Control Techniques Guidelines for Miscellaneous Industrial Adhesives

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U.S. Environmental Protection Agency
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I. Introduction

Clean Air Act (CAA) section 172(c)(1) provides that state implementation plans (SIPs) for nonattainment areas must include "reasonably available control measures" (RACM), including "reasonably available control technology" (RACT), for sources of emissions. Section 182(b)(2)(A) provides that for certain nonattainment areas, States must revise their SIPs to include RACT for each category of volatile organic compound (VOC) sources covered by a control techniques guidelines (CTG) document issued between November 15, 1990 and the date of attainment.

The United States Environmental Protection Agency (EPA) defines RACT as "the lowest emission limitation that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility." 44 FR 53761 (September 17, 1979). In subsequent Federal Register notices, EPA has addressed how States can meet the RACT requirements of the CAA.

Clean Air Act section 183(e) directs EPA to list for regulation those categories of products that account for at least 80 percent of the VOC emissions, on a reactivity-adjusted basis, from consumer and commercial products in areas that violate the NAAQS for ozone (i.e., ozone nonattainment areas). EPA issued the list on March 23, 1995, and has revised the list periodically. See 60 FR 15264 (March 23, 1995); see also 71 FR 28320 (May 16, 2006), 70 FR 69759 (Nov. 17, 2005); 64 FR 13422 (March 18, 1999). Miscellaneous Industrial Adhesives are included on the current section 183(e) list.

This CTG is intended to provide State and local air pollution control authorities information that should assist them in determining RACT for VOCs from miscellaneous industrial adhesive application processes. In developing this CTG, EPA, among other things, evaluated the sources of VOC emissions from miscellaneous industrial adhesives application processes and the available control approaches for addressing these emissions, including the costs of such approaches. Based on available information and data, EPA provides recommendations for RACT for miscellaneous industrial adhesives.

States can use the recommendations in this CTG to inform their own determination as to what constitutes RACT for VOCs for miscellaneous industrial adhesive application processes in their particular nonattainment areas. The information contained in this document is provided only as guidance. This guidance does not change, or substitute for, requirements specified in applicable sections of the CAA or EPA's regulations; nor is it a regulation itself. This document does not impose any legally binding requirements on any entity. It provides only recommendations for State and local air pollution control agencies to consider in determining RACT. State and local pollution control agencies are free to implement other technically-sound approaches that are consistent with the CAA and EPA's implementing regulations.

The recommendations contained in this CTG are based on data and information currently available to EPA. These general recommendations may not apply to a particular situation based upon the circumstances of a specific source. Regardless of whether a State chooses to implement the recommendations contained herein through State rules, or to issue State rules that adopt

different approaches for RACT for VOCs from miscellaneous industrial adhesives, States must submit their RACT rules to EPA for review and approval as part of the SIP process.

EPA will evaluate the rules and determine, through notice and comment rulemaking in the SIP approval process, whether the submitted rules meet the RACT requirements of the CAA and EPA's regulations. To the extent a State adopts any of the recommendations in this guidance into its State RACT rules, interested parties can raise questions and objections about the substance of this guidance and the appropriateness of the application of this guidance to a particular situation during the development of the State rules and EPA's SIP approval process.

Clean Air Act section 182(b)(2) requires that a CTG issued between November 15, 1990, and the date of attainment include the date by which States subject to section 182(b) must submit SIP revisions in response to the CTG. Accordingly, EPA is providing in this CTG a one-year period for the required submittal. Pursuant to section 182(b)(2), States required to submit rules consistent with section 182(b) must submit their SIP revisions within one year of the date of issuance of the final CTG for miscellaneous industrial adhesives.

II. Background and Overview

There are no previous EPA actions that affect miscellaneous industrial adhesive application operations.

In 1998, the California Air Resources Board (ARB) issued a guidance document that includes ARB's determination of Reasonably Available Control Technology (RACT) and Best Available Retrofit Control Technology (BARCT) for Adhesives and Sealants[1]. The 1998 ARB document presented RACT and BARCT for controlling VOC emissions from the commercial and industrial application of adhesives and sealants. The ARB RACT determination prescribes VOC emission limits for various industrial adhesives and sealants and was developed based on eight existing California air pollution control district rules for adhesives and sealants that were in effect in 1998. Those eight districts included Bay Area (BAAQMD), El Dorado County (EDCAPCD), Placer County (PCAPCD), Sacramento Metropolitan (SMAQMD), South Coast (SCAQMD), Ventura County (VCAPCD), Yolo-Solano (YSAQMD), and San Diego County (SDCAPCD).

Since the development of the ARB RACT determination, five additional California air pollution control districts have adopted rules based on the ARB RACT standards, resulting in a total of 13 air pollution control districts in California having established rules for adhesives.

In 2007, the Ozone Transport Commission issued its Model Rule for Adhesives and Sealants.[2] The model rule was based almost entirely on the 1998 California ARB RACT determination. The model rule is designed for adoption by member states in 2009. To date, only Maryland has adopted an adhesives rule based on the OTC model rule. Connecticut, Delaware, District of Columbia, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia are all either currently in various stages of formal rule adoption or are developing a proposed rule.

At least eight California Districts and Maryland regulate cleaning materials used in adhesive application processes. These regulations require a combination of work practice, equipment standards, and limits on the VOC content, boiling point, or composite vapor pressure

of the solvent. Some California District rules allow the use of add-on controls as an alternative to the VOC content/boiling point/vapor pressure limits for cleaning materials.

EPA developed the recommended approaches contained in this document after reviewing the existing State and local VOC emission reduction approaches.

The remainder of this document is divided into six sections. Section III describes the scope of sources to which the control recommendations in this CTG could apply. Section IV describes the miscellaneous industrial adhesives, including the types of adhesive materials and the application processes, and identifies the sources of VOC emissions from those processes. Section V describes the available control approaches for addressing VOC emissions from this product category and summarizes State and local approaches for addressing such emissions. Section VI provides our recommendations for RACT for miscellaneous industrial adhesives application processes. Section VII discusses the cost-effectiveness of the recommended control approaches. Section VIII contains a list of references.

III. Applicability

This CTG provides control recommendations for reducing VOC emissions from miscellaneous industrial adhesives and adhesive primer application processes. Please see section IV of this CTG for a description of the miscellaneous industrial adhesives category under section 183(e) of the CAA. This section addresses EPA's recommendations as to the scope of entities to which the RACT recommendations in this CTG should apply. As explained above, this document is a guidance document and provides information for States to consider in determining RACT. When State and local pollution control agencies develop RACT rules, they may elect to adopt control approaches that differ from those described in this document and/or promulgate applicability criteria that differ from those recommended here.

In terms of applicability, we recommend that the control approaches discussed in section VI of this CTG apply to each miscellaneous industrial adhesive application process[1] at a facility where the total actual VOC emissions from all miscellaneous industrial adhesive application processes, including related cleaning activities, at that facility are equal to or exceed 6.8 kg/day (15 lb/day), or an equivalent level such as 3 tons per 12-month rolling period, before consideration of controls. We do not recommend these control approaches for facilities that emit below this level because of the very small VOC emission reductions that can be achieved. The recommended threshold level is equivalent to the evaporation of approximately two gallons of solvent per day. Such a level is considered to be an incidental level of solvent usage that could be expected even in facilities that use very low-solvent adhesives, such as radiation cured adhesives (these adhesives will be discussed in more detail in section IV.B.1 of this document). Furthermore, based on the 2002 NEI data and the 2004 ozone nonattainment designations, facilities emitting below the recommended threshold level collectively emit less than 6 percent of the total reported VOC emissions from miscellaneous industrial adhesive application processes in ozone nonattainment areas. For these reasons, we did not extend our recommendations in this CTG to these low-emitting facilities. For purposes of determining whether a facility meets our

[1] An application process consists of a series of one or more adhesive applicators and any associated drying area and/or oven wherein an adhesive is applied, dried, and/or cured. An application process ends at the point where the adhesive is dried or cured, or prior to any subsequent application of a different adhesive. It is not necessary for an application process to have an oven or flash-off area.

recommended applicability threshold, aggregate emissions, before consideration of control, from all miscellaneous industrial adhesive application processes (including related cleaning activities) at a given facility are included.

In developing their RACT rules, State and local agencies should consider carefully the facts and circumstances of the affected sources in their States. As noted above, States can adopt the above recommended 6.8 kg/day (15 lb/day) actual VOC emissions or an equivalent applicability threshold, or they can develop other applicability criteria that they determine are appropriate considering the facts and circumstances of the sources in their particular nonattainment areas. EPA will review the State RACT rules in the context of the SIP revision process.

The 2002 National Emission Inventory (NEI) was used as the source of emissions data and other information concerning facilities operating miscellaneous industrial adhesive application processes.

In developing this CTG, the 2002 NEI database was queried for facilities likely performing miscellaneous industrial adhesive application based on Source Classification Code (SCC) 40200701, 40200706, 40200707, 40200710, 40200711, and 40200712. This activity resulted in 1,048 facilities with miscellaneous industrial adhesive application processes in the 2002 NEI, and VOC emissions totaled an estimated 8,660 Mg/yr (9,546 tpy) from adhesive application processes. Of the 1,048 facilities identified in the 2002 NEI, 720 facilities were located in ozone nonattainment areas and 180 of the facilities located in ozone nonattainment areas emit more than the 6.8 kg/day (15 lb/day) VOC applicability threshold described above. These 180 facilities emitted an estimated 4,428 Mg (4,881 tons) of VOC in 2002 from adhesive application processes.

IV. Process Description and Sources of VOC Emissions

The miscellaneous industrial adhesives product category includes adhesives (including adhesive primers used in conjunction with certain types of adhesives) used at industrial manufacturing and repair facilities for a wide variety of products and equipment that operate adhesives application processes.

The miscellaneous industrial adhesives product category does not include adhesives that are addressed by CTGs already issued for categories listed under CAA Section 183(e) or by earlier CTGs. These include the CTGs issued under Section 183(e) for aerospace coatings; metal furniture coatings; large appliance coatings; flat wood paneling coatings; paper, film, and foil coatings; offset lithographic printing and letterpress printing; and flexible package printing. Coil coating, fabric coating, and rubber tire manufacturing were not listed under CAA Section 183(e), however, they were the subject of earlier CTGs which address adhesives used in those processes.

Motor vehicle adhesives, glass bonding primers, and weatherstrip adhesives that are used at a facility that is not an automobile or light-duty truck assembly coatings facility, are addressed in this CTG for miscellaneous industrial adhesives. Please see section VI of this CTG for our VOC control recommendations for these motor vehicle materials. The VOC control recommendations for these motor vehicle materials in the CTG for miscellaneous industrial adhesives are the same as the VOC control recommendations for similar materials used at

automobile and light-duty truck assembly coating facilities, which are addressed in the final automobile and light-duty truck assembly coatings CTG.

A. Process Description

Adhesives are used for joining surfaces in assembly and construction of a large variety of products. Adhesives allow for faster assembly speeds, less labor input, and more ability for joining dissimilar materials than other fastening methods. Although there are a wide variety of adhesives formulated from a multitude of synthetic and natural raw materials, all adhesives can be generally classified as solution/waterborne, solvent-borne, solventless or solid (e.g., hot melt adhesives), pressure sensitive, hot-melt, or reactive (e.g., epoxy adhesives and ultraviolet-curable adhesives). Adhesives can also be generally classified according to whether they are structural or nonstructural. Structural adhesives are commonly used in industrial assembly processes and are designed to maintain product structural integrity.

1. Surface Preparation

The vast majority of adhesives require the application of a primer to the substrate before the adhesive is applied. Adhesive primers are usually applied in very thin films, and serve to wet the substrate surface and provide improved bonding capability for the adhesive. Adhesive primers are commonly solvent-borne materials[3].

2. Adhesive Application

Adhesive application is accomplished by applying an adhesive to a substrate, followed by curing or drying the adhesive. The adhesive itself may be in the form of an aerosol applied by spraying, or liquid applied by spraying, rolling, or dipping.

There are several different types of applicators that may be used to apply adhesives, and are generally similar or identical to surface coating application techniques. The most common types of applicators include: air atomized spray, electrostatic spray, high volume/low pressure (HVLP) spray, dip coating, flow coating, brush or roll coating, electrocoating, and hand application.

Spray application operations are typically performed in a spray booth by manual or automated (e.g., robotic) means to capture overspray, remove solvent vapors from the workplace, and to keep the application operation from being contaminated by dirt from other operations. In some instances, productivity is maximized by using automated application followed by manual touchup. Typically, overspray is collected within the booth on either dry filter media or a waterwash booth. Air flow in a booth equipped with dry filter media generally passes from the spray applicator, over the substrate, and through a dry filter bank. Waterwash booths are less commonly used than dry filter booths. In a waterwash booth, air is drawn through a continuous curtain of moving water and overspray is removed by contact with the water. In booths equipped with dry filters and in waterwash booths, the overspray can be collected on a series of baffles in front of the dry filters or waterwash, and, in some cases, the collected overspray can be reused. This recycling method substantially reduces both air emissions and waste (including spent dry filters) generated by the adhesive application operation.

Several different types of application technologies are used to apply adhesives, and the selection of the application technology can significantly affect the amount of adhesive used and the resulting VOC emissions from the application process.

Conventional air spray application uses compressed air at high pressure (e.g., 30 to 90 pounds per square inch, psi) to pull the adhesive from a reservoir and atomize the adhesive as it is expelled from the spray gun tip. The mixture of air and atomized adhesive then deposits the adhesive on the substrate. Because of the high pressure of air used, most of the adhesive does not land on the substrate and is carried away from the substrate as overspray and is wasted. The fraction of adhesive solids that reaches the substrate is termed transfer efficiency, and conventional air spray has a relatively low transfer efficiency compared to other application methods. Therefore, many application processes have adopted other types of spray application to use adhesives more efficiently.

Airless Spray. With airless spray, a pump forces the adhesive through an atomizing nozzle at high pressure (1,000 to 6,000 psi). Airless spray is ideal for rapid coverage of large areas and when a heavy film build is required. The size of airless spray adhesive droplets is larger, the spray cloud is less turbulent, and the transfer efficiency is typically superior to conventional air spray.

Air-Assisted Airless Spray. An air-assisted airless system combines the benefits of conventional air spray and airless spray. The system consists of an airless spray gun with a compressed air jet at the gun tip to atomize the adhesive. It uses lower fluid pressures than airless spray and lower air pressures than conventional air spray (e.g., 5 to 20 psi versus 30 to 90 psi). This fluid/air pressure combination delivers a less turbulent spray than conventional air systems and applies a more uniform finish than airless systems. However, the amount of time needed to apply adhesives is greater because of the lower fluid and air pressure.

Electrostatic Spray. In electrostatic spray application, the adhesive and substrate are oppositely charged. The substrate is grounded and attracts the negatively charged adhesive particles. Electrostatic spray systems are reported to have the highest transfer efficiency of any of the spray application techniques because of minimal overspray, which also results in lower adhesive loss and lower VOC emissions.

HVLP systems use lower air pressures (generally not more than 10 psi at the spray cap) and greater volumes than conventional air atomized spray systems. Specialized nozzles provide better air and fluid flow at the lower air pressure, and shape the air/spray pattern and guide the atomized adhesive particles to the substrate. The lower air pressures result in greater transfer efficiency compared to conventional air atomized spray systems.

Dip coating is another available method for applying liquid adhesives. It is typically used for large complicated parts where it would be difficult to use other methods. The substrates are manually or automatically dipped into a tank containing the adhesive. The substrates are then withdrawn from the tank and any excess adhesive is allowed to drain, thus achieving very high transfer efficiencies. Typical systems have some means of recirculation of the tank contents, filters to remove paint sediment and solid contaminants, and means for controlling the viscosity of the fluid. Because the tank opening exposes a large surface area of liquid adhesive,

solvent losses occur from the tank. To maintain the desired adhesive viscosity in the tank, these losses are compensated by adding thinner (water or solvent, depending on the adhesive used).

Flow coating is similar to dip coating and involves conveying the substrate over an enclosed sink, where the adhesive is applied at low pressure as the item passes under a series of nozzles. Excess adhesive drains back into the sink, is filtered, and pumped back into a holding tank. A typical flow coater tank is enclosed and is smaller than the equivalent dip coating tank. As a result, less adhesive is used and less solvent is evaporated than in dip tank operations. This application method results in an increase in production rate.

Roll coating, brush coating, and hand application are often used for high viscosity adhesives and for application onto small surface areas.

Electrocoating (electrodeposition) is a specialized form of dip coating where opposite electric charges are applied to the waterborne adhesive and the substrate. The adhesive is deposited on the part by means of electrical attraction, which produces a more uniform application on the substrate than traditional dip application.

After each of the adhesive application operations described above, the applied adhesive is usually air dried or cured. For liquid spray and dip coating operations, the substrate is typically first slowly moved through a flash-off area after the adhesive is applied. The adhesive is either then allowed a specified drying time to allow tackification before bonding, or the substrate is immediately bonded.

3. Cleaning Activities

Cleaning activities other than surface preparation and priming also occur at facilities operating miscellaneous industrial adhesive application processes. Cleaning materials are used during these activities to remove adhesive residue or other unwanted materials from equipment related to application operations, as well as the cleaning of spray guns, transfer lines (e.g., tubing or piping), tanks, and the interior of spray booths. These cleaning materials are typically mixtures of VOC-containing solvents.

B. Sources of VOC Emissions

The VOC emissions from miscellaneous industrial adhesives result from evaporation of the solvents contained in many of the primers, adhesives and cleaning materials during adhesive application and drying processes, as well as during surface preparation and cleaning processes associated with adhesives application. The primary VOC emissions from miscellaneous industrial adhesives occur during application and flash-off.

A lesser amount of emissions occur from mixing and as the adhesive dries. Essentially all of the remaining VOC in the organic solvent contained in the adhesives is emitted during the drying process. The VOC emissions from mixing of adhesives occur from displacement of VOC-laden air in containers used to mix adhesives containing solvents (thinners) prior to adhesive application. The displacement of VOC-laden air can also occur during filling of containers and can be caused by changes in temperature, changes in barometric pressure, or agitation during mixing.

The following discussion describes these primary emission sources (adhesives and cleaning materials).

1. Adhesives

The VOC emissions from adhesive application occur when solvent evaporates from the adhesive as it is being applied to the substrate. The transfer efficiency (the percent of adhesive solids deposited on the substrate) of an application method affects the amount of VOC emitted during application. The more efficient an application method is in transferring adhesives to the substrates, the lower the volume of adhesives (and therefore solvents) needed per given amount of production; thus resulting in lower VOC emissions.

Conventional air atomized spray equipment utilizes high atomizing air pressure with typical transfer efficiencies of 25 to 40 percent. The transfer efficiency of a dip coater is very high (approximately 90 percent); however, some VOC is emitted from the liquid coating bath due to its large exposed surface area. For liquid adhesives, electrostatic spray coating is more efficient than conventional air atomized spray, with transfer efficiency typically ranging from 60 to 90 percent.

After adhesives are applied by any of the typical application methods, the adhesive is usually allowed a drying period. Immediately after application, a fraction of the solvents in the adhesives flash-off. The amount of VOC emissions from flash-off depends on the type of adhesive used, how quickly the substrate moves through the flash-off area, and the distance between the application area and the drying area.

In spray application operations, the majority of VOC emissions occur in the spray booth. For liquid spray applications, it is estimated that 65-80 percent of the volatiles are emitted during the application and flash-off operations, and the remaining 20-35 percent from the drying/curing operation.

The trend in controlling VOC emissions from solvent-borne adhesives is not to control through a specific control technology, but rather to replace them with low VOC adhesives, some of which can perform as well as solvent-borne adhesives. Since the late 1970's, adhesive formulations that eliminate or reduce the amount of solvent in the formulations have been increasing, thus reducing VOC emissions per unit amount of adhesive used.

Various types of low solvent adhesive include waterborne, hot-melt, solventless two-component, and radiation-cured adhesives. Hot-melt adhesives are the most widely used of these alternative processes.

2. Cleaning Materials

Cleaning materials are another source of VOC emitted by miscellaneous industrial adhesive application processes. The VOC are emitted when solvents evaporate from the cleaning materials during use.

Cleaning materials with low-VOC composite vapor pressure and/or low-VOC content generate less VOC emissions than materials with higher VOC vapor pressure and/or content. The VOC composite vapor pressure of a cleaning material is a weighted average of the vapor

pressures of the VOC components of that cleaning material. The vapor pressure of each VOC component is weighted by the mole fraction of that VOC component in the whole cleaning material, including non-VOC components such as water or exempt compounds.[2] Water and exempt compounds thereby reduce the VOC composite vapor pressure of cleaning materials in which they are present.

Although use of lower vapor pressure cleaning materials may reduce VOC emissions, these materials may not be feasible with the broad range of adhesives used in miscellaneous industrial adhesive application processes. Similarly, cleaning materials with low VOC content would generate less VOC emissions than materials with high VOC content, but may not be feasible with the broad range of adhesives used in miscellaneous industrial adhesive application processes.

V. Available Controls and Regulatory Approaches

As previously mentioned, there are two main sources of VOC emissions from miscellaneous industrial adhesive application processes: (1) evaporation of VOC from the adhesives and adhesive primers; and (2) evaporation of VOC from the cleaning materials. This section summarizes the available control options for reducing these VOC emissions and existing State, and local VOC recommendations or requirements that address these emissions.

A. Available Controls for VOC Emissions from Adhesives

There are two general emission control techniques for reducing VOC emissions from miscellaneous industrial adhesive application processes: pollution prevention measures, and emission capture and add-on control systems. Pollution prevention is the most prevalent control technique being used by facilities operating miscellaneous industrial adhesive application processes. Add-on control systems are available to industry, but few facilities utilize this control technique. Provided below is a summary of these control techniques.

1. Pollution Prevention Measures

Pollution prevention measures that are applicable to miscellaneous industrial adhesive application processes, including product substitution/reformulation, work practice procedures, and equipment substitution, may be used to decrease VOC emissions from adhesive application operations. Lower VOC content adhesives, higher solids adhesives and waterborne adhesives, may be used to reduce VOC emissions by reducing or eliminating the organic solvent present in the adhesive. Work practice procedures may also result in VOC emission reductions during the application process by reducing waste. The use of efficient application equipment can reduce VOC emission by increasing the adhesive transfer efficiency (i.e., the percentage of adhesive solids used that is deposited onto the substrate) and reducing the amount of adhesive used and wasted as overspray.

[2] Exempt compounds are those classified by EPA as having negligible photochemical reactivity as listed in 40 CFR 51.100(s). Exempt compounds are not considered to be VOC.

Product Substitution/Reformulation

One pollution prevention measure is to substitute higher-solvent adhesives with adhesives containing little or no solvents. As previously discussed, these adhesives include waterborne adhesives, higher solids adhesives, and reactive adhesives. Manufacturers have developed and are continuing to develop waterborne and reactive formulations that replace conventional organic solvent-borne adhesives. These adhesives are generally available. Conversion to waterborne adhesives (for example) can lower VOC emissions greatly, and many miscellaneous industrial adhesive application processes are capable of converting to these adhesives. However, the currently available low-VOC adhesives or adhesives with no solvents do not meet the performance requirements of some industrial manufacturing applications and therefore are not viable options for these operations.

Work Practices

Work practice procedures are physical actions intended to affect emission reductions. Because work practice procedures are specifically tailored to an industry, they may vary from a few manual operations to a complex program.

Waste is generated during adhesive material preparation, application, and equipment cleaning. If waste is reduced, overall VOC emissions from application processes will be reduced because less VOC adhesive material will be needed for production. Adhesive waste may be reduced by effectively controlling material preparation, maximizing the amount of adhesive transferred to the substrate through the use of application methods with higher transfer efficiencies and improved spray technique, and using proper equipment maintenance procedures.

Equipment Substitution

The use of the more effective application equipment also reduces VOC emissions. Conventional air atomized spray application systems utilize high atomizing air pressure with typical transfer efficiencies of 25 to 40 percent.

More modern technologies, such electrostatic and HVLP spray equipment, can achieve much higher transfer efficiencies. The increase in transfer efficiency translates to a decrease in usage of materials containing VOC.

In electrostatic spraying, the adhesive is charged and the substrate is grounded, thereby attracting the atomized adhesive to the substrate. Transfer efficiencies of up to 90 percent may be achieved depending on the product shape, size, and substrate.

HVLP systems use reduced air pressure to atomize adhesives and the reduced air reduces turbulence at the part surface and increases transfer efficiency. HVLP spray systems can achieve transfer efficiencies of up to 65 percent under optimal conditions of part size and shape, and with good operator technique.

2. Emission Capture and Add-on Control Systems

In addition to pollution prevention measures, VOC emissions from miscellaneous industrial adhesive application processes can be reduced by the use of capture systems, in

conjunction with add-on control systems that either destroy or recover the VOC in the exhaust streams. As stated previously, although capture systems and add-on control devices are available to facilities operating miscellaneous industrial adhesive application processes, they are generally not used when low VOC adhesives and alternative application methods can be used to reduce VOC emissions. The majority of VOC emissions from miscellaneous industrial adhesive application processes occur in the spray booth. Spray booths typically exhaust a high volume of air to dilute the concentration of VOC for safety reasons to reduce potential worker exposure to solvent vapors and to reduce the flammability of the air-vapor mixture. Although VOC emissions in spray booth exhaust can be controlled with add-on controls, it is generally not cost effective to do so because of the large volume of air that must be treated and the low concentration of VOC.

Capture Systems

Capture systems, such as hoods and enclosures, collect solvent-laden air from process vents (e.g., spray booth vents) and/or fugitive emissions (e.g., flash-off area) and direct the captured air to a control device. The majority of VOC emissions from miscellaneous industrial adhesive application processes occur in the spray booth. These emissions can be ducted from the spray booth directly to the control device. In addition, hoods, floor air sweeps or enclosures can be used to collect fugitive emissions from solvents that evaporate in flash-off areas and route them to a control device.

The design of the capture system can greatly contribute to the overall VOC control efficiency. An efficient capture system maximizes the capture of emissions and minimizes the capture of dilution air. Spray booth design and air management can reduce the volume of exhaust air and maximize the VOC concentration of the exhaust air which can reduce the cost of control. Facilities may combine several captured VOC-laden streams and duct them to a single control device *Add-on Control Systems* Add-on controls reduce the amount of VOC emissions by either destruction or recovery with or without recycling of VOC emission in the exhaust streams. Two categories of add-on control devices can be used by miscellaneous industrial adhesive application facilities: combustion (thermal or catalytic oxidation) and recovery (adsorption and absorption). While many control devices can be used to reduce VOC emissions, the following summary covers those control devices known to be used with adhesive application processes: oxidation, adsorption, and absorption. In addition, there are other control measures known to reduce VOC emissions, but are not currently being widely used in facilities operating miscellaneous industrial adhesive application processes. These alternative control technologies are also discussed below.

Oxidation destroys VOC emissions in an exhaust stream by exposing the stream to an oxidizing atmosphere at high temperatures. Oxidizers may be of thermal or catalytic design and combust VOC-containing exhaust streams. Catalytic oxidizers are similar to thermal oxidizers but employ a catalyst to aid in the oxidation reaction. As a result, catalytic oxidizers operate at lower combustion temperatures relative to that required in thermal oxidizers. Both types of oxidizers generally utilize either regenerative or recuperative techniques to preheat inlet gas in order to decrease energy costs associated with high oxidation temperatures. They may also use primary or secondary heat recovery to reduce energy consumption. In general, oxidizers may achieve destruction efficiencies of greater than 95 percent as applied to adhesive application operations with high and constant concentrations of VOC.

Adsorption occurs when the unbalanced molecular forces on the surface of solids (the adsorbant) attract and retain gases and particulate matter that come in contact with the solid. Several materials are widely used as the adsorbent, such as activated carbon, organic resin polymer, and inorganic materials. Each has substantial surface area per unit volume. Carbon adsorbers are most commonly used in adhesive application processes.

In a carbon adsorber, activated carbon is used as the adsorbent in a regenerable fixed bed. In a typical carbon adsorber, VOC-laden air is passed through a fixed bed of granular activated carbon. Adsorber beds are typically operated in parallel to avoid interruption of VOC control. In this arrangement, when the adsorption capacity of one bed is exhausted, it can be removed from service and a second adsorber bed can be put into service, ensuring that a control device is operating at all times. The spent carbon bed in the first adsorber bed is then regenerated and can be put into service again.

Carbon adsorption systems can achieve control device efficiencies greater than 95 percent. In contrast to combustion, carbon adsorption does not destroy the VOC it removes from the air stream. Carbon adsorbers used in miscellaneous industrial adhesive application processes are thermally regenerated, usually by passing steam through the carbon beds. The VOC are removed from the carbon (desorbed) and transferred to the steam. The VOC-containing steam is then condensed, and the VOC solvent is separated from the water. The recovered solvent can then be decanted for sale or reuse. Regeneration can also be achieved with hot air. Hot-air regeneration can be quite attractive when dealing with water soluble solvents. Carbon adsorption is most amenable to coatings that use a single solvent; if solvent mixtures are collected by adsorbers, they usually are distilled for reuse.

There are two options for disposing recovered solvents that cannot be reused. The first is to sell the material back to the solvent supplier or an independent firm that specializes in reclaiming contaminated solvents. The other option is to use the recovered solvent as a fuel in coating ovens or in boilers. However, many coating ovens and boilers are gas-fired and would require burner modifications to burn solvent. Carbon adsorption is generally economically attractive only if the recovered solvent can be reused directly.

Carbon adsorbers are most suitable for solvents that are immiscible with water, such as toluene and xylene, but are not recommended for water-soluble VOC, such as methyl ethyl ketone and methyl isobutyl ketone. In the case where a water-soluble VOC is present, the water vapor will be adsorbed and desorbed along with the VOC vapor, and the VOC may require subsequent purification if it is to be reused.

The presence of solid particles or polymerizable substances in the inlet air stream to a carbon adsorber may require pretreatment of the inlet air. In addition, adsorption is usually used for adhesive application exhaust streams at ambient temperature up to approximately 38°C (100°F). Therefore, cooling and dehumidification may also be required as pretreatment in some cases. Adding equipment, such as a dehumidification system, increases the costs associated with the use of a carbon adsorption system.

Absorption is the process by which a gas stream is contacted with a liquid so that one or more of the components of the gas stream will dissolve in the liquid. Water is the most common absorbent, but organic solvents may also be used. Removal efficiency can be enhanced by the

addition of reactive chemical additives to the absorbent to increase solubility of the absorbed pollutant or change the equilibrium.

Alternative control technologies, such as condensation, biodegradation, and UV oxidation are applicable for control of VOC emissions from adhesives. However, EPA is not aware of any miscellaneous industrial adhesive application facilities currently using these types of control technologies.

B. Available Controls for VOC Emissions from Cleaning Materials

Pollution prevention is the most common emission control technique for reducing VOC emissions from cleaning materials. The pollution prevention measures applicable to miscellaneous industrial adhesive application processes include product substitution or reformulation, and work practice procedures. Cleaning materials with low or no VOC content or low-VOC composite vapor pressure may be used to reduce or eliminate VOC emissions from using these materials. Work practice procedures may also reduce VOC emission during cleaning operations by reducing the amount of VOC that can evaporate due to exposure to air.

No add-on control technologies are being used specifically for reducing VOC emissions from cleaning operations associated with miscellaneous industrial adhesive application processes. However, if cleaning operations are performed within a capture system that is ducted to an add-on control system, such as a hood routed to a thermal oxidizer, the VOC emissions from the cleaning operations would be reduced by destruction in the thermal oxidizer.

1. Product Substitution/Reformulation

Reducing the composite VOC vapor pressure or VOC content of the cleaning material used, either by substitution or reformulation, is one pollution prevention measure that is used to reduce VOC emissions from cleaning operations. However, little information is available regarding the types of low-VOC or VOC-free cleaning materials that could be used in miscellaneous industrial adhesive application processes and whether they are feasible for the broad types of adhesives used.

2. Work Practice Procedures

Work practice procedures are commonly used in industry to reduce VOC emissions from cleaning operations. The following work practice procedures are used to reduce VOC emissions from miscellaneous industrial adhesive application processes:

- Cover mixing and storage vessels for VOC-containing cleaning materials, and cleaning waste materials except when adding, removing, or mixing contents.
- Use closed containers or pipes to store and convey VOC-containing cleaning and cleaning waste materials.
- Minimize spills of VOC-containing cleaning and cleaning waste materials.
- Minimize VOC emissions during cleaning operations.

C. Existing Federal, State, and Local Recommendations or Regulations

The following discussion is a summary of State and local regulations that address VOC emissions from miscellaneous industrial adhesive application processes. In addition, Appendices B and C summarize the State and local provisions for adhesive VOC content limits and application equipment requirements. There are no previous EPA actions that address miscellaneous industrial adhesives.

1. Existing State and Local VOC Requirements

In 1998, the California Air Resources Board (ARB) issued a guidance document that included ARB's determination of Reasonably Available Control Technology (RACT) and Best Available Retrofit Control Technology (BARCT) for Adhesives and Sealants. This document presented RACT and BARCT for controlling VOC emissions from the commercial and industrial application of adhesives and sealants. The ARB RACT determination prescribes VOC emission limits for various industrial adhesives and sealants and was developed based on eight existing California air pollution control district rules for adhesives and sealants that were in effect in 1998. Those eight districts included Bay Area Air Quality Management District (AQMD), El Dorado County Air Pollution Control District (APCD), Placer County APCD, Sacramento Metropolitan AQMD, South Coast AQMD, Ventura County APCD, Yolo-Solano AQMD, and San Diego County APCD.

The ARB based the majority of its RACT determination on limits already in effect in South Coast AQMD, Bay Area AQMD, and Ventura County APCD, and concluded that the VOC limits for adhesives and sealants presented in its RACT determination were achievable and cost-effective. Furthermore, the ARB stated in its RACT determination that most of the adhesive and sealant products being sold in 1998 were already compliant with the VOC limits that were determined to be RACT.

Since the development of the ARB RACT determination, 5 additional California air pollution control districts have adopted rules based on the ARB RACT standards.

In 2007, the Ozone Transport Commission issued a Model Rule for Adhesives and Sealants. The Model Rule was based almost entirely on the 1998 CARB RACT determination. The Model Rule is for adoption by member states in 2009. To date, only Maryland has adopted an adhesives rule based on the OTC model rule. Maine and New Jersey are either currently considering adopting or are in the process of adopting the model rule.

Some states regulate VOC emissions from adhesives as part of their regulations for specific surface coating operations.

A total of 13 air pollution control districts in California have established rules specifically for adhesives. The various district adhesives rules do not all contain the same categories and limits as the ARB RACT guidance. Among these districts, the South Coast AQMD has generally adopted the most stringent VOC content limits for the adhesives categories included in SCAQMD Rule 1168 and in other districts with similar categories. If add-on controls are used, South Coast Rule 1168 requires that the control system capture at least 80 percent of the VOC emissions.

Several California air districts require the use of specific types of high-efficiency adhesive application methods to further reduce VOC emissions. For example, in addition to limiting the VOC contents in the adhesives, South Coast Rule 1168 requires the use of one of the following types of application equipment: electrostatic application; flow coating; dip coating; roll coating; hand application; high-volume, low-pressure (HVLP) spray; or an alternative method that is demonstrated to be capable of achieving a transfer efficiency equal to or better than HVLP spray. Alternative methods must be approved by the District based on actual transfer efficiency measurements in a side-by-side comparison of the alternative method and an HVLP spray gun. At least seven other District's rules that regulate emissions from adhesives are similar to South Coast Rule 1168 in that they also require that sources use methods that achieve high transfer efficiency.

At least eight Districts in California and Maryland regulate cleaning materials used in adhesive application processes. These regulations require a combination of work practice and equipment standards and limits on the VOC content, boiling point, or composite vapor pressure of the solvent. Some District rules allow the use of add-on controls as an alternative to the VOC content/boiling point/vapor pressure limits for cleaning materials. The work practice and equipment standards that have been adopted by California Districts include, for example, using closed containers for storing solvent and solvent containing wipes and rags, using enclosed and automated spray gun washing equipment, and prohibiting atomized spraying of solvent during spray gun cleaning. However, the cleaning material VOC content/boiling point/vapor pressure limits, overall control efficiency requirements, and work practices vary by District.

VI. Recommended Control Options

Based on a review of the current State and local requirements discussed above, we are recommending various options, such as the use of low VOC content adhesives, specified application methods and control devices, for controlling the VOC emissions from the adhesives used by facilities operating miscellaneous industrial adhesive application processes. We are also recommending work practices to further reduce VOC emissions from adhesives as well as to minimize emissions from cleaning materials used in miscellaneous industrial adhesive application processes.

To provide flexibility to facilities, we are recommending various options for controlling VOC emissions from miscellaneous industrial adhesives. We recommend specific VOC emission limits based on application processes (i.e., the types of adhesives and substrates). We recommend two options for achieving the recommended emission limits: (1) through the use of low-VOC content adhesives and specified application methods with good adhesive transfer efficiency; or (2) through the use of a combination of low-VOC adhesives, specified application methods, and add-on controls. As an alternative to the emission limits, we recommend an overall control efficiency of 85 percent. This alternative provides facilities the operational flexibility to use high efficiency add-on controls instead of low-VOC content adhesives and specified application methods, especially when the use of high VOC adhesives is necessary or desirable for product efficacy. We expect the 85 percent control efficiency recommendation to result in VOC emission reduction that is equivalent to or exceed the reduction from our recommended emission limits. Both the emission limits and the control efficiency recommendations reflect what we have concluded to be reasonably available VOC control

measures for miscellaneous industrial adhesives based on our review of Maryland's adhesives rule, the OTC model rule, and the various California air district rules.

As mentioned above, we are recommending the use of adhesive application methods with good adhesives transfer efficiency in conjunction with the use of low-VOC content adhesives. Specifically, we recommend the following application methods: electrostatic spray, HVLP spray, flow coat, roll coat, dip coat (including electrodeposition), airless spray, air-assisted airless spray, or other coating application method capable of achieving good transfer efficiency.

We are recommending that the VOC emission limits and 85% control efficiency described above not be applied to the following types of adhesives and adhesives primer application processes:

- Adhesives or adhesive primers being tested or evaluated in any research and development, quality assurance, or analytical laboratory.
- Adhesives or adhesive primers used in the assembly, repair, or manufacture of aerospace or undersea-based weapon systems.
- Adhesives or adhesive primers used in medical equipment manufacturing operations.
- Cyanoacrylate adhesive application processes.
- Aerosol adhesive and aerosol adhesive primer application processes.[3]
- Processes using polyester bonding putties to assemble fiberglass parts at fiberglass boat manufacturing facilities and at other reinforced plastic composite manufacturing facilities.
- Processes using adhesives and adhesive primers that are supplied to the manufacturer in containers with a net volume of 16 ounces or less, or a net weight of one pound or less.

We recommend, however, that the work practices recommended in this CTG be implemented to reduce VOC emissions during these types of adhesives and adhesives primer application processes.

Our recommended emission limits are based on the OTC Model Rule for Adhesives and Sealants. As previously mentioned, the emission limits in the OTC rule were California ARB RACT standards, which were based on numerous California District rules and adopted by other California District rules. Furthermore, the OTC model rule is intended for adoption by States. In light of the above, we consider the limits in the OTC model rule to be representative of what sources in nonattainment areas nationwide can achieve technically and economically and have therefore adopted these VOC limits as our recommendations in the CTG.

[3] Aerosol adhesives are regulated under EPA's VOC Emission Standards for Consumer Products at 40 CFR 59 subpart C. Aerosol adhesive primers are regulated as "primers" under EPA's VOC Emission Standards for Aerosol Coatings at 40 CFR 59 subpart E.

The recommended VOC emission limits can be met by averaging the VOC content of materials used on a single application unit for each day (i.e., daily within-application unit averaging). We do not recommend the use of cross-application unit averaging (i.e., averaging across multiple application units) to meet the VOC emission limits recommended in the CTG. However, we have previously provided guidance on cross-line averaging.[4] The guidance is directed to State and local agencies that elect to adopt a discretionary economic incentive program (EIP) and includes guidance on the use of cross-line averaging.

For cleaning materials, we are recommending work practices for use with all three of the control options to reduce VOC emissions. We are not recommending the application of add-on controls in conjunction with these work practices for the same reasons stated above for adhesive application. The use of add-on controls to reduce emissions from cleaning operations at miscellaneous industrial adhesive application facilities would be a costly alternative because the area to be controlled is quite large and a large volume of air would be captured and directed to a control device. We are also not recommending the use of a VOC content or VOC composite vapor pressure limit for cleaning materials. We do not have information available regarding current VOC content or VOC composite vapor pressure usage to determine a RACT limit for cleaning materials used in miscellaneous industrial adhesive application processes.

The following discussion summarizes our specific recommendations, including the recommended VOC emission limits, application methods, add-on controls, and work practices during miscellaneous industrial adhesive application and related cleaning processes.

A. Adhesive and Adhesive Primer Emission Limits

We are recommending separate sets of emission limits for general adhesive application processes, specialty adhesive application processes, and adhesive primer application processes. Provided in Table 1 are the recommended emission limits expressed in terms of mass of VOC per volume of adhesive or adhesive primer (excluding water and exempt compounds, as applied). We are recommending that all VOC-containing materials used by each miscellaneous industrial adhesive application process be included when determining the emission rate of the application process.

We also recommend that the VOC content of adhesives, other than reactive adhesives, used at facilities operating miscellaneous industrial adhesive application processes be determined using EPA Method 24. We recommend that the procedure for reactive adhesives in Appendix A of the NESHAP for surface coating of plastic parts (40 CFR part 63, subpart PPPP) be used to determine the VOC content of reactive adhesives. In addition, we recommend that manufacturer's formulation data be accepted as an alternative to these methods. If there is a disagreement between manufacturer's formulation data and the results of a subsequent test, we recommend that States use the test method results unless the facility can make a demonstration to the States' satisfaction that the manufacturer's formulation data are correct.

General adhesive application processes are those processes that are not specifically identified in Table 1 below as specialty adhesives application processes. Table 1 below includes

[4] Improving Air Quality with Economic Incentive Programs. U.S. Environmental Protection Agency. Research Triangle Park, NC. EPA-452/R-01-001. January 2001.

recommended VOC emission limits for general adhesives application processes based on the substrates that are being bonded during these processes. For general adhesive application processes using an adhesive to bond dissimilar substrates, we recommend that the highest VOC emission limit apply. Appendix A contains definitions of each of the application processes identified in Table 1 below.

Table 1. Recommended VOC Emission Limits for General and Specialty Adhesive Application Processes

General Adhesive Application Processes	Recommended VOC Emission Limit[1,2]	
	(g/l)	(lb/gal)
Reinforced Plastic Composite	200	1.7
Flexible vinyl	250	2.1
Metal	30	0.3
Porous Material (Except Wood)	120	1.0
Rubber	250	2.1
Wood	30	0.3
Other Substrates	250	2.1
Specialty Adhesive Application Processes	**Recommended VOC Emission Limit[1]**	
	(g/l)	**(lb/gal)**
Ceramic Tile Installation	130	1.1
Contact Adhesive	250	2.1
Cove Base Installation	150	1.3
Floor Covering Installation (Indoor)	150	1.3
Floor Covering Installation (Outdoor)	250	2.1
Floor Covering Installation (Perimeter Bonded Sheet Vinyl)	660	5.5
Metal to Urethane/Rubber Molding or Casting	850	7.1
Motor Vehicle Adhesive	250	2.1
Motor Vehicle Weatherstrip Adhesive	750	6.3
Multipurpose Construction	200	1.7
Plastic Solvent Welding (ABS)	400	3.3
Plastic Solvent Welding (Except ABS)	500	4.2
Sheet Rubber Lining Installation	850	7.1
Single-Ply Roof Membrane Installation/Repair (Except EPDM)	250	2.1
Structural Glazing	100	0.8
Thin Metal Laminating	780	6.5
Tire Repair	100	0.8
Waterproof Resorcinol Glue	170	1.4
Adhesive Primer Application Processes	**Recommended VOC Emission Limit[1]**	
	(g/l)	**(lb/gal)**
Motor Vehicle Glass Bonding Primer	900	7.5
Plastic Solvent Welding Adhesive Primer	650	5.4
Single-Ply Roof Membrane Adhesive Primer	250	2.1
Other Adhesive Primer	250	2.1

[1] Emission limits are mass of VOC per volume of adhesive or adhesive primer excluding water and exempt compounds, as applied.

[2] If an adhesive is used to bond dissimilar substrates together, then the applicable substrate category with the highest VOC emission limit is recommended as the limit for such application.

B. Adhesive Application Methods

In addition to the VOC emission limits in Section A, we recommend that one of the following application methods be used in conjunction with using low-VOC adhesives or adhesive primers:

- Electrostatic spray.
- HVLP spray.
- Flow coat.
- Roll coat or hand application, including non-spray application methods similar to hand or mechanically powered caulking gun, brush, or direct hand application.
- Dip coat (including electrodeposition).
- Airless spray.
- Air-assisted airless spray.
- Other adhesive application method capable of achieving a transfer efficiency equivalent to or better than that achieved by HVLP spraying.

C. Add-on Controls for Adhesive Application Operations

Should product performance requirements or other needs dictate the use of higher-VOC materials than those that would meet the recommended emission limits, a facility could choose to use add-on control equipment with an overall control efficiency of 85 percent. Alternatively, a facility could use a combination of adhesives and add-on control equipment on an application unit to meet the recommended mass of VOC per volume of adhesive or adhesive primer limits. Add-on devices include, for example, oxidizers, adsorbers, absorbers, and concentrators. Add-on devices coupled with capture systems to collect the VOC being released at the affected facilities can achieve an overall control efficiency of 85 percent. This control option, like the options noted above, applies to all adhesives and adhesive primers applied in miscellaneous adhesive application processes.

D. Work Practices for Adhesive-Related Activities

In addition to the control options above, this CTG recommends work practices to further reduce VOC emissions from miscellaneous industrial adhesive application-related activities. Although VOC reductions achieved by implementing the recommended work practices may not be quantifiable, they are beneficial to the overall goal of reducing VOC emissions. We recommend work practices for storage, mixing operations, and handling operations for adhesives, thinners, and adhesive-related waste materials. We recommend these practices for use with all three of the control options described above.

Specifically, we recommend the following work practices: (1) store all VOC-containing adhesives, adhesive primers, and process-related waste materials in closed containers; (2) ensure that mixing and storage containers used for VOC-containing adhesives, adhesive primers, and

process-related waste materials are kept closed at all times except when depositing or removing these materials; (3) minimize spills of VOC-containing adhesives, adhesive primers, and process-related waste materials; and (4) convey VOC-containing adhesives, adhesive primers, and process-related waste materials from one location to another in closed containers or pipes.

E. Work Practices for Cleaning Materials

This CTG recommends work practices to reduce VOC emissions from cleaning materials used in miscellaneous industrial adhesive application processes. These cleaning materials include both materials used to clean surfaces before adhesive or adhesive primer application (surface preparation) and to clean application equipment. Although VOC reductions achieved by implementing the recommended work practices may not be quantifiable, they are beneficial to the overall goal of reducing VOC emissions. We recommend work practices for storage, mixing operations, and handling operations for cleaning materials. We recommend these practices for use with all three of the control options described above

Specifically, we recommend that, at a minimum, the work practices include the following: (1) store all VOC-containing cleaning materials and used shop towels in closed containers; (2) ensure that storage containers used for VOC-containing cleaning materials are kept closed at all times except when depositing or removing these materials; (3) minimize spills of VOC-containing cleaning materials; (4) convey VOC-containing cleaning materials from one location to another in closed containers or pipes; and (5) minimize VOC emission from cleaning of application, storage, mixing, and conveying equipment by ensuring that equipment cleaning is performed without atomizing the cleaning solvent and all spent solvent is captured in closed containers.

VII. Cost Effectiveness of Recommended Control Options

We used the 2002 National Emissions Inventory (NEI) database to estimate the number of facilities operating miscellaneous industrial adhesive application processes. Based on the 2002 NEI, we estimated that there are a total of 1,048 such facilities in the U.S. Using the 2004 ozone nonattainment designations, we estimated that a total of 720 of these facilities are in ozone nonattainment areas. Based on the NEI VOC emissions data, 180 of the 720 facilities in ozone nonattainment areas emitted at or above the 6.8 kg/day (15 lb/day) recommended VOC emissions applicability threshold from miscellaneous industrial adhesive application processes. These 180 facilities emitted a total of about 4,428 Mg/yr of VOC (4,881 tpy), or an average of about 25 Mg/yr (27 tpy) of VOC per facility.

As previously mentioned, we are recommending in this CTG the VOC limits in the OTC rule. We also mentioned earlier that the emission limits in the OTC rule were the California ARB RACT standards, which were based on eight California Districts' adhesives rules (including the Ventura County APCD regulation) and have been adopted by other California Districts and Maryland. The ARB based its cost effectiveness estimate on an analysis performed by Ventura County APCD in 1993[4] for a facility that manufactures commercial furniture. We therefore use the cost analyses by Ventura County APCD and the California ARB scaled to 2007 dollars to estimate the cost effectiveness of our recommendations in this CTG. These cost estimates are relevant to this CTG's recommended levels of control because they are based on

the use of similar control measures (i.e., product substitution/reformulation and work practices) for miscellaneous industrial adhesive application processes.

In our analysis of the impacts of implementing the recommended levels of control in this CTG, we have assumed that all miscellaneous industrial adhesive application facilities will choose to utilize the low-VOC adhesive materials alternative. We made this assumption for two reasons. First, since facilities are meeting equivalent State and local limits, we believe that low-VOC adhesives that can meet the recommended control levels in this CTG are already available at a cost that is not significantly greater than the cost of adhesives with higher VOC contents. Secondly, the use of add-on controls to reduce emissions from typical adhesive application processes is a more costly alternative.

According to the 1993 Ventura County APCD Rule 74.20 Staff Report and the 1998 California ARB RACT determination, the annualized cost for a facility to convert to waterborne adhesives was estimated to be $2,300 (1993$). Using the producer price index for adhesive manufacturing and scaling the 1993 annualized cost to 2007, we estimate the annualized cost to be $3,356. We believe that this estimate also represents the cost of implementing this CTG's recommended VOC limits because the Ventura County APCD regulation and the ARB RACT determination is based on similar control measures. We assume that facilities in California and Maryland are already implementing the recommended measures in this CTG. For the facilities we identified as emitting more than 6.8 kg/day (15 lb/day) in ozone nonattainment areas outside of California and Maryland, we estimate the total annual cost to be $603,997, based on the use of low-VOC content adhesives. We estimate that the recommendations in this CTG will reduce VOC emissions from miscellaneous industrial adhesives application processes by about 64 percent. This is a reduction of 2,070 Mg/yr (2,281 tpy of VOC) from these facilities. Therefore, we estimate the cost effectiveness to be $292 per Mg ($265 per ton) of VOC emission reduction.

We believe that the work practice recommendations in this CTG will result in a net cost savings. Implementing work practices reduces the amount of cleaning materials used by reducing the amount that evaporates and is wasted. Similarly, we also believe that the recommendation to use the specified adhesive application methods will also result in net cost savings. Increasing the transfer efficiency of adhesive application to reduce VOC emissions will also reduce adhesive consumption and costs. However, these cost savings cannot be accurately estimated.

VIII. References

1. State of California Air Resources Board. *Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Adhesives and Sealants*. December 1998.

2. Ozone Transport Commission. *Model Rule for Adhesives and Sealants*. Available at http://www.otcair.org/projects_details.asp?FID=99&fview=stationary#

3. State of California Air Resources Board. *Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Adhesives and Sealants*. December 1998.

4. Ventura County Air Pollution Control District. *Staff Report Rule 74.20, Adhesives and Sealants*. June 8, 1993.

Appendix A

Definitions

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Definitions

Acrylonitrile-butadiene-styrene or **ABS welding** means any process to weld acrylonitrile-butadiene-styrene pipe.

Adhesive means any chemical substance that is applied for the purpose of bonding two surfaces together other than by mechanical means.

Adhesive primer means any product intended by the manufacturer for application to a substrate, prior to the application of an adhesive, to provide a bonding surface.

Aerosol adhesive or adhesive primer means an adhesive or adhesive primer packaged as an aerosol product in which the spray mechanism is permanently housed in a non-refillable can designed for handheld application without the need for ancillary hoses or spray equipment.

Ceramic tile installation adhesive means any adhesive intended by the manufacturer for use in the installation of ceramic tiles.

Chlorinated polyvinyl chloride plastic or **CPVC plastic welding** means a polymer of the vinyl chloride monomer that contains 67% chlorine and is normally identified with a CPVC marking.

Chlorinated polyvinyl chloride welding or **CPVC welding** means an adhesive labeled for welding of chlorinated polyvinyl chloride plastic.

Contact bond adhesive means an adhesive that: (i) is designed for application to both surfaces to be bonded together, and (ii) is allowed to dry before the two surfaces are placed in contact with each other, and (iii) forms an immediate bond that is impossible, or difficult, to reposition after both adhesive-coated surfaces are placed in contact with each other, and (iv) does not need sustained pressure or clamping of surfaces after the adhesive-coated surfaces have been brought together using sufficient momentary pressure to establish full contact between both surfaces. *Contact adhesive* does not include rubber cements that are primarily intended for use on paper substrates. *Contact adhesive* also does not include vulcanizing fluids that are designed and labeled for tire repair only.

Cove base means a flooring trim unit, generally made of vinyl or rubber, having a concave radius on one edge and a convex radius on the opposite edge that is used in forming a junction between the bottom wall course and the floor or to form an inside corner.

Cove base installation adhesive means any adhesive intended by the manufacturer to be used for the installation of cove base or wall base on a wall or vertical surface at floor level.

Cyanoacrylate adhesive means any adhesive with a cyanoacrylate content of at least 95 percent by weight.

EPDM roof membrane means a prefabricated single sheet of elastomeric material composed of ethylene propylenediene monomer and that is field applied to a building roof using one layer or membrane material.

Flexible vinyl means non-rigid polyvinyl chloride plastic with at 5 percent by weight plasticizer content.

Indoor floor covering installation adhesive means any adhesive intended by the manufacturer for use in the installation of wood flooring, carpet, resilient tile, vinyl tile, vinyl backed carpet, resilient sheet and roll or artificial grass. Adhesives used to install ceramic tile and perimeter bonded sheet flooring with vinyl backing onto a non-porous substrate, such as flexible vinyl, are excluded from this category.

Laminate means a product made by bonding together two or more layers of material.

Metal to urethane/rubber molding or casting adhesive means any adhesive intended by the manufacturer to bond metal to high density or elastomeric urethane or molded rubber materials, in heater molding or casting processes, to fabricate products such as rollers for computer printers or other paper handling equipment.

Motor vehicle adhesive means an adhesive, including glass bonding adhesive, used at a facility that is not an automobile or light-duty truck assembly coating facility, applied for the purpose of bonding two vehicle surfaces together without regard to the substrates involved.

Motor vehicle glass bonding primer means a primer, used at a facility that is not an automobile or light-duty truck assembly coating facility, applied to windshield or other glass, or to body openings, to prepare the glass or body opening for the application of glass bonding adhesives or the installation of adhesive bonded glass. Motor vehicle glass bonding primer includes glass bonding/cleaning primers that perform both functions (cleaning and priming of the windshield or other glass, or body openings) prior to the application of adhesive or the installation of adhesive bonded glass.

Motor vehicle weatherstrip adhesive means an adhesive, used at a facility that is not an automobile or light-duty truck assembly coating facility, applied to weatherstripping materials for the purpose of bonding the weatherstrip material to the surface of the vehicle.

Multipurpose construction adhesive means any adhesive intended by the manufacturer for use in the installation or repair of various construction materials, including but not limited to drywall, subfloor, panel, fiberglass reinforced plastic (FRP), ceiling tile and acoustical tile.

Outdoor floor covering installation adhesive means any adhesive intended by the manufacturer for use in the installation of floor covering that is not in an enclosure and that is exposed to ambient weather conditions during normal use.

Panel installation means the installation of plywood, pre-decorated hardboard (or tileboard), fiberglass reinforced plastic, and similar pre-decorated or non-decorated panels to studs or solid surfaces using an adhesive formulated for that purpose.

Perimeter bonded sheet flooring installation means the installation of sheet flooring with vinyl backing onto a nonporous substrate using an adhesive designed to be applied only to a strip of up to four inches wide around the perimeter of the sheet flooring.

Plastic solvent welding adhesive means any adhesive intended by the manufacturer for use to dissolve the surface of plastic to form a bond between mating surfaces.

Plastic solvent welding adhesive primer means any primer intended by the manufacturer for use to prepare plastic substrates prior to bonding or welding.

Plastic foam means foam constructed of plastics.

Plastics means synthetic materials chemically formed by the polymerization of organic (carbon-based) substances. Plastics are usually compounded with modifiers, extenders, and/or reinforcers and are capable of being molded, extruded, cast into various shapes and films, or drawn into filaments.

Polyvinyl chloride plastic or **PVC plastic** means a polymer of the chlorinated vinyl monomer that contains 57% chlorine.

Polyvinyl chloride welding adhesive or **PVC welding adhesive** means any adhesive intended by the manufacturer for use in the welding of PVC plastic pipe.

Porous material means a substance that has tiny openings, often microscopic, in which fluids may be absorbed or discharged, including, but not limited to, paper and corrugated paperboard. For the purposes of this CTG, *porous material* does not include wood.

Reinforced plastic composite means a composite material consisting of plastic reinforced with fibers.

Rubber means any natural or manmade rubber substrate, including but not limited to, styrene-butadiene rubber, polychloroprene (neoprene), butyl rubber, nitrile rubber, chlorosulfonated polyethylene and ethylene propylene diene terpolymer.

Sheet rubber lining installation means the process of applying sheet rubber liners by hand to metal or plastic substrates to protect the underlying substrate from corrosion or abrasion. These operations also include laminating sheet rubber to fabric by hand.

Single-ply roof membrane means a prefabricated single sheet of rubber, normally ethylene-propylenediene terpolymer, that is field applied to a building roof using one layer of membrane material. For the purposes of this CTG, *single-ply roof membrane* does not include membranes prefabricated from ethylene-propylenediene monomer (EPDM).

Single-ply roof membrane installation and repair adhesive means any adhesive labeled for use in the installation or repair of single-ply roof membrane. Installation includes, as a minimum, attaching the edge of the membrane to the edge of the roof and applying flashings to vents, pipes and ducts that protrude through the membrane. Repair includes gluing the edges of

torn membrane together, attaching a patch over a hole and reapplying flashings to vents, pipes or ducts installed through the membrane.

Single-ply roof membrane adhesive primer means any primer labeled for use to clean and promote adhesion of the single-ply roof membrane seams or splices prior to bonding.

Structural glazing means a process that includes the application of adhesive to bond glass, ceramic, metal, stone or composite panels to exterior building frames.

Subfloor installation means the installation of subflooring material over floor joists, including the construction of any load bearing joists. Subflooring is covered by a finish surface material.

Thin metal laminating adhesive means any adhesive intended by the manufacturer for use in bonding multiple layers of metal to metal or metal to plastic in the production of electronic or magnetic components in which the thickness of the bond line(s) is less than 0.25 millimeters.

Tire repair means a process that includes expanding a hole, tear, fissure or blemish in a tire casing by grinding or gouging, applying adhesive and filling the hole or crevice with rubber.

Waterproof resorcinol glue means a two-part resorcinol-resin-based adhesive designed for applications where the bond line must be resistant to conditions of continuous immersion in fresh or salt water.

Appendix B

Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

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Appendix B. Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

California District	Antelope Valley	Bay Area	El Dorado County	Placer County	Sacramento Metropolitan	San Diego County	San Joaquin Valley
Rule Citation	**Rule 1168**	**Rule 8-51**	**Rule 236**	**Rule 235**	**Rule 460**	**Rule 67.21**	**Rule 4653**
General Adhesive Application Processes							
Fiberglass	200		200	200	200	200	
Flexible vinyl				250	250		
Flexible vinyl to other substrate				250			
Metal	30	30	30	30	30	30	30
Other Substrates		250		250	250	250	250
Plastic Foams	120	120	120	120			120
Porous Material		120			120	120	120
Porous Material (e.g. wood, plastic foam, but not a plastic)				120			
Porous Material (except wood and plastic foam)							
Porous Material (except wood)	120		120				
Rubber		250		250	250		250
Wood	30	30	30				30
Specialty Adhesive Application Processes							
ABS Welding	400	400	350	400	400	400	400
Adhesive Primer for Plastic	250		250				
Carpet Pad Installation	150		150				
Cellulosic plastic welding (except ethyl cellulose)							
Ceramic Tile Installation	130	130	130	130	130	130	130
Computer Diskette Manufacturing	350	850	350	850	850	850	
Contact Adhesive - General						250	
Contact Adhesive - Special						400	250
Contact Adhesive - Specialty Substrate					250		
Contact Adhesive				200	250		250
Cove Base Installation	150	150	150	150	150	150	
CPVC Welding	270	490	250	490	490	490	490
Dry Wall and Panel Installation	200		200				
Elastomeric Adhesive						750	
Floor covering installation (except ceramic tile)							

Appendix B. Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

California District	Antelope Valley	Bay Area	El Dorado County	Placer County	Sacramento Metropolitan	San Diego County	San Joaquin Valley
Rule Citation	**Rule 1168**	**Rule 8-51**	**Rule 236**	**Rule 235**	**Rule 460**	**Rule 67.21**	**Rule 4653**
Floor covering installation						150	
Immersible Product Manufacturing		650					
Indoor Carpet Adhesives							
Indoor Floor Covering Installation		150		150	150	150	
Metal to Urethane/Rubber Molding or Casting Adhesive				250	250	850	
Multipurpose Architectural (except cove base installation)							
Multipurpose Construction		200		200	200	200	200
Nonmembrane Roof Installation/Repair		300		300	300	300	
Non-Vinyl Backed Indoor Carpet Installation	150		150				
Other Plastic Cement Welding Adhesive				450	450	510	450
Other Plastic Welding		500					
Outdoor Floor Covering Installation		350		250	250	250	
Perimeter Bonded Sheet Vinyl Flooring Installation		660			660	660	660
Plastic Cement Welding	250		250				
PVC Welding	285	510	250	510	510	510	510
Rubber Floor Installation	150		150				
Rubber Vulcanization Bonding		850					850
Sheet rubber lining installation adhesive						850	
Single-Ply Roof Material Installation/Repair		250					250
Single-Ply Roof Membrane Installation/Repair Adhesive				250	250	250	
Solvent welding adhesive							
Staple and Nail Manufacturing							640
Structural Glazing		100		100	100	100	100
Structural Wood Member Adhesive							
Styrene-acrylonitrile welding adhesive							
Subfloor Installation	200		200				
Thin Metal Laminating		780		250	780	780	

Appendix B. Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

California District	Antelope Valley	Bay Area	El Dorado County	Placer County	Sacramento Metropolitan	San Diego County	San Joaquin Valley
Rule Citation	**Rule 1168**	**Rule 8-51**	**Rule 236**	**Rule 235**	**Rule 460**	**Rule 67.21**	**Rule 4653**
Tire Retread		100		100	100	100	
Top and Trim Installation		540					
Traffic Marking Tape Adhesive							
VCT and Asphalt Tile Installation	150		150				
Waterproof Resorcinol Glue		170		170	170	170	170
Wood Flooring Installation	150		150				
Adhesive Primer Application Processes							
Automotive Glass	Included Above	700	Included Above	700	700	700	
Plastic Cement Welding		650		650	400	650	650
Single-Ply Roof Membrane					250	250	
Traffic Marking Tape		150		150	150	150	
Other		250		250	250	250	250
Natural gas pipeline tape adhesive primer						600	

Appendix B. Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

California District / State	Santa Barbara County	Shasta County	South Coast	Tehama County	Ventura County	Yolo-Solano	Maryland (OTC Model Rule)
Rule Citation	**Rule 353**	**Rule 3:32**	**Rule 1168**	**Rule 4:40**	**Rule 74.20**	**Rule 2.33**	**COMAR 26.11.35**
General Adhesive Application Processes							
Fiberglass	200	200	80	200	200		200
Flexible vinyl	250	250		250	250		250
Flexible vinyl to other substrate	250			250	250		
Metal	30	30	30	30	30	30	30
Other Substrates	250	250		250	250	250	250
Plastic Foams	120		50	120	120	120	
Porous Material		120				150	120
Porous Material (e.g. wood, plastic foam, but not a plastic)	120			120			
Porous Material (except wood and plastic foam)					150		
Porous Material (except wood)			50				
Rubber	250	250		250			250
Wood			30		30		
Specialty Adhesive Application Processes							
ABS Welding	400	400	325	400	400		400
Adhesive Primer for Plastic							
Carpet Pad Installation			50				
Cellulosic plastic welding (except ethyl cellulose)					100		
Ceramic Tile Installation	130	130	65	130	130	130	130
Computer Diskette Manufacturing	850	850	350	850			850
Contact Adhesive - General							
Contact Adhesive - Special			250				
Contact Adhesive - Specialty Substrate	400	250		250	200		
Contact Adhesive	250	250	80	250	200		250
Cove Base Installation	150	150	50	150	150		150
CPVC Welding	490	490	490	490	490		490
Dry Wall and Panel Installation			50				
Elastomeric Adhesive							

Appendix B. Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

California District / State	Santa Barbara County	Shasta County	South Coast	Tehama County	Ventura County	Yolo-Solano	Maryland (OTC Model Rule)
Rule Citation	**Rule 353**	**Rule 3:32**	**Rule 1168**	**Rule 4:40**	**Rule 74.20**	**Rule 2.33**	**COMAR 26.11.35**
Floor covering installation (except ceramic tile)					150		
Floor covering installation							
Immersible Product Manufacturing							
Indoor Carpet Adhesives			50				
Indoor Floor Covering Installation	150	150		150		150	150
Metal to Urethane/Rubber Molding or Casting Adhesive	850	250		250			850
Multipurpose Architectural (except cove base installation)					200		
Multipurpose Construction	200	200	70	200		200	200
Nonmembrane Roof Installation/Repair	300	300		300	300		300
Non-Vinyl Backed Indoor Carpet Installation							
Other Plastic Cement Welding Adhesive	510	450		450			510
Other Plastic Welding					500		
Outdoor Floor Covering Installation	250	250	150	250			250
Perimeter Bonded Sheet Vinyl Flooring Installation	660	660		660			660
Plastic Cement Welding			250			450	
PVC Welding	510	510	510	510	510		510
Rubber Floor Installation			60				
Rubber Vulcanization Bonding							
Sheet rubber lining installation adhesive	850		850				850
Single-Ply Roof Material Installation/Repair						250	
Single-Ply Roof Membrane Installation/Repair Adhesive	250	250	250	250	250		250
Solvent welding adhesive						450	
Staple and Nail Manufacturing						640	
Structural Glazing	100	100	100	100	100	100	100
Structural Wood Member Adhesive			140				
Styrene-acrylonitrile welding adhesive					100		
Subfloor Installation			50				

Appendix B. Summary of State and Local Requirements for VOC Emissions from Adhesives and Adhesive Primers

California District / State	Santa Barbara County	Shasta County	South Coast	Tehama County	Ventura County	Yolo-Solano	Maryland (OTC Model Rule)
Rule Citation	**Rule 353**	**Rule 3:32**	**Rule 1168**	**Rule 4:40**	**Rule 74.20**	**Rule 2.33**	**COMAR 26.11.35**
Thin Metal Laminating	780	780		780			780
Tire Retread	100	100	100	100	100		100
Top and Trim Installation		540	250	540			
Traffic Marking Tape Adhesive					150		
VCT and Asphalt Tile Installation			50				
Waterproof Resorcinol Glue	170	170		170			170
Wood Flooring Installation			100				
Adhesive Primer Application Processes							
Automotive Glass	700	700	Included Above	700	700	Included Above	700
Plastic Cement Welding	650	650		400	650		650
Single-Ply Roof Membrane	250	250		250	250		250
Traffic Marking Tape	150	150		150			150
Other	250	250		250	250		250
Natural gas pipeline tape adhesive primer							

Appendix C

Summary of State and Local Requirements for Application Method and Control Efficiency

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Appendix C. Summary of State and Local Requirements for Application Method and Efficiency

California District	Antelope Valley	Bay Area	El Dorado County	Placer County	Sacramento Metropolitan	San Diego County	San Joaquin Valley
Rule Citation	**Rule 1168**	**Rule 8-51**	**Rule 236**	**Rule 235**	**Rule 460**	**Rule 67.21**	**Rule 4653**
Adhesive Application Method							
Aerosol Cans				x	x		
Air-Assisted Airless Spray			x				
Air-Atomized (for contact adhesives)							x
Airless Spray, Air-Assisted Airless Spray, Air-Atomized Spray (for contact adhesives)				x	x		
Airless Spray, Air-Assisted Airless Spray, Air-Atomized Spray (for viscosity 200 cp or grater)	x						
Brush or Roll Coat	x		x	x	x		x
Dip Coat	x		x	x	x		x
Electrodeposition			x	x	x		
Electrostatic Spray	x		x	x	x		x
Flow Coat	x		x	x	x		x
Hand Application	x		x	x	x		x
HVLP Spray	x		x	x	x		x
LVLP Spray			x	x	x		
Other, Transfer Efficiency Minimum	65%			x, none specified			65%
Add-On Control Efficiency							
Capture Efficiency			90% by wt		90% by wt		
Control Efficiency			95% by wt		95% by wt		
Overall Efficiency	85%			85%		85% by wt	85% by wt
Overall VOC Reduction Efficiency	80% by wt						

Appendix C. Summary of State and Local Requirements for Application Method and Efficiency

California District / State	Santa Barbara County	Shasta County	South Coast	Tehama County	Ventura County	Yolo-Solano	Maryland (OTC Model Rule)
Rule Citation	**Rule 353**	**Rule 3:32**	**Rule 1168**	**Rule 4:40**	**Rule 74.20**	**Rule 2.33**	**COMAR 26.11.35**
Adhesive Application Method							
Aerosol Cans		x		x		x	
Air-Assisted Airless Spray							
Air-Atomized (for contact adhesives)							
Airless Spray, Air-Assisted Airless Spray, Air-Atomized Spray (for contact adhesives)		x		x		x	
Airless Spray, Air-Assisted Airless Spray, Air-Atomized Spray (for viscosity 200 cp or grater)			x				
Brush or Roll Coat		x	x	x		x	
Dip Coat		x	x	x		x	
Electrodeposition		x		x		x	
Electrostatic Spray		x	x	x		x	
Flow Coat		x	x	x		x	
Hand Application		x	x	x		x	
HVLP Spray		x	x	x		x	
LVLP Spray		x		x		x	
Other, Transfer Efficiency Minimum		x, none specified	65%	x, none specified		x, none specified	
Add-On Control Efficiency							
Capture Efficiency		90% by wt		90% by wt			
Control Efficiency		95% by wt		95% by wt			
Overall Efficiency	85% by wt				85% by wt		85% by wt
Overall VOC Reduction Efficiency			80%			85% by wt	

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