State Of The Art (SOTA)
Manual for Surface Coating Operations

July 1997

State of New Jersey
Department of Environmental Protection
Air Quality Permitting Program

State of the Art (SOTA)
Manual for Surface Coating Operations
Section 3.7

Table of Contents

3.7.i TABLES

3.7.ii ABBREVIATIONS

ACT	Alternative Control Techniques
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
CE	Cost Effectiveness
CFR	Code of Federal Regulations
CO	Carbon Monoxide
DOE	Department of Energy
DRE	Destruction or Removal Efficiency
EMF/RFI	Electromagnetic Interference/Radio Frequency Interference
HAP	Hazardous Air Pollutant
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
LAER	Lowest Achievable Emission Rate
MACT	Maximum Achievable Control Technology
MSDS	Material Safety Data Sheet
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection (The Department)
NSPS	New Source Performance Standard
PPM	Parts Per Million
PSD	Prevention of Significant Deterioration
RACT	Reasonably Available Control Technology
SCAQMD	South Coast Air Quality Management District
THC	Total Hydrocarbon
TSP	Particulate Matter
TXS	Toxic Substance
USEPA	United States Environmental Protection Authority
UV	Ultraviolet
VOC	Volatile Organic Compound

3.7 SOTA MANUAL FOR SURFACE COATING OPERATIONS

3.7.1. Scope

These SOTA performance levels apply to all newly constructed, reconstructed, or modified surface coating operations and spray booths. They are defined, but are not limited to the following categories of surface coating operations:

- Can Coating - Two piece can manufacturing (stores beer and other beverages) and three piece can manufacturing (stores edible and non-edible products).

- Magnetic Wire Coating - The application of a coat of electrically insulating varnish or enamel to aluminum or copper wire used in machinery.

- Miscellaneous Metal Parts - Coating of metal and plastic parts not fitting the general categories specifically listed here.

- Flat Wood Panel Coating - The undercoating and finish coating of interior panels of hardwood plywood (natural and veneer, particle board, and hardboard).

- Paper Coating - Decorative or functional coating of a uniform layer across a substrate that improves printability, gloss, weatherability, scuff, and chemical resistance. This category does not include printing and graphic arts operations.

- Polymeric Coating Of Supporting Substrates - A web coating process other than paper coating that supplies elastomer or other polymeric material to a substrate (woven, nonwoven, textiles, fiberglass, leather, yarn, and cord). Typical products include rainwear, conveyor belts, V-belts, diaphragms, gaskets, printing blankets, luggage, and aircraft and military products.

- Automobile and Light Duty Truck Coating - An assembly line conveyor coating operation consisting of several steps in the coating process of new automobiles and light duty trucks.

- Pressure Sensitive Tapes And Labels - Coating of backing material (cloth, paper, or film) with a material that results in a label or tape that will stick on contact without wetting, heating, or adding a curing agent.

- Metal Coil Coating - A linear coating process that provides protective and decorative surfaces to flat metal sheet or strip that is packaged in rolls or coils.

- Large Appliance Coating - The application of protective and decorative surfaces to preformed large appliances.

- Metal Furniture Coating - Coating of metal desks, chairs, tables, cabinets, bookcases, and lockers at the point of manufacture.

- Magnetic Tape Manufacturing - A mixture of magnetic particles, resins, and solvents is coated on foil and plastic film or web.

- Plastic Parts Coatings For Business Machines - Coatings applied to plastic parts used in the assembly of business machines to improve appearance, protect parts from chemical and physical stress, or antenuate EMF/RFI.

- Wood Furniture Manufacturing Surface Coating - Coating of any product made of wood, a wood product such as rattan or wicker, or engineered wood product such as particleboard, used in the manufacture of wood furniture.

- Aerospace Manufacturing And Rework Facilities Coating - Any material applied to the surface of an aerospace vehicle or component to form a decorative or functional solid film.

- Vinyl Coating - The application of any surface coating formulation, except ink and plastisol, to vinyl-coated fabric or vinyl sheets. Printing on flexible vinyl is covered under graphic arts in a separate manual. The use of plastisols is a miscellaneous surface coating operation for which SOTA will be determined on a case-by-case basis.

- Urethane Coating - The application of any surface coating formulation, except plastisol, to urethane coated fabric or urethane sheets that are more than 0.002 inches (50 micrometers) thick, except resilient floor covering and flexible packaging. The use of plastisols is a miscellaneous surface coating operation for which SOTA will be determined on a case-by-case basis.

- Miscellaneous Surface Coating - This category includes coating of fabrics, leather, pharmaceutical tablets, glass, and pipe, in addition to any other operation not described in the categories listed above.

3.7.2. SOTA Performance Levels

State of the Art (SOTA) performance levels for individual surface coating categories are given in Table 1. These performance levels are primarily specifications for compliant coatings. All VOC content levels in Table 1 are for “as applied” coatings. If an applicant proposes to use coatings that comply with the VOC content levels specified in Table 1, the applicant is using SOTA technology. If an applicant cannot meet the specifications in Table 1, add-on controls are SOTA. If an applicant proposes to use coatings formulated to meet the performance levels in Table 1 and emissions from the source will exceed 25 tons per year after controls, a case-by-case analysis must be submitted to further reduce emissions using pollution prevention and/or add-on control techniques.

To achieve SOTA with add-on controls, the following requirements must be met:

1. Capture Efficiency = 100 percent

2. DRE for oxidizers = 99 percent (design) and 95 percent (demonstrated by test). To be designed to achieve a design DRE of 99 percent, thermal oxidizers must have a temperature of 1,500°F and a 0.5 second residence time.

3. DRE for carbon adsorption systems = 95 percent

Add-on controls meeting the above specification is SOTA for all surface coating operations having gas streams with a VOC concentration (without the addition of dilution air) of 50 ppmv or greater. Sources that have gas streams with a VOC concentration less than 50 ppmv must submit a case-by-case analysis to demonstrate that there are no low-solvent technologies with a lower VOC emission rate that can be used cost-effectively to meet the requirement for SOTA except the proposed technology. But, the use of add-on controls need not be addressed.

Table 1
State of the Art Performance Levels for Surface Coating Operations

Surface Coating SOTA	
Coating Operation Type	***Performance Level***
Can Coating	Base coat - ≤ 2.34 lbs VOC/gal of solids Inside spray coating - ≤ 1.84 lbs VOC/gal of solids. Overvarnish - ≤ 2.92 lbs VOC/gal of solids. Rim varnish - ≤ 3.51 lbs VOC/gal of solids. End sealing compound - ≤3.7 lbs VOC/gal - (H_2O + exempt solvents)
Magnet Wire Coating	≤ 1.7 lbs VOC/gal - (H_2O + exempt solvents)
Miscellaneous Metal Parts	*General and military specification coatings*: Air dried - ≤ 2.8 lbs VOC/gal - (H_2O + exempt solvents). Baked - ≤ 2.3 lbs VOC/gal - (H_2O + exempt solvents). *Prefabricated architectural component*: Air dried - ≤ 3.5 lbs VOC/gal - (H_2O + exempt solvents). Baked - ≤ 2.3 lbs VOC/gal - (H_2O + exempt solvents). *Solar-absorbent, heat-resistant, extreme high gloss, touch up, and repair*: Air dried - ≤ 3.5 lbs VOC/gal - (H_2O + exempt solvents). Baked - ≤ 3.0 lbs VOC/gal - (H_2O + exempt solvents). *Etching filler, metallic, silicone release, camouflage, vacuum-metalizing, mold-seal, high-temperature, electric-insulating varnish, pan backing, and pretreatment coatings:* Air dried or baked - ≤ 3.5 lbs VOC/gal - (H_2O + exempt solvents). Material used for stripping - ≤ 1.7 lbs VOC/gal - (H_2O + exempt solvents)

Surface Coating SOTA	
Coating Operation Type	***Performance Level***
Flat Wood Panel Coating	*Coating and adhesive - interior* - ≤ 2.1 lbs VOC/gal - (H_2O + exempt solvents). *Inks - interior* - ≤ 2.5 lbs VOC/gal - (H_2O + exempt solvents). *Coatings - exterior* - ≤ 2.9 lbs VOC/gal - (H_2O + exempt solvents).
Paper Coating	2.2 lbs VOC - (H_2O + exempt solvents)
Polymeric Coating of Supporting Substrates	Leather coating - ≤ 5.8 lbs VOC/gal - (H_2O + exempt solvents). Fabric coating - ≤ 2.9 lbs VOC/gal - (H_2O + exempt solvents) Vinyl coating - ≤ 3.8 lbs VOC/gal - (H_2O + exempt solvents)
Automobile and Light Duty Truck Coating	Electrophoric prime Coat - ≤ 1.2 lb VOC/gal - (H_2O + exempt solvents) Spray prime Coat - ≤ 15.0 VOC/gal of solids applied Primer surfacer - ≤ 15.0 VOC/gal of solids applied Spray topcoat - ≤ 15.0 VOC/gal of solids applied Flexible primer - ≤ 4.1 lbs VOC/gal - (H_2O + exempt solvents) Color topcoat - ≤ 3.8 lbs VOC/gal - (H_2O + exempt solvents) Basecoat/clearcoat -≤ 4.5 lbs VOC/gal - (H_2O + exempt solvents) Off-line coatings - ≤ 2.8 lbs VOC/gal - (H_2O + exempt solvents) Paint Stripe - ≤5.6 lb VOC/gal - (H_2O + exempt solvents) Repair - ≤ 4.8 lb VOC/gal - (H_2O + exempt solvents) Custom topcoating - ≤5.0 lb VOC/gal - (H_2O + exempt solvents)
Pressure Sensitive Tapes and Labels	Adhesives ≤ 2.2 lb VOC/gal - (H_2O + exempt solvents)
Metal Coil Coating	≤ 1.67 VOC/gal - (H_2O + exempt solvents)
Large Appliance Coating	≤ 2.8 lbs VOC/gal - (H_2O + exempt solvents) - Air dried ≤ 2.3 lbs VOC/gal - (H_2O + exempt solvents) - Baked coating
Metal Furniture Coating	≤ 2.8 lbs VOC/gal - (H_2O + exempt solvents) - Air dried ≤ 2.3 lbs VOC/gal - (H_2O + exempt solvents) - Baked coating
Magnetic Tape Manufacturing	HAP emissions: Comply with MACT. VOCs: Coating ≤ 2.21 lb VOC/gal - (H_2O + exempt solvents) Wash premixer ≤ 2.21 lb VOC/gal - (H_2O + exempt solvents)
Plastic Parts Coating for Business Machines	**General coating:** One-component ≤ 2.3 lb VOC/gal - (H_2O + exempt solvents) Two-component ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) **Military spec. coating** One-component ≤ 2.8 lb VOC/gal - (H_2O + exempt solvents) Two-component ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) Multi-colored coatings ≤ 5.7 lb VOC/gal - (H_2O + exempt solvents) Electric Dissipating coatings and shock-free coatings ≤ 6.7 lb VOC/gal - (H_2O + exempt solvents) Metallic coatings ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents)
Wood Furniture Manufacturing Operations	HAP emissions: Comply with MACT. VOCs: Finishing materials applied with an air spray gun - ≤ 1.0 lb VOC/lb solids, as applied. Topcoat - ≤ 0.8 lb VOC/lb solids, as applied. **or** Sealer system - ≤ 1.9 lb

Surface Coating SOTA	
Coating Operation Type	***Performance Level***
	VOC/lb solids, as applied and topcoat - ≤ 1.8 lb VOC/lb solids, as applied. **or** Acid-cured alkyd amino vinyl sealers ≤ 2.3 lb VOC/lb solids, as applied and Acid-cured alkyd amino conversion varnish topcoat ≤ 2.0 lb VOC/lb solids, as applied. **or** If not using acid-cured alkyd amino vinyl sealers and acid-cured alkyd amino conversion varnish topcoat, then sealers - ≤ 1.9 lb VOC/lb solids, as applied, and topcoat - ≤ 2.0 lb VOC/lb solids, as applied. **or** If using an acid-cured alkyd amino vinyl sealer and a topcoat other than an acid-cured alkyd amino conversion varnish topcoat, the sealer - ≤ 2.3 lb VOC/lb solids, as applied, and the topcoat - ≤ 1.8 lb VOC/lb solids, as applied. Strippable booth coating ≤ 0.8 lb VOC/lb solids, as applied
Aerospace Manufacturing and Rework Facility Coating	HAP emissions: Comply with MACT. Primer ≤ 2.9 lb VOC/gal - (H_2O + exempt solvents) Topcoat ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) Pretreatment ≤ 6.5 lb VOC/gal - (H_2O + exempt solvents) Adhesion promoter ≤ 7.0 lb VOC/gal - (H_2O + exempt solvents) Adhesive bonding primer Cured at 250^0F or below ≤ 2.1 lb VOC/gal - (H_2O + exempt solvents) Cured above 250^0F ≤ 2.1 lb VOC/gal - (H_2O + exempt solvents) **Flight-testing coating**: Used on missiles or single use target craft ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) All other ≤ 7.0 lb VOC/gal - (H_2O + exempt solvents) Fuel tank coating ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) Fuel tank adhesive ≤ 5.1 lb VOC/gal - (H_2O + exempt solvents) Electronic- or radiation -effect coating ≤ 6.6 lb VOC/gal - (H_2O + exempt solvents) Touch-up, line seal maskants ≤ 6.2 lb VOC/gal - (H_2O + exempt solvents) Photolithography maskants ≤ 7.0 lb VOC/gal - (H_2O + exempt solvents) Temporary protective coating ≤ 2.1 lb VOC/gal - (H_2O + exempt solvents) **Space-vehicle coatings** Electrostatic discharge protective coatings ≤ 6.63 lb VOC/gal - (H_2O + exempt solvents) Other space-vehicle coatings ≤ 8.3 lb VOC/gal - (H_2O + exempt solvents) Adhesives ≤ 6.63 lb VOC/gal - (H_2O + exempt solvents) Wing coating ≤ 6.21 lb VOC/gal - (H_2O + exempt solvents) Impact-resistant coating ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) High-temperature coating ≤ 7.0 lb VOC/gal - (H_2O + exempt solvents) Antichafe coating ≤ 4.97 lb VOC/gal - (H_2O + exempt solvents) Rain erosion-resistant coating ≤ 6.63 lb VOC/gal - (H_2O + exempt solvents) **Fire-resistant coatings** Civilian ≤ 5.4 lb VOC/gal - (H_2O + exempt solvents) Military ≤ 8.0 lb VOC/gal - (H_2O + exempt solvents)

Surface Coating SOTA	
Coating Operation Type	***Performance Level***
	Conformal coating ≤ 6.2 lb VOC/gal - (H_2O + exempt solvents) Sealant ≤ 5.0 lb VOC/gal - (H_2O + exempt solvents) **Adhesives** Non-structural ≤ 2.1 lb VOC/gal - (H_2O + exempt solvents) Structural Autoclavable ≤ 0.41 lb VOC/gal - (H_2O + exempt solvents) Non-autoclavable ≤ 7.0 lb VOC/gal - (H_2O + exempt solvents) Optical anti-reflective coating ≤ 5.8 lb VOC/gal - (H_2O + exempt solvents) **Wire coating** Electronic wire coating ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) Anti-wicking ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) Pre-bonding etchant ≤ 3.5 lb VOC/gal - (H_2O + exempt solvents) Phosphates ester resistant ink ≤ 7.66 lb VOC/gal - (H_2O + exempt solvents) Metallized epoxy coating ≤ 5.8 lb VOC/gal - (H_2O + exempt solvents) Clear topcoat ≤ 4.3 lb VOC/gal - (H_2O + exempt solvents) Scale inhibitor ≤ 7.3 lb VOC/gal - (H_2O + exempt solvents) Primer compatibles with rain erosion-resistant coating ≤ 7.0 lb VOC/gal - (H_2O + exempt solvents)
Vinyl Coating	2.2 lbs VOC/gal - (H_2O + exempt solvents)
Urethane Coating	2.2 lbs VOC/gal - (H_2O + exempt solvents)
Miscellaneous Surface Coating	Fabric coating - 2.2 lbs VOC - (H_2O + exempt solvents) Tablet coating - ≤ 5.5 lbs VOC/gal - (H_2O + exempt solvents) Glass coating - ≤ 3.0 lbs VOC/gal - (H_2O + exempt solvents) Metal and Concrete Pipe: Clear coating - ≤ 4.3 lbs VOC/gal - (H_2O + exempt solvents) Air-dried - ≤ 3.5 lbs VOC/gal - (H_2O + exempt solvents) Extreme performance - ≤ 3.5 lbs VOC/gal - (H_2O + exempt solvents) All other coatings - 3.0 lbs VOC/gal - (H_2O + exempt solvents)

3.7.3. Technical Basis

To define SOTA performance levels for surface coating, levels are developed from emission limitations that are being met by working sources, from permits issued by the New Jersey Department of Environmental Protection, New Jersey's VOC RACT rules (N.J.A.C. 7:27-16), California's VOC RACT rules, guidance from the USEPA BACT/LAER Control Technologies Database, National Emission Standards for Hazardous Air Pollutants (40 CFR 63), and the SCAQMD BACT Guidelines. Additional guidance was received during discussions with state environmental protection agencies in Oregon, Texas, Illinois, Michigan, South Carolina, and Wisconsin.

3.7.4 Control Technologies

Pollution prevention and add-on control technology are used to reduce emissions from surface-coating operations. Special requirements for product performance may limit the use of pollution prevention measures in some cases.

The primary pollutants of concern for surface coating operations are VOC and HAPs. Inks and coatings consist of coating solids that include a resin, pigment, various additives and a carrier solvent. The coating solids are suspended in the carrier solvent. The coating is applied in a variety of ways including spraying in a spray booth, dip coating and roll coating. After the coating is applied, the carrier solvent evaporates allowing the coating to harden on the substrate. Organic solvents have been commonly used as the carrier solvent since they evaporate quickly allowing the coating to dry rapidly. The amount of organic solvents used in a conventional solvent-borne coating varies greatly. However, typical formulations consist of between 50 to 90 percent organic solvent by volume, For many applications, a drying oven is used to evaporate the carrier solvent more quickly. Most of the organic solvents are classified as VOCs that are a precursor to the formation of ozone in the troposhere. Thus, the evaporation of solvents from coatings contributes to the ozone nonattainment problem in New Jersey.

3.7.4.1 Pollution Prevention

Two general approaches have been used to reduce VOC emissions from surface coating operations:

1. reducing or replacing the organic solvent in a coating system; and/or

2. improving the transfer efficiency of the coating operation.

The ability to use pollution prevention techniques is limited by the ability of alternative coatings or coating methods to meet product quality standards. The availability of acceptable alternative coatings and methods varies between the different types of surface coating operations. Even within a type of surface coating operation, individual sources may not be able to use an alternative coating although most other sources in the category can.

3.7.4.1.a Alternative Coating Systems

Alternative coating systems can be classified as (1) powder coatings, (2) radiation-cured coatings, (3) waterborne coatings and (4) high-solids coatings.

Powder Coating. Powder coatings are thermoplastic or thermosetting powders. They contain no organic solvents. Thermoplastic powder coatings melt and flow when heated. However, they continue to have the same chemical composition upon cooling and solidifying. Thermosetting powder coatings melt and flow when

heated. However, they continue to have the same chemical composition upon melting and solidifying. Thermosetting powder coatings melt when heated, flow into a uniform thin layer and cross-link chemically within themselves or with other reactive components to form a higher molecular weight reaction product. Electrostatic application techniques or the fluidized bed process can be used to apply powder coatings.

Radiation-Cured Coatings. Radiation-cured coatings typically contain no organic solvent carriers. These coatings consist of mixtures of low molecular weight polymers or oligomers dissolved in low molecular weight acrylic monomers. Electron beam or ultraviolet light sources are used to cure these coatings.

Waterborne Coatings. Waterborne coatings use water as the carrier solvent. Organic solvents are reduced or eliminated. In most cases, a small amount of organic solvent is required to aid in wetting the pigments, to produce solubility (in the case of partially water-soluble, film-forming components) and to promote good flow and viscosity characteristics in the coating system. The amount of solvent of organic in a waterborne coating varies between 2% and 15% of the total volume of the coating formulation. However, the use of waterborne coatings can significantly reduce VOC emissions when compared to using conventional solvent-borne coatings.

High Solids Coatings. High solids coatings are those with solids content of 62% or higher by volume. VOC emissions are reduced because of the lower solvent content. Most of the reasonably available control technology (RACT) regulations apply to existing surface coating operations are based on using high solids coatings. Although other technologies often provide a greater reduction in VOC emissions, using high solids coatings may constitute SOTA for some surface coating operations if other technologies are unavailble.

3.7.4.1.b Transfer Efficiency Improvements

Transfer efficiency is the ratio of the amount of coating solids deposited on the surface to the amount of coating solids used. If the transfer efficiency for a particular surface coating operation can be increased, the amount of coating (and the resultant VOC emissions) will be reduced. Typical technologies used to improve transfer efficiency and reduce emissions in surface coating operations include dip-coating, flow-coating and electrostatic spraying.

Dip-Coating. Dip-coating can be used for some surface coating operations such as metal furniture and large appliances to improve transfer efficiency. The mixed coating is applied in a large main tank. After emerging from the tank, coated parts are moved into an area where excess paint drips off. The excess paint is collected and returned to the main tank. Fresh, properly mixed paint and water or organic

solvent is added to the main tank to compensate for usage and evaporation and to maintain a constant solids concentration. Transfer efficiencies for dip-coating can be as high as 85%.

Flow-Coating. Flow-coating can also be used for metal furniture and large appliance surface coating. In this technique, articles on a conveyor line are coated from overhead nozzles from which the coating is fed in a steady stream. The excess coating dripping from the coated articles collects in a holding tank for reuse. The transfer efficiency of flow-coating can also be as high as 85%.

Electrostatic Spraying. Electrostatic spraying uses an electrical transformer capable of delivering up to $60{,}000^{+}$ volts to create an electric potential between paint particles and the surface to be coated. Transfer efficiency is increased because the paint particles are electrically attracted to the surface. There are electrostatic versions of air atomized and airless spray guns. Although the transfer efficiency will vary depending upon the type of surface sprayed and the operator's skills, these guns can achieve transfer efficiencies of 65% to 80%. Use of bells or disks are another type of electrostatic spraying. A rotating bell or disk that is negatively charged atomizes the coating that is attracted to the positively grounded surface. Bell or disk electrostatic spraying can achieve efficiencies of 90% to 95%.

3.7.4.2 Add-On Control Devices

The use of add-on control is the approach for many surface coating operations when pollution prevention techniques are unavailable or cannot provide a sufficient level of control. Typical add-on control devices include oxidation, carbon adsorption and hybrid systems.

3.7. 4.2.a Oxidation

Oxidation uses heat to combust the VOCs in a solvent-laden gas stream. In most cases, an auxiliary fuel is required to raise the temperature of the gas stream to a point where the VOCs will be combusted. The types of oxidizers used in the surface coating industry are (1) thermal, (2) catalytic and (3) thermal regenerative.

Thermal. Thermal oxidizers are the simplest type of oxidizer. They essentially consist of a burner and a combustion chamber. VOC destruction depends upon the residence time during which the VOCs are in the combustion chamber, the temperature to which the VOCs are raised and the turbulence in the combustion chamber that ensures that all VOCs are heated to the proper temperature. Thermal oxidizers typically have a heat exchanger to recover usable heat from the exhaust gas stream and to preheat the solvent-laden gas stream. Without heat recovery, thermal oxidization would be impractical for almost all applications in this industry because of the high cost of auxiliary fuel. Recuperative-type thermal afterburners are a common type of thermal oxidizer used in the industry. Recuperative type

systems include a heat exchanger inside the unit so that the cold solvent-laden gas stream is heated continuously in a countercurrent flow arrangement. To achieve the destruction efficiencies associated with SOTA, thermal oxidizers should be designed so that the minimum temperature at the exit of the combustion chamber is at least 1,500 ^{O}F and the dwell time is at least 0.5 seconds.

Catalytic. Catalytic oxidizers have a catalyst bed. The catalyst serves to reduce the temperature at which the VOCs can be destroyed. The catalyst is often platinum combined with other metals that are deposited in porous form on an inert substrate. Metallic oxide catalysts are usually homogeneous granules. To achieve SOTA destruction efficiencies, catalytic oxidizers should be operated with a minimum temperature at the exit of the catalyst bed of 650 ^{O}F and a minimum dwell time of 0.1 seconds.

Thermal Regenerative. Recently, thermal regenerative oxidizers have been used to control VOC emissions from surface coating sources. Regenerative units use beds of ceramic pieces to recover and store heat. Solvent-laden air from a surface coating operation passes through a heated ceramic bed before being combusted. The exhaust gases from the combustion camber are used to heat another ceramic bed. Periodically, the flow is reversed so the bed that was being heated is now used to preheat the solvent-laden gas stream. Usually, there are three or more beds that are continually cycled.

3.7.4.2.b Carbon Adsorption

Adsorption is a physical and/or chemical process whereby a contaminant in an air stream is attracted to the surface of an adsorbent. 'Physical' or van der Waals adsorption is the result of the intermolecular forces between the molecules of the solvent and those on the surface of the adsorbent. When the intermolecular attractive forces between molecules of the surface of the solid and a gas are greater than those existing between molecules of the gas itself, the gas will condense on the surface of the solid even though the pressure may be lower than vapor pressure corresponding to the prevailing temperature. Chemisorption or activated adsorption is a result of the chemical interaction between the solid and the adsorbed solvent. Chemisorption is frequently irreversible. On desorption, the original substance will often have undergone a chemical change. Although there are various adsorbents, activated carbon is the most common used. Activated carbon is usually formed by heat treating nut shells or coal in the absence of air. If coal is used, heat treatment is followed by steam activation at high temperatures.

Carbon adsorption units can be either onsite regenerable or non-regenerable. Regenerable systems have more than one bed. While solvents are being adsorbed in one bed, those adsorbed onto another bed are desorbed using steam or hot air. Desorbed solvents are condensed. Then, the solvents are decanted from the condensed steam. Occasionally, distillation units are used to reclaim the solvents.

The ability to reuse reclaimed solvents is a major attraction of adsorption systems. For some industry sectors, they are very cost effective. In non-regenerable systems, the carbon is discarded after its adsorption capacity is reached. Recently, a variation of a regenerable adsorption system has been used with low concentration gas streams. In these modified systems, the solvent is adsorbed. After desorption, an oxidizer destroys the concentrated solvent stream.

The efficiency of a carbon adsorption system depends upon the carbon adsorption efficiency for individual solvents. Other factors important for the design of a carbon adsorption system include cycle time, the velocity, the inlet concentration of the solvent-laden air and the temperature. Carbon adsorption systems can achieve the same efficiency as oxidizers.

3.7.4.3 Capture Systems

Using add-on control devices to reduce VOC emissions from surface coating operations often requires the VOC emissions first be captured. For some operations,, most of the emissions occur in a drying oven. Thus, controlling the drying oven with as add-on control device is usually feasible. In other operations, most of the emissions may be fugitive in nature. Although rotogravure and flexographic presses typically have dryers, emissions occur outside the dryers. Therefore, a system to capture these emissions must be used. In general, two types of capture systems are used. The simplest approach is to totally enclose the source and exhaust the air in the enclosure to the control device. If the following criteria are met, EPA allows a source to assume that a total enclosure captures 100% of the emissions.

1. Natural draft openings (NDOs) are at least four equivalent diameters from each VOC emitting source.

2. The total area of all the NDOs shall not exceed five percent of the surface area of the enclosure's walls, floor and ceiling.

3. The average facial velocity of air through all NDOs shall be at least 3,600 m/hr (200 fpm) or the static pressure in the enclosure must be -0.007 in. H_2O. The direction of flow through all NDOs shall be into the enclosure.

4. All access doors and windows whose areas are not included in Criterion 2 and are not included in the calculation in Criterion 3, shall be closed during routine process operation.

5. All exhaust gases from the enclosure are directed to the control device.

(See 40 CFR Part 51 Appendix M - EPA Reference Method 204 for complete details)

A partial enclosure attempts to assume to capture the emissions using hoods, balanced dryers, and floor sweeps. Essentially, every location where VOCs may escape must be closed off or solvent-laden air collected. Often, the best that can be achieved with a partial enclosure system is 90-95% capture.

3.7.4.4 Surface Coating Control Technologies

Table 3 lists both pollution prevention and control technologies that are in use for each category of surface coating. Additionally, periodic reviews of new industrial equipment developments should be taken as a part of any pollution prevention plan.

Table 2
Control Technologies and Pollution Prevention for Surface Coating Operations

Coating Operation Type	Control Technology and Pollution Prevention
Can Coating	Oxidation - Thermal Oxidation - Catalytic Carbon Adsorption Ultraviolet curable coatings Waterborne coatings Low solvent coatings Electrostatic spray powder coatings
Magnet Wire Coating	Dip coating Catalytic Oxidation for drying oven
Miscellaneous Metal Parts	Flow application Dip application Electrostatic spray application Powder Coatings Waterborne coatings Electrodeposition Carbon Adsorption Oxidation
Flat Wood Interior Panel Coating	Roll Coating Waterborne coatings Ultraviolet curing Afterburner Airless spray system
Paper Coating	Oxidation Carbon Adsorption Low solvent water based coatings
Polymeric Coating of Supporting Substrates	Total enclosures Carbon adsorption - fixed bed Carbon adsorption - fluidized bed Condensers Oxidation
Automobile and Light Duty Truck Coating	Waterborne primer using electro-deposition Electrostatic Spray

Coating Operation Type	Control Technology and Pollution Prevention
	Oxidation - Thermal Oxidation - Catalytic Carbon Adsorption High solids coatings Flow coater, dip tank, roller coater
Pressure Sensitive Tapes and Labels	Fixed-bed Carbon Adsorption Oxidation - Thermal
Metal Coil Coating	Low VOC coating Oxidation - Thermal Oxidation - Catalytic
Large Appliance Coating	Waterborne coatings High solids content coatings Electrostatic spray techniques Electrodeposition Powder coating
Metal Furniture Coating	Waterborne coatings Powder coatings Solventborne high solids coatings Airless spray Manual electrostatic spray Nonrotational automatic spray Rotating head electrostatic spray Dip coat and flow coat Electrodeposition
Magnetic Tape Manufacturing	Partial enclosure Total enclosure Carbon adsorption - fixed bed Carbon adsorption - fluidized bed Condensers - air or nitrogen Oxidation - Thermal Oxidation - Catalytic
Plastic Parts Coating for Business Machines	Air-assisted airless spray Electrostatic air spray High solid coatings Waterborne coatings Molded in color and texture
Wood Furniture Manufacturing Operations	Compliant coatings Oxidation - thermal Oxidation - catalytic Other add-on controls
Aerospace Manufacturing and Rework Facility Coating	Compliant coatings Oxidation - thermal Oxidation - catalytic Other add-on controls
Vinyl Coating	Compliant coating Solvent recovery Oxidation - thermal Oxidation - catalytic Other add-on controls
Urethane Coating	Compliant coating Solvent recovery

Coating Operation Type	Control Technology and Pollution Prevention
	Oxidation - thermal Oxidation - catalytic Other add-on controls

3.7.5 Recommended Review Schedule

The recommended review schedule is every two years after the effective date of this manual since:

- The surface coating industry in New Jersey is an industry that has experienced much growth during the past few years.

- New technologies in coatings, application techniques, and control equipment uses are being rapidly developed and demonstrated throughout the nation.

- States are becoming more innovative in their goal of meeting SIP plan requirements under the Clean Air Act Amendments of 1990. As a result, cost effective permitted requirements in nonattainment areas will continue to trend toward more control of VOC emissions.

3.7.6 References

Air & Waste Management Association, *Air Pollution Engineering Manual*, Van Nostrand Reinhold,1992

Air Pollution Engineering Manual, Environmental Protection Agency, Office of Air and Water Systems, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, Second Edition, May, 1973.

Compilation of Air Pollutant Emission Factors: Volume I: AP-42, Fifth Edition, United States Environmental Protection Agency, Research Triangle Park, NC 27711, January, 1995

Guideline Series, *Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations,* U. S. Environmental Protection Agency, Emission Standards Division, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April, 1996

Robert A. Corbitt, *Standard Handbook of Environmental Engineering*, McGraw Hill, 1989.

Robert H. Perry and Don Green, *Perry's Chemical Engineers' Handbook*, Sixth Edition, McGraw Hill, 1973.

South Coast Air Quality Management District, *Best Available Control Technology Guideline, December 12, 1994.*

Technology Transfer Network, *RACT, BACT, LAER Clearing House,* United States Environmental Protection Agency, Research Triangle Park, NC 27711, August, 1996.

Beyond VOC RACT CTG Requirements, U. S. Environmental Protection Agency, Information Transfer and Program Interim Division, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, EPA-453/R-95-010, April 1995.

Surface coating RACT rules for the following states: Colorado, Connecticut, Florida, Illinois, Michigan, New York, Oregon, Rhode Island, Maine, Texas, California Districts (Bay Area and South Coast Air Quality Management Districts).

Oregon Department of Environmental Quality, Mr. Greg Dahmen, phone conversation with Mr. Paul Grable, Pacific Environmental Services, Inc.

Texas Natural Resources Board, Mr. Eddy Mac, phone conversation with Mr. Paul Grable, Pacific Environmental Services, Inc.

Illinois Environmental Protection Agency, Mr. Darrine Clutch, phone conversation with Mr. Paul Grable, Pacific Environmental Services, Inc.

Michigan Department of Environmental Quality, Mr. Bob Irvine, phone conversation with Mr. Paul Grable, Pacific Environmental Services, Inc.

South Carolina Board of Health and Environmental Control, Ms. Florence Berry, phone conversation with Mr. Paul Grable, Pacific Environmental Services, Inc.

Wisconsin Natural Resources Board, Mr. Dan Johnson, phone conversation with Mr. Paul Grable, Pacific Environmental Services, Inc.