to 250 grams per liter.

The same approaches to lower the VOC content of solvent-based bonding adhesives have been used with primers: solvent substitution. Primers may have solids content as low as 5%, meaning that the remainder of the material will be solvents. The solid portion of the primer typically includes butyl-based rubbers, hydrocarbon tackifying resins and sometimes curatives.

PCBTF has been found to be a good substitute solvent for many primers to comply with VOC content limits. PCBTF based primers require longer open time than primers with VOC containing solvents. There is also the potential that PCBTF based primers may swell an EPDM membrane to a greater degree than primers that use VOC containing solvents. Since primers are typically coated much thinner than bonding adhesives, that possibility is minimized. However, puddling or excessive application rates can lead to membrane blistering and extended open times.

SEALANTS

The definition of a sealant in the SCAQMD rule 1168 is any material that is used to fill, seal or waterproof gaps or joints between two surfaces. The definition of sealants also includes many sealant primers and caulks.

As noted, the VOC content of sealants is also regulated in many areas. When regulated, the VOC content limit for sealants is 450 grams per liter. This is considerably higher than the limit for adhesives (250 grams per liter).

Sealants are an important part of the waterproofing system, and failure of a sealant may result in a leak. However, a sealant failure probably will not result in a catastrophic failure of the roof, the way that a bonding adhesive failure could.

Additionally, the volume of sealants is relatively small compared to that of bonding adhesives.

Most roofing sealants have a much higher solids content than adhesive and primers, thus sealants contain much less solvent. Most roofing sealants meet the VOC content regulations.

WHAT LIES AHEAD?

There will continue to be changes in the rules and regulations regarding the environment that will affect the roofing industry. In 2008, the EPA significantly strengthened the air quality standards for ground-level ozone. More areas around the country may be required to implement plans to reduce ground-level ozone levels. This will lead to more regulations on the VOC content of many products, possibly including adhesives and sealants used in the commercial roofing industry.

Advocates for the roofing industry must express their concerns to the legislatures and rulemaking bodies to ensure that other issues are not compromised in the name of the environment. For example, if adhesives do not work properly and the integrity of a roofing system is compromised during a storm event, then the safety of the people in that building may be at risk.

In particular, roofing system specifiers must be aware of the current and proposed regulation changes, especially the phased- in, seasonal implementation schedule that many states have already incorporated. This is an important industry issue that can be accomplished successfully with cooperation and open communication between state and federal regulatory bodies, roofing product manufacturers, specifiers, consultants, owners, installation contractors and others.

Table 1 - Summary of OTC Rules on Single-Ply Roof Membrane Adhesives and Sealants

Jurisdiction	Status	VOC Content Limit		Phase In Periods			
		Adhesives	Sealants	2009	2010	2011	2012
Connecticut[7]	Effective 10/3/2008	250	450	June 1 – Aug 31	May 1 - Sept 30	May 1 - Sept 30	After Jan 1
Delaware[8]	Effective 5/1/2009	250	450	June 1 – Aug 31	May 1 - Sept 30	May 1 - Sept 30	After Jan 1
District of Columbia	Under Consideration						
Maine[9]	Effective 1/1/2011	250	450	N/A	N/A	May 1 - Sept 30	After Jan 1
Maryland[10]	Effective 1/1/2009	250	450	May 15 - Sept 15	May 1 - Sept 30	May 1 - Sept 30	After Jan 1
Massachusetts	Nothing has been adopted						
New Hampshire	No action yet						
New Jersey[11]	Effective 1/1/2009	250	450	June – Aug	May - Sept	May - Sept	After Jan 1
New York	Under Consideration						
Pennsylvania[12]	Proposed	250	450				
Rhode Island[13]	Effective 7/1/2009	250	450	July 1 - Aug 31	May 1 - Sept 30	May 1 - Sept 30	After Jan 1
Vermont	Nothing has been adopted						
Virginia[14]	Proposed	250	450	N/A	May 1 - Sept 30	May 1 - Sept 30	After Jan 1

[1] U.S Environmental Protection Agency, http://www.epa.gov/air/emissions/voc.htm (accessed 9/1/2009).
[2] 40 C.F.R. § 59 National Volatile Organic Compound Emission Standards For Consumer And Commercial Products
[3] Maine 06-096 Chapter 159 Control of Volatile Organic Compounds from Adhesives and Sealants, Section 2.G. (2009).
[4] South Coast Air Quality Management District, Rule 1168 (2005), http://www.arb.ca.gov/DRDB/SC/CURHTML/R1168.PDF (accessed 9/1/2009).
[5] U.S. Environmental Protection Agency, 11/18/2004. http://yosemite.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/50d1d8b63a857ce785256f500065d12e!OpenDocument (accessed 9/1/2009).
[6] OTC Model Rule For Adhesives and Sealants, http://www.otcair.org/projects_details.asp?FID=99&fview=stationary# (accessed 9/1/2009).
[7] Regulations of Connecticut State Agencies, Section 22a-174-44
[8] Delaware Register of Regulations, Volume 12, Issue 10, Issue Date April 1, 2009, pp. 1333 – 35.
[9] Maine 06-096 Chapter 159 Control of Volatile Organic Compounds from Adhesives and Sealants (2009).
[10] Maryland Title 26, Subtitle 11, Chapter 35, Control of Emissions of Volatile Organic Compounds from Adhesives and Sealants (2008).
[11] New Jersey Administrative Code, Title7, Chapter 27, Subchapter 26, Prevention of Air Pollution from Adhesives, Sealants, Adhesive Primers and Sealant Primers (2008).

[12] Executive Summary – Amendments to 25 Pa. Code Chapters 121, 129 and 130, http://www.depweb.state.pa.us/pubpartcenter/lib/pubpartcenter/eqb/2008/12162008/adhesivesexecutivesummaryeqbproposed11_7_2008.pdf (accessed 9/1/2009).
[13] State of Rhode Island and Providence Plantations, Department of Environmental Management, Office of Air Resources, Air Pollution Control Regulation No. 44, Control of Volatile Organic Compounds from Adhesives and Sealants (2009).
[14] Virginia Regulatory Town Hall, http://www.townhall.virginia.gov/L/viewchapter.cfm?chapterid=2497 (Accessed 9/1/2009)