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GUIDE FOR INSPECTING CAPTURE SYSTEMS AND CONTROL DEVICES AT SURFACE COATING OPERATIONS

Office of Air, Noise and Radiation Enforcement
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GUIDE FOR INSPECTING CAPTURE SYSTEMS AND CONTROL DEVICES AT SURFACE COATING OPERATIONS

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SECTION 1.0

INTRODUCTION

1.1 PURPOSE AND USE OF THIS GUIDE

This guide has been developed for the purpose of providing assistance to state and local agency personnel when they are preparing for and conducting inspections of surface coating facilities. It is intended for use by field inspectors and entry-level engineers whose familiarity with surface coating operations and their emission controls may be limited.

This is not a technical design manual for surface coating processes and associated emission controls. This guide provides only basic descriptions of surface coating unit operations and emissions. Its primary focus is on the capture systems (hoods and ductwork) and control devices (adsorbers, incinerators, etc.) used to collect and eliminate the emissions from industrial surface coating processes. However, a detailed presentation of engineering data and design theory is not provided for these capture/control systems. Instead, detailed information regarding the purpose, operation and maintenance of these systems is provided as guidance to an inspector who is involved in field surveillance and monitoring of sources for continuing compliance. Guidance is also provided on where to look for and how to identify existing or potential operation and maintenance problems. It is stressed that the procedures presented in this guide are for follow-up inspections related to checking the continuing compliance of a source which has previously proven compliance with applicable regulations.

The capture/control systems concentrated on in this guide are normally employed on surface coating operations to reduce the quantity of volatile organic compounds (VOC) emitted to the ambient air from those operations. Although other pollutants are emitted from surface coating operations, VOC receive emphasis in this document because their emission from surface coating operations can be significant and because these compounds are one of the prime reactants involved in the formation of photochemical oxidants (smog). At surface coating facilities, VOC are emitted as a result of the intentional evaporation of solvents from coatings during the application and curing (drying or hardening) steps in the process.

In recent years, most states have promulgated regulations which limit the amount of VOC that certain surface coating operations are allowed to emit. In efforts to comply with these regulations, companies have tried to reduce the VOC content of the coatings being applied or have installed systems that capture and eliminate the VOC before they can enter the atmosphere. Some have employed both approaches in efforts to comply with emission limits. The procedures for determining that a surface coating operation complies with an emission limit are too complex to be addressed in this document. Therefore, emphasis is placed on the mechanical aspects of capture/control system operation, maintenance, and equipment condition that will allow a qualitative assessment of compliance status relative to originally permitted conditions.

1.2 ORGANIZATION OF THIS GUIDE

This guide consists of five sections and three appendices. The last part of this section provides background information on industries that perform surface coating as a major step in their overall production processes.

Section 2.0 presents a general description of the overall surface coating process. Block flow diagrams illustrate the typical unit operations that are used to form a surface coating line. The relative magnitude of VOC emissions from these unit operations are presented.

Section 3.0, Inspection Procedures, and especially subsection 3.2, Control System Inspection, is the primary focus of this guide. Equipment used to capture and eliminate VOC emissions from surface coating operations are described in detail. The operation and maintenance (O&M) of these capture/control systems are discussed and methods of identifying existing or potential O&M problems are presented. Relationships between capture/control system effectiveness (reductions of emissions) and O&M activities are discussed. Procedures are presented which inform inspectors as to why, where, how, and what to look for so they can conduct a thorough inspection of these capture/control systems. A description of some basic, often encountered instruments is presented. Checklists are provided in the text for field use to guide and aid the inspector in observing and noting the condition and operation of the capture/control systems. Additional copies of all the checklists are also available in Appendix C. Section 3 also provides guidance on preparing for an inspection, surface coating process inspection, and general plant inspection.

Section 4.0 contains the reference materials used in the development of this guide. The material presented herein has been purposely written in a simple and general manner that might mask the true complexity of VOC capture and control at surface coating operations. Therefore, throughout this guide, references are made to documents which provide technical data.

Section 5.0 contains a bibliography of references relating to the surface coating industry, volatile organic compounds, and emission controls. The surface coating process or control equipment related subjects covered by each document are indicated.

There are three appendices. Appendix A is a listing of abbreviations commonly encountered in the surface coating industry or used in reference to emission controls. Definitions of the abbreviations and other words and terms used in this guide are provided in Appendix B. Appendix C contains the checklists discussed in Section 3 of this guide.

1.3 SURFACE COATING INDUSTRIES

1.3.1 General Description

Surface coating involves the application of a wet or dry coating material to the surface of another material. Steps prior to application include preparation of the coating and cleaning of the material to be coated. Subsequent to the application step, the coated material is exposed to heat, light, or invisible radiation to dry or cure the coating. Figure 1-1 depicts the major steps in the surface coating process.

Coatings are applied to a wide variety of materials (substrates). These materials include metal, wood, paper, plastic, and cloth. The shapes made from these materials, and subsequently coated, vary from flat wood panels to automobile and truck bodies. The composition of a coating is dependent on the substrate to which it will be applied, the shape of the object to be coated, and the desired characteristics of the coating once dryed or cured. Likewise, the method used to apply the coating is related to the characteristics of the coating and the shape to be coated. The curing or drying method used also depends on the coating characteristics and the coated object's shape. Additional information on coatings and application and drying/curing methods is given in Section 2.0 of this guide. The point made here is that nearly every surface coating operation is different.

1.3.2 Surface Coating Industries

Regardless of the large number of different surface coatings available, some similarities exist when surface coating operations are grouped according to the products they produce. The U.S. Environmental Protection Agency (EPA) has used this approach to study different industrial surface coating categories in its efforts to develop Control Techniques Guidelines (CTG) and New Source Performance Standards (NSPS) for VOC emissions. Table 1-1 is a list of industrial surface coating categories and the EPA published CTG and/or Background Information Document (BID) for those categories that are the results of the EPA's studies. The CTGs and BIDs are excellent references for those who desire a more industry-specific and detailed discussion of the surface coating processes than is available in this guide.

Note that the 11 source categories in Table 1-1 are only those for which the EPA has completed studies. However, the variety of surface coating operations covered under the Miscellaneous Metal Parts and Products category gives an indication of the diversity of surface coating operations.

1.3.3 Areas of Commonality

In spite of the diversity of the surface coating industries, there are areas and operations that are common among them. One obvious area is the common use of solvents synthesized from petroleum products. Further, most surface coaters will use one of four general coating application techniques; roller, dip, flow coat, or spray. Finally, where coating operations have applied add-on control technology to reduce VOC emissions, the control system will be comprised of two major components; a capture system (hooding, ductwork,

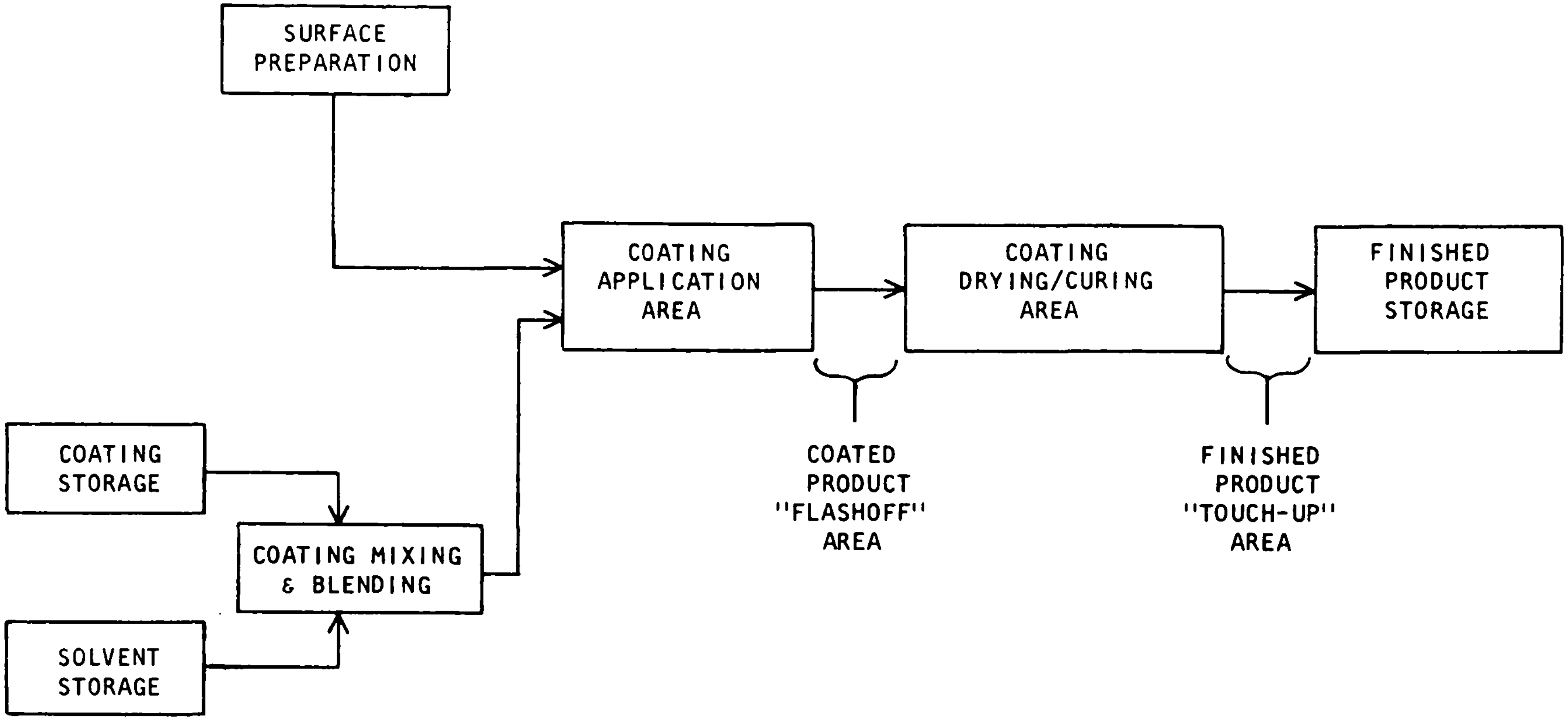


Figure 1-1. General steps in a surface coating process.

TABLE 1-1. PUBLISHED EPA STUDIES OF INDUSTRIAL SURFACE COATING CATEGORIES THROUGH DECEMBER 1981

Category	Control Technique Guideline (RACT)[a] title	Background Information Document (NSPS) title[b]
Cans	Control of Volatile Organic Emissions from Existing Stationary Sources - Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks. EPA-450/2-77-008, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, May 1977.	Beverage Can Surface Coating Industry - Background Information for Proposed Standards. EPA-450/3-80-036a. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 1980.
Metal Coils	See Cans above.	Metal Coil Surface Coating Industry - Background Information for Proposed Standards. EPA-450/3-80-035a. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, October 1980.
Paper	See Cans above.	Pressure Sensitive Tape and Label Surface Coating Industry - Background Information for Proposed Standards. EPA-450/3-80-003a. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 1980.
Fabrics	See Cans above.	None
Automobiles and Light-Duty Trucks	See Cans above.	Automobile and Light-Duty Truck Surface Coating Operations - Background Information for Proposed Standards. EPA-450/3-79-030a. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 1979.
Metal Furniture	Control of Volatile Organic Emissions from Existing Stationary Sources - Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, December 1977.	Surface Coating of Metal Furniture - Background Information for Proposed Standards. EPA-450/3-80-007a. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, April 1980.
Magnet Wire	Control of Volatile Organic Emissions from Existing Stationary Sources - Volume IV: Surface Coating for Insulation of Magnet Wire. EPA-450/2-77-033, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, December 1977.	None

(continued)

TABLE 1-1 (continued)

Category	Control Technique Guideline (RACT)[a] title	Background Information Document (NSPS) title[b]
Large Appliances	Control of Volatile Organic Emissions from Existing Stationary Sources - Volume V: Surface Coating of Large Appliances. EPA-450/2-77-034, U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards, December 1977.	None
Metal Parts and Products	Control of Volatile Organic Emissions from Existing Stationary Sources - Volume VI: Surface Coating of Miscellaneous Metal Parts and Products. EPA-450/2-78-015. U.S. Environmental Protection Agency, Office of Air Quality Standards, June 1978.	None
Graphic Arts (printing)	Control of Volatile Organic Emissions from Existing Stationary Sources, Volume VIII: Graphic Arts - Rotogravure and Flexography, EPA-450/2-78-033. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. December 1978.	Publication Rotogravure Printing - Background Information for Proposed Standards. EPA-450/3-80-031a. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October 1980.

[a] RACT = Reasonably Available Control Technology.

[b] BIDs are typically published in two parts designated by lower case "a" or "b" after the EPA report number. The "a" volume is available when an NSPS is proposed and the "b" volume becomes available after the NSPS has been promulgated. Both volumes should be consulted.

and fans) to collect the VOC emissions at their point of origin in the process and a control device that prevents release of the captured VOC to the ambient air. The principal control devices are all based on one of four techniques; incineration, adsorption, absorption or condensation.

It is because capture systems and control devices are so widely used to reduce VOC emissions from surface coating operations, regardless of industrial category, that this guide has been developed. The inspection procedures presented here apply to any VOC capture/control system since these systems are basically the same in all industrial categories. That is, an incinerator employed to reduce VOC emissions from a can coating line will have common operation and maintenance requirements with an incinerator on a metal furniture coating line.

SECTION 2.0

SURFACE COATING OPERATIONS

Although surface coating operations vary substantially, a typical surface coating process consists of four major steps:

- surface preparation
- coating preparation
- coating application
- curing

The sequence of these operations was presented in Figure 1-1.

2.1 SURFACE PREPARATION

Preparation of the surface to be coated is necessary to ensure proper bonding between the surface and the coating. The extent of surface preparation depends on factors such as the condition of the material surface, the method in which the coating is to be applied and the ease with which the coating will adhere to an untreated surface. Preparation methods include cleaning and texturing.

Surfaces are cleaned to remove dirt, grease, dust, corrosion and other contaminants. Common cleaning techniques include degreasing and caustic washing. The material to be coated may be simply dipped or washed or it may undergo a more rigorous mechanical cleaning.

Texturing refers to increasing surface roughness, mostly on metal and wood surfaces. Roughness can be increased in a number of ways including contact with high-speed abrasives such as sand, grit and shot blasting or by manual methods such as sanding, scraping and brushing.

After cleaning and brushing a surface is usually rinsed to ensure complete removal of contamination.

2.2 COATING PREPARATION

Specifications for coating formulations often require the introduction of additional ingredients prior to application. These additive ingredients affect certain formulation properties such as viscosity, color and evaporation rate. Blending of these ingredients is necessary in order to ensure a homogeneous mixture.

2.3 TYPES OF COATINGS

Different types of coatings are used in different surface coating applications. A typical coating consists of solids (e.g., pigments, metals, plasticizers) and a carrier (e.g., organic solvents, water). Some coatings contain no carrier but use other methods of dispersing the solids over the surface (e.g., electrostatic deposition).

The most common coating types are:

- solvent-borne
- water-borne
- powder
- high solids
- prepolymer

Solvent-borne coatings contain mostly volatile organic solvents. Water-borne coatings contain mostly water with some organic solvent (typically less than 20 percent by volume) added to enhance evaporation.[1,2,3,4] Powder coatings use no carrier solvent. They typically consist of thermoplastic or thermoset powder resins which are electrostatically applied to a surface and subsequently heated to a molten state.[2]

High solids formulations are solvent-borne but have a higher solids content (typically 60 to 80 percent by volume) than normal solvent-borne coatings. Prepolymer coatings consist of low molecular weight oligomers or monomers dissolved in acrylic monomers.[2,4] When the monomers are heated or irradiated they link together to form polymers.[2,4] A photosentisizer is often added to catalyze the crosslinking reactions that take place in the polymerization process.

2.4 COATING APPLICATION

A majority of coatings are applied to a surface in one of four ways:

- spray
- roller
- dip
- flow

Many variations of these four methods exist. These variations are presented in Table 2-1. Other coating techniques used less frequently include brush, tumble, wipe and gas polymerization.

Spray coating involves atomization of the coating mixture into finely dispersed droplets. Both liquids and powders can be applied by a spray.[5] Electrostatic spraying is a technique in which the atomized coating droplets are electrically-charged and the article to be coated is grounded. The charged droplets are electrostatically-attracted to the surface where they are evenly deposited.[1] Other spray coating methods include airless (hydraulic pressure) and hot melt.[5]

Roller coating is used when the surface to be coated is a flat and thin substrate (e.g., adhesive tape, newspapers, wood panels). Rollers are used for guiding the substrate, applying the coating, and maintaining tension.[4,6] Many individual roller coating techniques exist for uses in different applications, as shown on Table 2-1.

Dip coating is commonly used to coat irregularly-shaped articles such as appliances, metal furniture and automobile parts. Articles and parts to be coated are typically attached to an overhead coveyor and lowered into a dip tank. The parts are then raised out of the tank and the excess coating is allowed to drip off. Surfaces can also be electrocoated by applying a current to the dip bath.[1,2]

Flow coating essentially involves showering the article to be coated. The article passes under the opening of a trough or tank filled with liquid coating material. The liquid flows out and over the surface. Excess liquid is allowed to drip off over a drain board.

A surface may require the application of several different layers of coating for the purposes of protection and appearance. Five sequential layers which may be applied in a coating process are:

- primer
- sealer
- print
- topcoat
- touchup

The prime coat is applied directly to the prepared substrate. Sealers are the next coat(s) and are used to develop thickness. Any printing or lithography is applied on top of the sealer. The topcoat or finish coat is the final layer and is almost always for appearance. If a finish is marred in any way it will receive final touchup coating where required.[7] Not all coating operations perform these steps; some apply only a primer and topcoat while others apply only one coat (e.g., printing).

TABLE 2-1. COATING APPLICATION METHODS

Spray	Roller	Dip	Flow	Miscellaneous
● atomized air	● direct roll	● electrodeposition	● flow	● brush
● atomized airles	● reverse roll	● dip and squeeze	● curtain	● tumble
● electrostatic	● blade	● electrostatic fluidized bed		● wipe
● powder	● knife	● hot melt		● gas polymerization
	● air knife			
	● gravure			
	● lithographic			
	● flexographic			
	● die fountain			
	● fibrous belt			
	● metering rod			
	● puddle			
	● kiss-roll			
	● meniscus			
	● size press			
	● nip roll			
	● calendar			
	● cast			

Source: Reference 7

The number of times each layer is applied is a function of the wear and tear the object will experience during its use.[8] For example, a coating that will be exposed to a marine environment will consist of more layers than a coating applied to wood furniture. Many coating facilities also purchase precoated material which reduces the number of layers which must subsequently be applied.[9]

2.5 CURING

Curing of a coating is performed to either:

- dry the coating by evaporation of the solvent
- remelt the coating and cover scratches, streaks and bubbles, or
- polymerize a prepolymer coating

Different curing methods are used as a result of the desire to dry the coating as quickly as possible without causing deterioration. The most common forms of curing are:

Oven baking - the article or substrate passes through an oven where a heat source evaporates the solvent. Forced hot air is the usual heat source. Other heat sources are radiative types; infrared, ultraviolet and electron beams. Ovens can be either single or multipass and frequently have zones of varying temperature to ensure uniform drying.

Flashoff - an area of elevated temperature which precedes an oven in many facilities. A flashoff area allows solvent to slowly vaporize from the coating film. This helps prevent "popping" of the coating during baking.

Air drying - used for articles too large to fit in an oven (e.g., industrial, construction and transportation equipment) or for articles which contain heat sensitive materials. Air drying is typically performed in an open room.

Usually the coated material will be passed through a curing step after each subsequent application of coating. The curing method may be different for each of these curing steps in the overall surface coating process.

Most curing is performed on a continuous basis (e.g., on a conveyor belt) although some articles, such as wood furniture, must dry for long periods of time.

2.6 EMISSION SOURCES

Most of the pollutants in a coating application operation are emitted from application and curing of the coating. Table 2-2 lists typical sources in each category. Other emission sources include storage and handling, coating preparation, and equipment cleaning. Figure 2-1 displays the sources of VOCs in a typical coating operation.

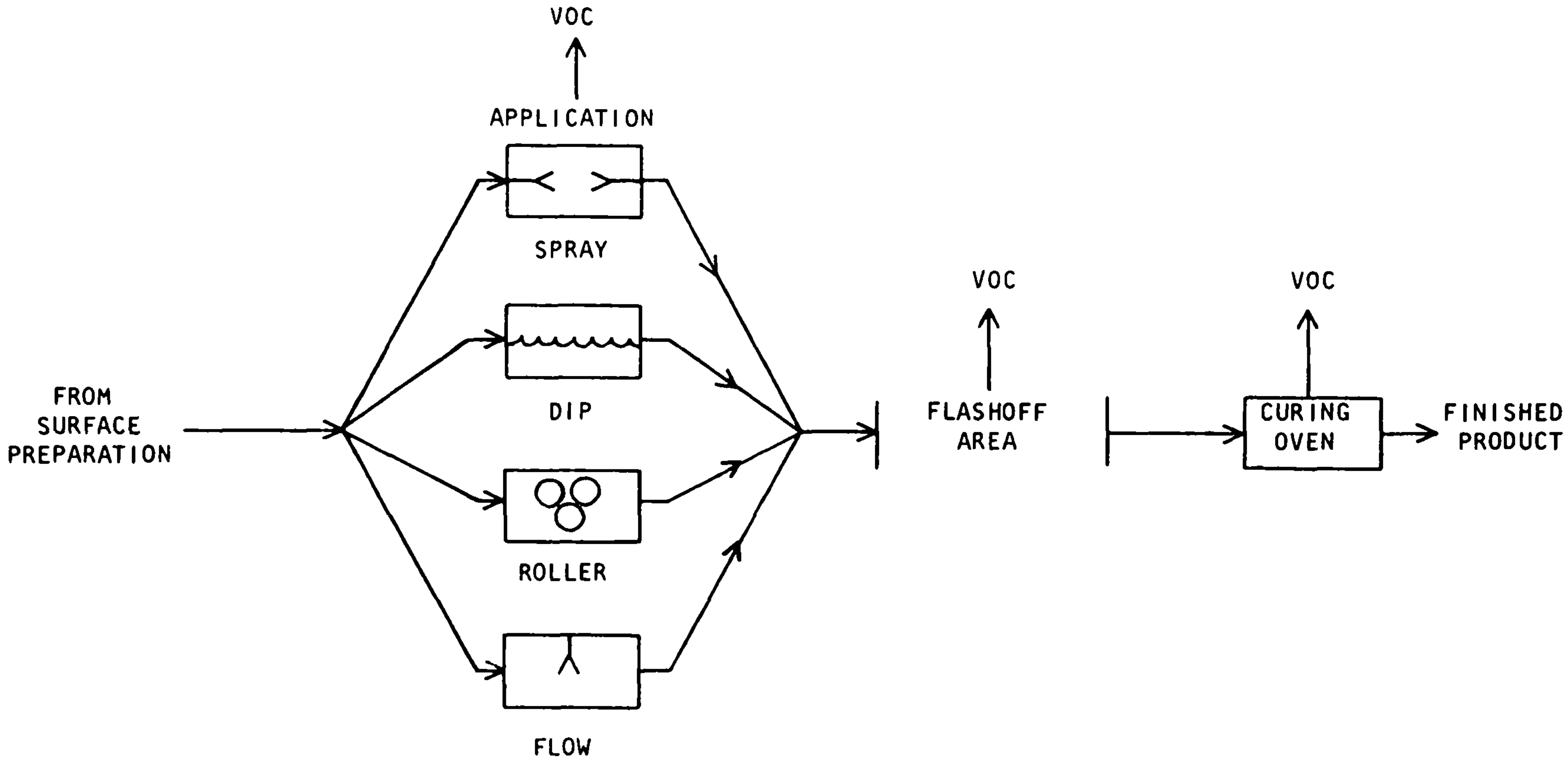


Figure 2-1. VOC sources--typical coating operation.

TABLE 2-2. EMISSION SOURCES IN COATING OPERATIONS

Application	Curing	Other
● primary	● flashoff	● equipment cleaning
● sealing	● oven	● surface texturing
● printing	● air drying	● coating blending
● topcoat		● coating storage
● touchup		

The relative magnitudes of emissions will vary according to the type of coating process. Some facilities experience greater emissions from the application and flashoff areas while others have greater emissions from curing. Table 2-3 provides a relative breakdown of emission source magnitude for several coating operations.

TABLE 2-3. RELATIVE EMISSION SOURCE MAGNITUDE[1,9,10,11]

	Percent emissions by source	
Coating operations	Application and flashoff	Curing
Metal Cans	40	60
Large Appliances	64	36
Metal Furniture	50	50
Miscellaneous Metal Parts and Products	69	31

Coating facilities must dilute VOC emissions with excess air for two reasons:

1. To reduce the possibilities of explosions or fire.
2. To maintain VOC concentrations below the level determined to cause adverse health effects in humans.

Insurance companies typically require that coating facilities maintain VOC concentrations in the air below 25 percent of the solvents' lower explosive limit (LEL). Occupational safety standards often require an even lower concentration, particularly when a solvent is thought to pose significant adverse health effects. Some newer coating lines are allowed to operate with higher VOC concentrations (up to 50 percent LEL for oven exhaust only). This is only permitted if the facility performs continuous concentration monitoring and installs alarms and automatic shutdown devices.[9]

Even coatings which contain little or no organic solvent can produce some form of emissions such as:

- Electrodeposition - although these are mostly waterborne coatings, the formulations often contain amines which cause odors and visible emissions when incinerated.
- Prepolymers - these emit volative monomers during curing.
- Powder coatings - these emit volatile monomers during the crosslinking reaction.

Other pollutants which can be emitted from coating facilities include particulates from sanding operations and combustion products (NO_x, SO_2) from direct-fired curing ovens.

The diversity of surface preparation, coatings, coating application techniques and curing methods makes it impossible to present all combinations that will be encountered during an inspection. A brief description of all the possibilities in these areas has been presented to make the inspector aware of the range of choices available to the plant personnel. The inspector should have a basic understanding of why the various operations are being undertaken, so that questions in these areas can be geared to those items which will affect VOC release, such as "what is the specific VOC content of that coating?" and "is the coating applied by spray (which tends to release more VOC per item coated) or dip?" A knowledge of the types of coating and curing techniques used in a facility is especially helpful in ascertaining how the VOC are captured and controlled, once they are deposited on a surface. Certain application techniques are usually associated with specific hood designs, and being able to recognize the method of coating application will guide you to the collection hood being used to capture the VOC. The types of capture systems used in surface coating facilities will be discussed in the next section.

SECTION 3.0

INSPECTION PROCEDURES

3.1 PREINSPECTION PROCEDURES

A certain amount of preparation prior to an inspection is always advisable. The preinspection procedures suggested here are intended as general guidelines on how to prepare for and begin the inspection of a surface coating operation. However, the procedures are only suggestions; you must become familiar with and follow the procedures established by your agency at all times.

It is important to remember that you represent your entire agency at all times during the inspection. The legal authority that you represent during the inspection will depend on your agency's enabling legislation. Make certain that you are aware of the limits of your authority. Both your agency, and you personally may be liable for your statements or actions while in the presence of a source's representatives or on a source's property. Do be professional, courteous and cooperative. Do not offer opinions or make statements in areas where you have limited experience or knowledge.

As stated in the Introduction, these procedures are for continuing compliance inspections. These are inspections of sources which have previously proved initial compliance with regulatory emission limits by installing air pollution control systems and/or modifying processes. A properly conducted continuing compliance inspection will, at a minimum, allow a qualitative comparison of present equipment operation and condition to the initially permitted conditions.

3.1.1 File Review

The first step in preparing for an inspection is a review of all information available in your agency's files on the surface coating operation that you will be inspecting. Efforts invested in reviewing the available information will reduce your onsite field time because you will know exactly what information you must collect.

First, conduct a general review of the documents on file. Note records of citizen complaints, previous inspection reports, and equipment malfunctions. Look for plot plans which show the layout of the facility, the location of equipment, and identification of emission points. You should be able to locate documents that provide specific design and operation data for processes and control equipment.

Next review the data specifically to determine the process or control equipment parameters that affect emissions from each emission point. For each emission point, the source should have either done something (process modification, control equipment installation) or submitted something (stack test, material balance) that would establish initial compliance with emission limits. The documentation that the source submitted to support its claim of compliance should contain the detailed information you need to familiarize yourself with the process and control equipment. However, there will be much more information than you need for the purposes of a continuing compliance inspection. You should concentrate on those specific values of process or control equipment operation parameters that can influence emissions. Section 3.2 of this guide identifies key data that you should review.

You may wish to summarize some of the data or previous inspection information so that you will have it available during your inspection. You will have a clearer idea of what that information might be once you have read Section 3.2 and reviewed the inspection forms/checklists there and in Appendix C. Regardless of whether you bring notes or other information with you on your inspection, you should be aware of the following information once you have completed the file review.

1. The emission points and the relative magnitude of their emissions.
2. The specific steps the source has taken at each emission point to comply with emission limits.
3. The key parameters that affect emissions from each emission point at the source.
4. The processes or process areas at the source.
5. The results, recommendations, or conclusions of previous inspections.
6. The history of citizen complaints against the source.
7. The history of process or control equipment malfunctions that have caused increased emissions.

For each capture system and control device installed on a surface coating operation, the specific information with which you should familiarize yourself, in detail, is presented in Table 3-1. If any of these items of information are not available from the file you should make a note to obtain it during your inspection.

3.1.2 Regulation Review

As you reviewed the source file you may have noticed reference to specific regulations that apply to the emission points at the source. Review, in particular, those regulations that apply to the emission of VOC from surface coating operations. Discuss the regulations with experienced personnel at your agency to make certain that you understand what they say, how they are applicable, and how they are interpreted.

TABLE 3-1. SPECIFIC CAPTURE SYSTEM/CONTROL DEVICE DATA

I. GENERAL

- A. Number of coating lines at plant
- B. Number of control systems at plant
- C. Major noncoating line related emission sources at plant

II. SURFACE COATING PROCESS

- A. Material being coated
- B. Production rate
- C. Coating applied
- D. Coating application method
- E. Coating application rate
- F. Drying/curing method
- G. Drying/curing temperature

III. CAPTURE SYSTEM

- A. Total number of hoods in each system.
- B. Type of hoods
- C. Distance of each hood from source
- D. Design capture/face velocity at each hood
- E. Location of filters
- F. Location of dampers
- G. Type and location of fan(s) in system
- H. Horsepower, voltage, amperage of fan motor
- I. Type of fan drive (direct, belt)
- J. RPM of fan
- K. Design flow rate of system

IV. CONTROL DEVICE

- A. Type of control device
- B. Inlet pollutant concentration
- C. Outlet pollutant concentration
- D. Air flow through device
- E. Design efficiency
- F. Depending on the type of control device, review Tables 3-5 through 3-8
- G. Disposal procedure for pollutant removed from control device

In addition to regulations that establish emission limits, your agency may have regulations that require certain operation, maintenance, record keeping, or reporting activities. You should also be aware of these and how they apply to the activities at the surface coating operation you will be inspecting.

Finally, your agency may have negotiated certain legally-binding agreements with the subject source. These agreements are likely to be in regard to issues unique to the activities at the source. They may allow the source some leniency from the strict interpretation of a regulation or they may have established requirements more stringent than a regulation. These agreements are sometimes called variances, consent decrees, or compliance schedules. If such an agreement exists with the source you will be inspecting, be certain that you understand it fully before your inspection.

3.1.3 Safety Considerations

The machinery used in a surface coating line has many moving parts. The movement is often high-speed and noisy. The odor of solvents used as diluents and cleaners is often noticeable. The first rule for your safety at these facilities is do not touch, lean on, or stand too close to any of the process equipment.

The availability of safety equipment for inspector use varies between agencies. At a minimum, a hard hat, safety glasses, and steel-toed safety shoes should be part of your equipment compliment. (For your own well-being, you should consider purchasing and using these items even if your employer does not supply them.) One or more of these three items are often required before a company will allow you to enter their process areas. Some companies will supply you with safety glasses and a hard hat for use during your visit. However, they are under no obligation to do so and can rightfully refuse or delay your entry if they require these safety items and you do not have them.

The specific safety rules will vary from plant to plant. You should discuss safety equipment and procedures when you call to announce your inspection (see Section 3.1.4). If your inspection is to be unannounced, you should discuss safety during the preinspection meeting at the plant. In addition to the risk of personal injury, your failure to comply with a company's safety equipment and procedure requirements is one of the quickest ways to destroy a cooperative, working relationship between a source and your agency.

The following safety measures should be kept in mind while at surface coating facilities and are also generally applicable to all inspections.

- Do not wear loose clothing. Long-sleeved shirts and long pants made of heavy material are appropriate. Pay special attention to drawstrings on jackets.
- Do not carry loose items in pockets - they may fall out when you bend, twist, or stretch.

- Do not lean on things, including guardrails, they may not be as secure as they appear.

- Do not wander around alone. You should insist on being accompanied by a company employee familiar with plant operating areas.

- Do not touch anything or attempt to operate switches, valves, levers, etc. without first asking for and receiving permission from your facility escort. If you see something obviously improper, bring it to a company employee's attention but do not attempt to take corrective action yourself.

- Do not ignore warning signs, look for them and do not enter roped-off areas.

- Do be constantly aware of your footing, your balance, and what is above and around you. Look and listen continuously.

- Do keep away from the surface coating equipment. Many times it is automatically controlled and can start without warning. Some parts operate at such high speeds that they do not appear to be moving.

- Do be courteous to company employees. If you stop to observe something make sure you are out-of-the-way and in a nonhazardous spot.

- Do be aware that coating drying/curing operations may employ intense heat, light or invisible radiation. Approach the equipment carefully and employ protective equipment.

- Do wear ear protection in high noise areas. Remember that other personnel in the area may also be wearing ear protection and will not hear you approaching. Attempt to make visual contact on your approach to avoid startling someone.

3.1.4 Inspection Announcement

If you desire or are required to announce your inspection in advance, you should contact the company a few days or a week before the date you plan to conduct your inspection. The name of the appropriate plant contact should be available from the file. Make certain that the person with whom you are making the appointment can arrange for access to the equipment you must inspect and has the authority to release any data and samples you will need. You should be somewhat flexible on the exact date of the inspection. If the appropriate plant contact cannot be available or if the equipment you want to inspect will not be operating on the day you originally intended to inspect the plant, you should give serious consideration to rescheduling the inspection to the earliest alternative date when both the plant contact and operating equipment will be available.

The following are topics you should cover during your inspection announcement communication with the plant contact.

- Establish the date and time of the inspection and the name of the company representative to be involved.
- Identify the agency personnel who will be conducting the inspection.
- Provide a brief statement on the purpose of the inspection, the equipment to be inspected, and anticipated data and sample needs.
- Solicit information on required safety equipment and procedures.
- Determine plant entry procedures. Get an explanation of any documents you may have to sign to gain entry.
- Provide an estimate of how long you think your inspection will take to complete.
- Confirm directions to the location of the plant or the place where you will meet the company contacts.
- Solicit information on the company's attitude toward photographs and the handling of confidential information.
- Provide instruction on who to contact at your agency should the company be unavoidably forced to request rescheduling of the inspection.

3.1.5 Pre-entry Observations

Your inspection can (and should) begin before you enter the plant if your schedule allows sufficient time. The observations outlined here can also be conducted after the in-plant inspection.

Circumnavigate the perimeter of the plant being careful not to trespass on either the company's or other people's property. Look for visible emissions from stacks in the plant and fugitive emissions and odors leaving the plant property. You can legally read stack opacities without obtaining permission from the company as long as you are not on the company's property and provided you can position yourself properly and you are currently certified to read visible emissions (VE). Take VE readings if you think you see a potential violation of your agency's regulations. Note the noise levels around the plant boundary and the proximity of homes, schools, and businesses to the plant property line.

3.1.6 Plant Entry

You should make every effort to arrive at the gate or front office of the plant 5 or 10 minutes before your scheduled time. Be sure to call the person you will be meeting with if you are going to be late.

When you arrive at the gate or front office of the plant, introduce yourself, present identification, and indicate that you have an appointment with the prearranged plant contact. Follow your agency's instructions regarding the signing of any forms that may limit the company's liability for your safety or restrict the scope of your inspection.

If you must pass through the plant gate, you may well be dealing with the plant security guards. Be prepared to respond to their procedures (you may have to leave matches, lighters, and pipes with them). If their instructions disagree with verbal arrangements you have made with the company representative you will be contacting, request that they discuss the matter with that representative.

If you are conducting an unannounced inspection, access to the plant may require more time. However, if you are denied entry to all or part of the facility, regardless of whether the inspection is announced or not, you should note the reasons for refusal, the name and title of the company official responsible for the refusal, and the date and precise time of refusal. Notify your supervisor of the refusal by telephone immediately. Never attempt to summarize for anyone at the plant the potential legal consequence of the company's refusal to allow you entry. Let your agency's legal staff handle the matter.

3.1.7 Preinspection Meeting

It is recommended that some time be spent in a brief meeting with plant personnel before the actual inspection is begun. The following topics are suggested for discussion during this meeting.

- State the purpose of the inspection, the equipment to be inspected, and the data and samples desired.
- Discuss the confidentiality requirements and procedures of the company as they will apply to your data collection or inspection needs.
- Solicit information regarding key personnel or ownership changes since the last inspection.
- Review process and control equipment plot plans and flow sheets to confirm your understanding of current operational equipment and to identify any changes or modifications in plant operations since the last inspection.
- Discuss the safety procedures, required safety equipment and hazard potential of areas you will be entering.

In addition to these topics, you should be prepared to discuss areas of concern to the plant management, such as:

- Your agency's authority to conduct the inspection.
- The organizational structure of your agency and your place and function in that structure.

- The specific applicability of regulatory requirements to the source.
- The purpose or uses for information collected during the inspection.

If you are at all in doubt about the response to a question by plant personnel, simply state your lack of knowledge regarding the subject. Make sure you thoroughly understand their inquiry and offer to have a person from your agency, who is knowledgeable in that area, contact them. If you make such an offer, write it down in your inspection notes and make sure that the company is contacted with the information.

3.2 CONTROL SYSTEM INSPECTION

Inspection of a plant's VOC capture and control system should start with the point of emission and proceed toward the air pollution control device. As most surface coating facilities will have multiple emission points, you should personally inspect as many as is reasonably possible. The diversity of surfaces that are coated, VOC that are used in conjunction with coatings, methods of coating application, capture hoods and VOC control devices make it impossible to describe a "typical" facility that you will encounter in the field. You must, therefore, assess each individual situation and diagnose the specific combination of VOC application, capture and control devices that are installed so as to select which checklist and/or questions are applicable. In addition, there will be many items that can only be checked when the equipment is not running. No one should reasonably expect a plant to spontaneously shut down production solely for the purpose of a visual inspection, so observe what you can given the situation. If you cannot see all parts of a device directly, ask the Plant Engineer or other company official who is accompanying you about the item and how it appeared when it was last checked by the plant. While one aspect of the inspection is meant to update your agency on the operating and maintenance (O&M) practices of the company, another aspect is intended to let the company know that you have a direct interest in how and when they maintain their equipment. In this regard, try to avoid asking company personnel "Yes" and "No" questions. For example, if you ask them "Do you lubricate this fan regularly?", they are inclined to answer "Yes," whether they do or not. However, if you ask "How often do you lubricate the fan?", they are forced to state their maintenance schedule or admit that they do not have one. Just asking the question may direct their attention to the idea of regular maintenance and, for the sake of consistency during future inspections, make them adopt the frequency they gave you. Remember, the overall purpose of this inspection is not necessarily to catch the plant making inconsistent or inaccurate statements, rather it is to direct their attention to the importance of regular operation and maintenance equipment inspections.

To the greatest extent possible, write down all information and observations you have on the capture and control equipment. Often, the only way to show that the equipment is no longer controlling VOC effectively is by the gradual change in various readings and measurements. Data taken today needs to be compared with last year's data to know if a part is wearing down and may no longer be effective. If you can during the inspection, obtain a copy of all log sheets that the company uses to record various control device parameters such as temperatures, pressures and flow rates. When something is unclear or appears to be wrong, say a noisy pump, then ask about it. Find out about its history, how and when it was serviced and why it is making the noise. A good inspection requires that no question is left unsaid if it serves to clarify what the plant is doing about operation and maintenance.

The emission control system at a surface coating operation will consist of two portions; the emission capture system and the emission control device. In this section, the capture system is discussed first, followed by a discussion of control devices. If either one of these two portions of the control system is operating less effectively than originally designed, pollutant emissions to the ambient air will increase.

The relationship between effective VOC emission capture and effective VOC emission control can not be over stressed. The purpose of the capture system is to collect the VOC emissions at their point of release in the surface coating process and deliver the VOC emissions to a control device which removes them from the air stream. The efficiency of the overall control system is directly related to the efficiency of both the capture system and the control device. For example, if the capture system collects 90 percent of the VOC released by the coating process and delivers them to a control device that removes or destroys 90 percent of them, then the overall control system VOC removal efficiency is 81 percent (90% x 90% = 81%). If either the capture system or the control device becomes less effective and its efficiency drops, for example, to 80 percent, then the overall control system efficiency drops to 72 percent. When you are quoted an efficiency by a company representative, be certain that you find out what the efficiency applies to, either the overall system or one of the two portions.

3.2.1 Capture Systems

3.2.1.1 Introduction--

The effective control of emissions generated by surface coating operations requires that two sequential events occur: the emissions are captured at the point where they are generated and conveyed to an air pollution control device; and the control device reduces the total amount of emissions so that they meet applicable emission standards. Unless both of these systems work successfully, uncontrolled or inadequately controlled emissions will be released to the ambient air. This section will address the various aspects of the capture system and the following section will cover control devices.

The capture system consists of three main parts: hoods that trap the emissions, ductwork that transfers the emission to the control device, and a fan that supplies the energy necessary to move the emissions through both the capture and control systems. These elements are graphically displayed in Figure 3-1. While the fan may be located after the control device, it will be discussed here, since it affects how well the capture system works. To

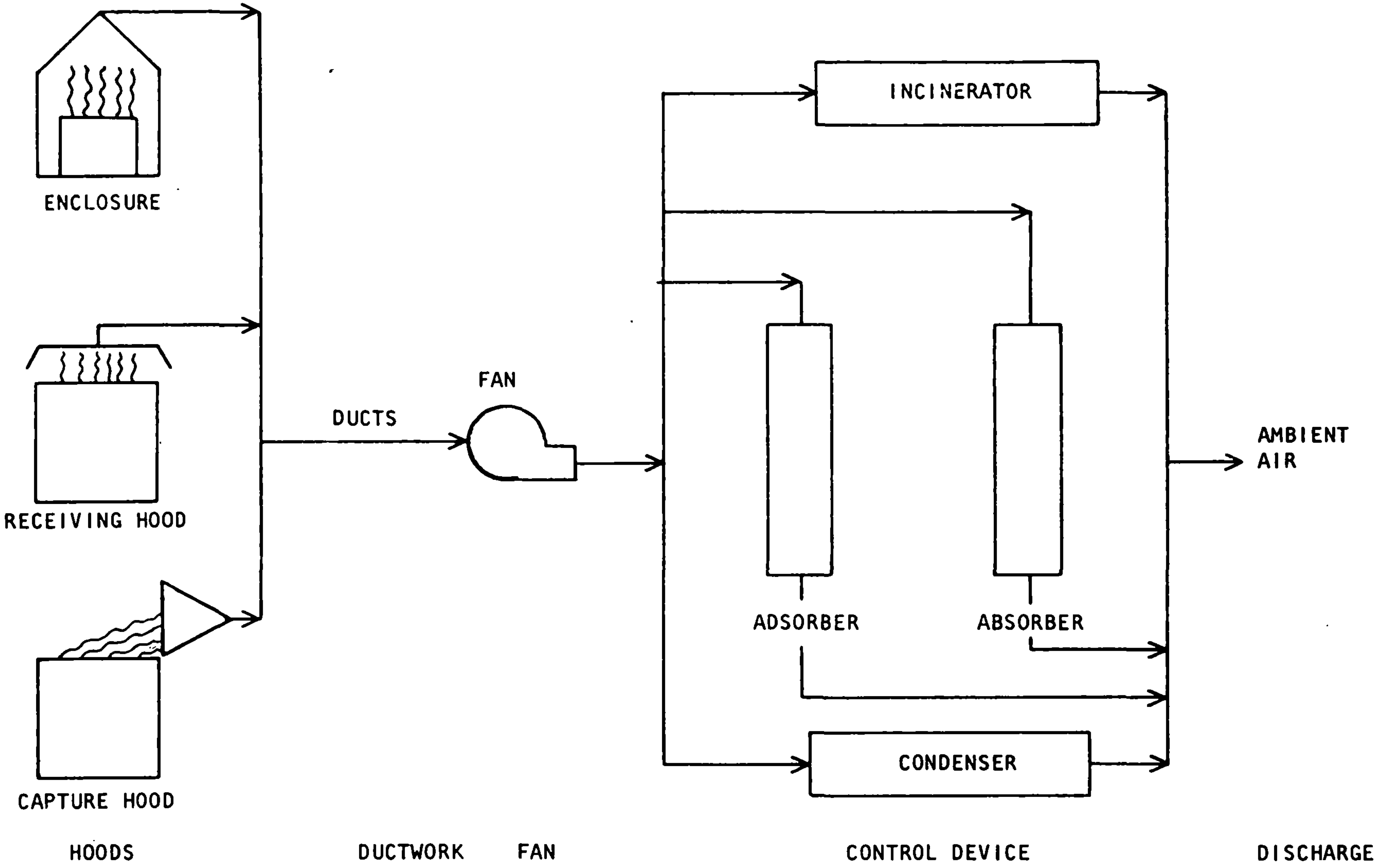


Figure 3-1. Typical collection hood/ductwork fan/control device layout.

understand what items must be checked in the inspection of a capture system it is useful to know how the system works and why the various pieces of equipment are used in the first place. The following discussion reviews the basic principles of ventilation systems without getting into specific design calculations. Inspections of both capture and control systems will be conducted with the assumption that each system was properly designed for its specific application. These inspection procedures will be aimed at determining (1) if the system no longer works as it was designed, owing to poor equipment maintenance or improper operation, or (2) if the system has been modified, through the addition of additional hoods, ductwork, etc. such that the original design is now insufficient. Regardless of how well the system was originally designed, the main purpose of these inspections is to determine if the capture and control system is properly operating now.

The flow of air between any two points is due to the occurrence of a pressure difference between the two points. This is true for large air masses such as weather systems as well as for small in-plant air movement. This pressure difference results in a force on the air causing air flow from the high pressure zone to the low pressure zone. In ventilation and air pollution control systems, the pressure difference is created by generating a low pressure in the system by means of a fan. The fan has to develop enough suction (low pressure) to pull the desired amount of air into the hoods and through the ducts and control device to the point of discharge. The suction, or low pressure, generated by the fan is called negative pressure because it is lower than ambient or atmospheric pressure. The measurement units for pressure are usually pounds per square inch (psi) or inches of water gauge (in. wg.).

Air traveling within a ductwork will exert two forces. One is called static pressure and is due to the air being confined within the ductwork.[12] Static pressure is the same pressure exerted on a balloon when you blow it up. It is there whether there is motion or not, and it can be positive (acting to burst the balloon, piping or ductwork) or negative, (acting to collapse the ductwork).

The second component is called velocity pressure and is the force which results from the air moving through the ducts. Velocity pressure is the force you feel if you hold your hand outside the window of a moving car. It is proportional to the square of the air velocity.[12] This relationship between velocity pressure and velocity is useful in other areas of air pollution control, such as stack testing, because it enables us to calculate the velocity of an airstream by measuring its velocity pressure. Air pressure measuring gauges, used for this purpose, are called manometers.[12] Manometers can be simple "U" tubes, they can be inclined, as the ones in stack testing are to give greater accuracy, or they can be in the form of easy to read gauges, such as a magnehelic gauge. Manometers can also be used to measure total system pressure, which is the combination of static and velocity pressures. This measurement is important in determining the pressure at any point(s) in the system and the difference in pressure between any two points. This aspect of pressure readings will be discussed later in this section.

Air flowing through ducts encounters resistance to flow due to friction and turbulence. Friction is caused by the air rubbing against the walls of the ducts. If the duct walls are relatively smooth, the friction will be low. If, however, the duct walls are irregular or uneven due to corrosion, rust or dents, the friction will be much greater. Friction also increases with higher air velocities, longer runs of ductwork, and smaller duct diameters.[12] If any one of these items is changed in this way, the system will have more friction than was originally designed.

Turbulence takes place whenever the duct changes direction or varies in crosssectional area. Smooth ductwork junctions cause little turbulence, while sudden changes in direction or abrupt contractions or enlargements cause a great deal of turbulence.

The combined ~~a~~effects of friction and turbulence cause a resistance to flow in the ductwork that is called a pressure drop. This pressure drop, like static and velocity pressure, is measured by a manometer in terms of inches of water. The resistance resulting from friction and turbulence must be overcome by adding more energy to the system and this is accomplished by the fan.

Pressure losses also result from the turbulence that is caused as the airflow enters the hood. Gradually tapered or bell mouth shaped hoods cause little "hood entry" losses, while right-angles flanged hoods and completely unflanged hoods result in significant pressure losses.[13] These losses, like friction and turbulence, must be overcome by increasing the energy supplied by the fan.

A ventilation system is designed with all of these factors in mind. The shape of the hood mouth, the number and interconnection of the various branches of the total system, the dimensions of the ductwork and the volume of air required for a specific application all affect the selection of a fan. Once the system is designed and installed, any changes that occur, such as adding additional branch connections, changing to a smaller duct diameter or an accident which noticeably dents the ductwork could add to the total system resistance. If this happens, the company must alter the original design by operating the fan at a higher speed or by installing a new, larger fan. If the fan is not changed, then the increase in system resistance due to these changes will cause the fan to pull less air, and this will decrease the effectiveness of the system to capture pollutants. This is a chief concern in the inspection, since the system resistance can increase slowly over time, and the plant personnel might not even be aware of it, or the slow decrease in VOC capture efficiency, that goes along with it.

One additional item that must be mentioned at this point is capture velocity. Capture velocity is the air velocity in front of a hood that is necessary to capture the contaminated air.[13] The minimum capture velocity that is required for any situation depends on several factors including the type of pollutants to be captured (solid or gas), the velocity with which the pollutant is emitted into the air, the shape of the collection hood and the presence of room air currents. This velocity is established by the volume of air being pulled through the hood by the fan and the size (area) of the hood opening (velocity=volume/area). It is designed into the system by controlling the volume of air that is allowed to flow in the ductwork and by the size and shape of the hood at the emission release point. The capture velocity must be great enough to remove the contaminated air around the source and to overcome any cross ventilation in the room. Contaminants such as VOC, that are usually released with no velocity require a smaller capture velocity than do contaminants such as solids from grinding and sanding operations, which may have a high initial velocity, and therefore require a high capture velocity in order to completely trap them in the capture system. Also, contaminants of low toxicity (such as VOC) released with low velocities in a room with low air currents and captured in a large hood will require a capture velocity much lower than those released with high initial velocities into a drafty room and captured by a small hood.[13]

The problem confronting the inspector is to observe the system in operation and to determine if it is working as designed during the inspection. Are the pollutants generated in the surface coating operation captured by the hood? As you shall see, some hood designs are more "tolerant" to changes that affect original design. They will continue to capture pollutants even when air flow rates decrease. Other designs will lose their effectiveness fairly rapidly if the capture system has been altered or has been allowed to deteriorate.

3.2.1.2 Hoods--

The hood is the most important part of the capture system. If contaminants are not initially captured as they are emitted from the surface coating applicator, flash-off area, curing oven, or other emission point, the entire capture and control system will be ineffective in limiting emissions. Before we discuss hood design, however, there is a common fallacy about air flow in and around hoods that must be dispelled. This has to do with the air flow characteristics of blowing and exhausting (see Figure 3-2). Air blown by a fan through a small duct opening retains its directional effect (forward velocity) for a considerable distance beyond the duct opening. You may have noticed this effect when you feel the force of a window fan across an entire room. When blowing, approximately 10 percent of the initial velocity of a fan still exists at distances equal to 30 duct diameters from the duct opening.[12] However, the same effect is not true when a fan is used in reverse, to exhaust air from a room or from an emission source. In this case, the air loses its initial velocity very quickly as you move away from the duct opening. You have to go very close to the back (suction side) of a room fan before you can feel the effect of the fan's suction. Expressed another way, when exhausting, approximately 10 percent of the initial capture velocity created by a fan still exists at a distance equal to only 1 duct diameter from the exhaust opening. The effect of a fan is 30 times greater when it is blowing compared to when it is exhausting! This effect is very important in designing exhaust hoods since it is the exhausting mode of the fan that is used. This effect says that you have to place the hood very close to the emission source if you want to maintain a set capture velocity across the entire face of the source.

A hood is generally defined as any point where air is drawn into the ventilation system to capture or control contaminants. There are three major types of hoods, each working on a different principle (see Figure 3-3).

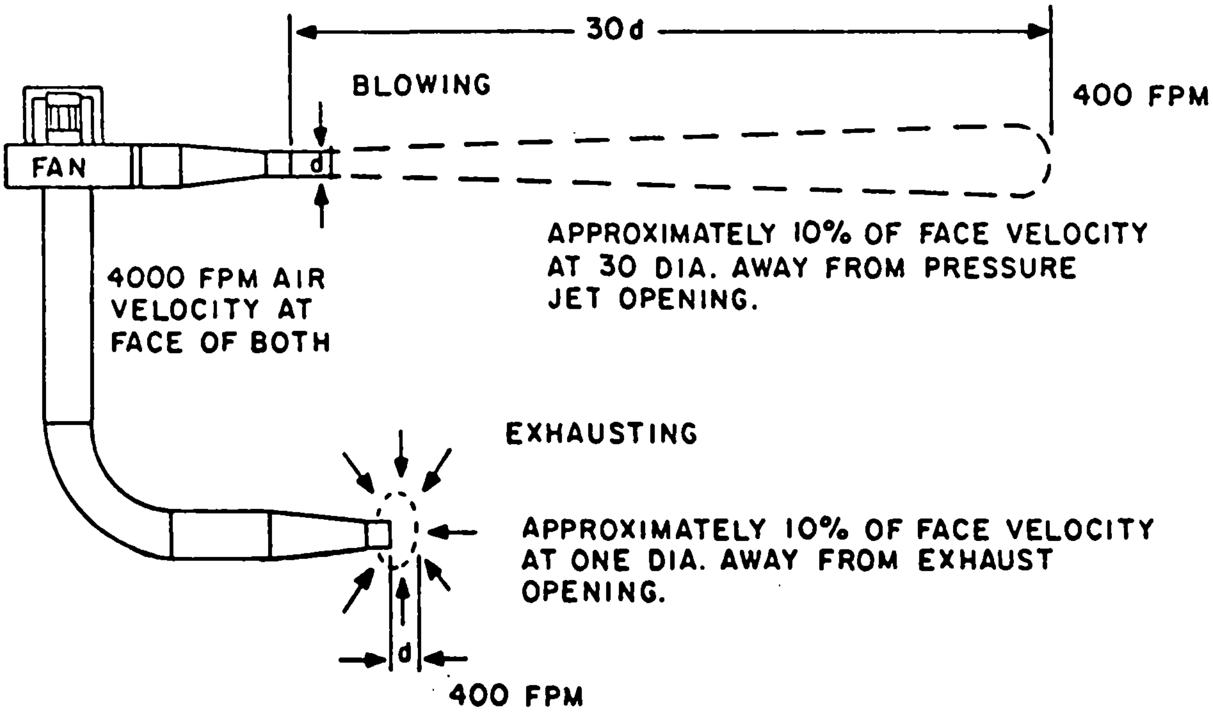


Figure 3-2. The air flow characteristics of blowing and exhausting.[12]

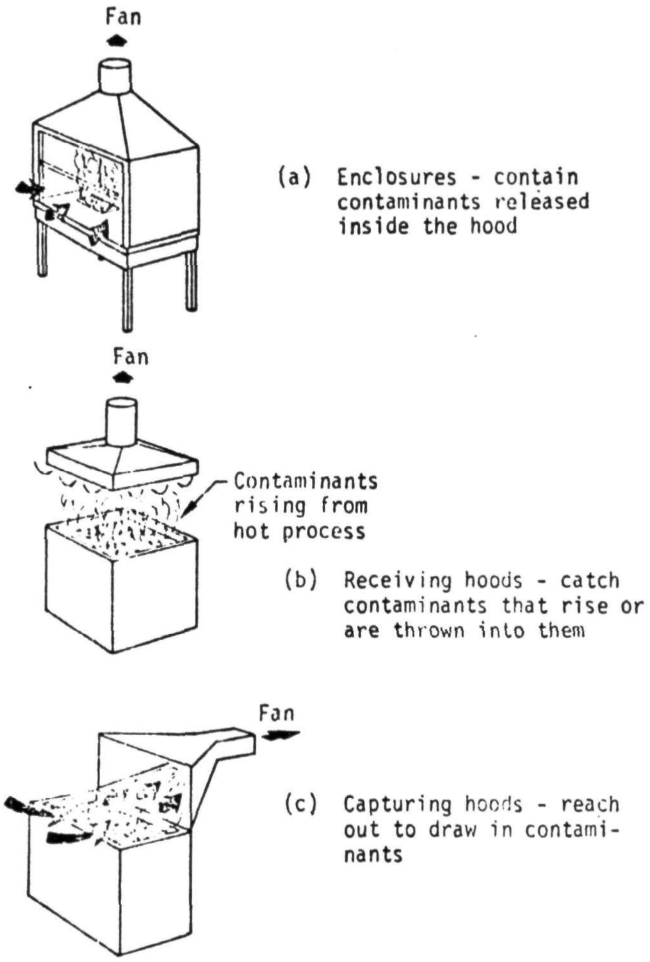


Figure 3-3. Three major hood types: (a) enclosures; (b) receiving hoods; and (c) capturing hoods.[13]

1. Enclosures are hoods that surround the contaminant sources as much as possible. Contaminants are kept inside the enclosure by air flowing in through openings in the enclosure. The more complete the enclosure, the less airflow is needed for control. Employees generally do not work inside enclosures while contaminants are being generated, although they may reach into the enclosure as long as they do not breathe the contaminated air. Enclosures are most commonly found in laboratory applications, where intermittent use of more hazardous chemicals are involved. Certain totally-enclosed surface coating operations, such as curing ovens utilize the design principles of enclosures. Because they totally enclose the emission source, enclosures are less prone to system upsets.[13]

2. Receiving hoods are designed and positioned to catch contaminants as they are released by the process. These contaminants may be particulates from a grinding operation or VOC from surface coating. In each case the hood is located in such a fashion to take advantage of the natural flow of contaminants. These hoods allow workers to operate in and around the process, however, their effectiveness is susceptable to cross drafts in the workroom.[13]

3. Capturing hoods make full use of the capture velocity to draw in contaminants from the process. This hood is widely used since it can be placed alongside the contaminant source rather than surrounding it as with an enclosure. The primary disadvantage is that large air volumes may be needed to generate an adequate capture velocity at the contaminant source. A second disadvantage is that the "reach" of most capturing hoods is limited to about 2 feet from the hood opening. This reach will decrease if the system air flow decreases. In this case pollutants released at a point furthest from the hood will not be captured and will escape into the room. These escaping pollutants can be observed and are indicative of a poorly functioning capture system.[13]

Any inspection of a surface coating facility will probably reveal one or more of the three major types of hoods. The problem confronting the inspector is to ascertain if the hood that is installed is working properly by capturing all emitted contaminants. This might be especially difficult since VOC are not as easily visible as particulates. Nonetheless, by using several of your senses, including sight, smell and touch, you can determine if any pollutants are escaping the hoods.

VOC emissions can often be distinguished by their vapor trails. They have the appearance of "wavy lines" when compared to a background. This phenomena can also be observed with spilled gasoline evaporating from a service station in the summer. These emissions would be noticeable at the entrance to an enclosure-type hood, on the perimeter of a receiving hood or on the side of the emission source that is furthest from a capture hood.

Escaping emissions might also cause a distinct odor in the room where the hood is located. The existence of this odor depends on the type of VOC and its concentration. Yet, if it is present it can signal a capture system problem.

Touch can also help diagnose a malfunction. While capture velocities for VOC emissions are usually very low, placing your hand near the capture hood can sometimes help detect if there is a noticeable air flow toward the hood, indicating that sufficient draft exists in the system. Conversely, if you feel an air velocity going up and around the hood, it is a good indication that there are escaping emissions.

There are several instruments available that can help you determine if there is an air flow into a hood, or if the air (and VOC) is bypassing the hood and going into the plant. One instrument is the velometer, also called a swinging vane anemometer.[12] This device is small, compact and portable and can be held in one hand. A small tube is inserted into the instrument, and the other end of the tube is held in and around the hood. With the velometer you can measure the exact velocity of the air flowing into the hood and capture system. If your agency has such a device, you should bring it with you to the inspection. Get familiar with how the instrument works when you are in your office. This will minimize time spent in taking measurements at the plant. If you do use the velometer, take several readings in and around the hood(s) you suspect as not working properly. Carefully note the location and velocity of each reading you take on your inspection checklists. Once back in the office you can check this data against the original design. Also, you can keep this data as a comparison to data obtained during the next inspection of this plant.

Another instrument that might prove valuable in inspecting capture hood efficiencies is the smoke tube.[12] This device emits a smoke trail and you can place it near a hood to see if the smoke flows into or around the hood. Smoke tubes can only give a rough estimate of airflow, they will not tell you exact air velocity. Nonetheless, this is all you need at times, and it can prove very useful if you cannot determine if VOC are flowing into a hood or not.

Even if you do not directly see escaping VOC emissions, you should look for secondary signs that may indicate a potential problem. Use your common sense as you look around each hood. Are there any signs of VOCs that have condensed in or around the hood? Does the hood surround the emission source? Perhaps the original machine which the hood controlled has been replaced by a larger one, and the hood was not enlarged. Is the operation running at maximum capacity? Maybe the hoods work well at low operating and emission rates, but cannot do the job when they are at 100 percent operation. Does the hood have any type of filter? If it does, how often is this filter changed and when was it last changed? A clogged filter can increase capture system resistance, cause lower air flows, and may make the hood ineffective. How does the hood look? Is it physically intact, or are there noticeable holes? In general, you must look for any obvious or secondary indication that the system is not working and that VOC are not being completely captured by the collection hood. Table 3-2 is a checklist for hoods which should be completed for every hood you inspect. It covers the main items that must be checked during each hood inspection. A copy of this checklist is also included in Appendix C. A table which summarizes some problems that may arise with hoods, and the effects that these problems would have on operations or emissions can be found in Appendix D (see Table D-1).

3.2.1.3 Ductwork--

Ducts and ductwork for containing and transporting the contaminated air stream to an air pollution control device are relatively simple. They contain no moving parts that require regular servicing and maintenance and once installed this part of the capture system should last indefinately. The principal considerations that go into designing a ductwork system are: keep the system resistance to airflow low by using as large a ductwork as is economically possible and by minimizing the number of bends, elbows and abrupt changes in duct diameter; balance the airflow resistance in the various branches of the system so that the capture velocity at each hood meets design criteria and insure that the air velocity within the ductwork is sufficient to transport the pollutant being controlled.[13]

Overall ductwork resistance must be minimized to reduce power costs. The greater the resistance to flow, the larger the fan must be to overcome friction in the system, and the greater the total power costs. Similarly, bends and elbows provide more resistance than do straight sections of ductwork, so the ideal design uses a minimum number of these pieces. Small diameter ductwork is cheaper to buy initially, but produces more resistance, so a balance must be struck between low initial cost (small ductwork) and small operating costs (large ductwork).

Balancing a total ductwork system to provide for equal or appropriate air flows in all hoods can be very complex. Many system designers will install restrictions, such as adjustable dampers, in branch ducts to create the proper resistance. Others use different diameter ducts to vary the resistance of each branch. Whatever technique is used, the important thing is, does it work? Does the system provide for sufficient air flow at all hoods to capture the contaminants?

Maintaining duct transport velocities is not a major problem with surface coating operations, since the principal pollutant, VOC, is in a gaseous form. For this application, low transport velocities are common and acceptable. Again, as long as the entire system captures the contaminant at the hoods, then specific system parameters, such as duct velocities and pressure drops are not critical and need not be measured directly.

Since these procedures assume that the ductwork network was properly designed to begin with, then your main concerns will be limited to insuring that nothing has been done to the network that would change the system pressure drop and hence the system flow. These changes could include additional branches that have been added to the system without a change in the fan size; holes, rust, and/or bends in the ductwork that would add additional friction and/or resistance to the system airflow; and a rerouting of the original ductwork design that would result in more bends and/or transition

TABLE 3-2. CHECKLIST FOR HOODS

PLANT XYZ

INSPECTOR J. JONES

DATE 4/12/82

I. PROCESS

A. PROCESS LINE DESIGNATION B1, B2, B3

B. PROCESS EQUIPMENT CONTROLLED BY HOOD COATING APPLICATION

C. PROCESS IN OPERATION DURING INSPECTION? YES ✓ NO ___

D. 1. PROCESS OPERATING AT MAXIMUM CAPACITY? YES ✓ NO ___

2. IF NOT, AT APPROXIMATELY WHAT PERCENT OF CAPACITY? ___%

II. HOOD

A. TYPE OF HOOD: ENCLOSURE ___ RECEIVING ___

CAPTURE ✓ OTHER (DESCRIBE) ___

B. 1. IS THE HOOD STRUCTURALLY SOUND? YES ✓ NO ___

2. IF THERE ARE HOLES, DENTS, ETC., WHERE ARE THEY? NONE

C. 1. DOES THE HOOD HAVE A FILTER? YES ✓ NO ___

2. WHEN WAS IT LAST INSPECTED? 1/shift LAST CHANGED? 1/shift

III. GENERAL OBSERVATIONS

A. ARE THE VOC EMITTED AT A NOTICEABLE RATE? YES ✓ NO ___

B. ARE THERE CROSS-DRAFTS IN THE ROOM? YES ✓ NO ___

C. IS THE HOOD WELL POSITIONED TO CAPTURE THE VOC? YES ✓ NO ___

D. WHAT IS THE APPROXIMATE DISTANCE FROM THE EMISSION POINT TO THE HOOD OPENING? 3 FT 0 INCHES

E. 1. DOES THE HOOD APPEAR TO HAVE BEEN MODIFIED OR ALTERED IN ANY WAY? YES ___ NO ✓

2. IF YES, HOW? ___

(continued)

TABLE 3-2 (continued)

F. 1. DOES THE HOOD CAPTURE THE VOC? YES ___ NO ✓

2. IF NOT, WHAT IS HAPPENING WITH THE VOC? FUGITIVES

G. 1. IS THERE AN ODOR IN THE ROOM? YES ✓ NO ___

2. IF SO, WHERE? near applicator

3. DOES IT SEEM TO BE RELATED TO THE HOOD CAPTURE EFFICIENCY?
YES ✓ NO ___

H. OBSERVATIONS filter clogged with coating

IV. MEASUREMENTS

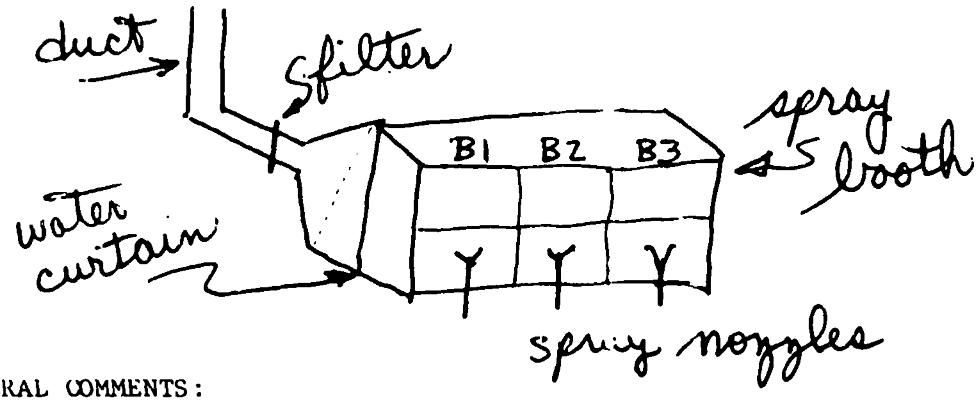
A. TYPE OF INSTRUMENT USED ___

B. WHERE WAS MEASUREMENT(S) TAKEN? (DRAW SKETCH BELOW)

C. INSTRUMENT READING(S) (IF APPLICABLE) ___

D. OBSERVATIONS ___

V. SKETCH PROCESS, LOCATION OF HOOD, POSITION OF MEASUREMENT DEVICE



VI. GENERAL COMMENTS: ___

pieces and hence more system resistance. The easiest way to inspect the ductwork is to follow the individual branches from each hood. As ductwork will often be installed overhead and is not easily accessible, use your own judgment and only inspect what is practical to see up close. Check for holes in the ductwork. Since the system is under a negative pressure, any hole will cause room air to be sucked into the hole and may cause an audible noise. There will be no obvious emission to signal the existence of a hole, so a careful inspection is required. A hole will result in room air and not contaminated VOC-laden air being sucked into the system. If the hole is large, the VOC will not be captured at the hood, and as has been stated, the capture of all pollutants at the hoods is the real test of how well a capture and control system works. Nonetheless, if a hole is discovered, point it out to your plant escort. It should be fixed as soon as possible to prevent it from becoming worse. Also, try and see what caused the hole in the first place. If it was due to an accidental puncture, then accidents happen and it is hard to completely eliminate them, but if it was due to the position of the ductwork in a busy area, or to the deterioration of the ductwork resulting from condensation or excessive heat, then a long term remedy must be sought. This aspect of the inspection requires some investigative cause and effect thinking and some common sense. The problem must be understood and whatever action necessary taken to insure that it does not happen again.

Ductwork inspections should pay particular attention to areas where problems may show up, such as bends, transition pieces and dampers. Due to the action of the moving, contaminated air, these pieces may see extra wear and tear, and must be thoroughly checked for obvious signs of corrosion and general deterioration. If a manual damper is installed, ask about how, when, and why it is moved. Is it adjusted depending on which surface coating line is in use? Or has it been placed in one position and never touched? Whichever method is employed, the damper should be clearly labeled with instructions on who is to be notified when it is adjusted. An out-of-position damper can throw an entire capture system out of balance with disasterous effects on the capture efficiency.

Because ductwork systems contain no moving parts, they may have been forgotten and never checked by plant personnel. An inspection conducted as part of an overall capture and control system inspection will serve to uncover any unexpected deterioration in this area. Table 3-3 is a checklist for ductwork which lists the principal items that must be addressed in a ductwork inspection. You should complete one for each ductwork inspection. A copy of this checklist is also included in Appendix C. A table which summarizes some problems that may arise with ductwork and the effects that these problems would have on operations or emissions can be found in Appendix D (see Table D-2).

3.2.1.4 Fans--

After the hoods, fans are the most important part of the capture system. The fan generates the suction in the system that draws the contaminated air in through the hoods. If the fan is too small, or operating too slow, the airflow will be too low. Fortunately, fan selection does not always have to be perfectly accurate; fans have some built-in flexibility since their capacity increases with higher fan speeds and the speed is adjustable with certain fan designs.

TABLE 3-3. CHECKLIST FOR DUCTWORK

PLANT XYZ

INSPECTOR J. JONES

DATE 4/12/82

1. SYSTEM LAYOUT

A. 1. SKETCH BELOW THE WAY IN WHICH THE DUCTWORK TIES TOGETHER THE HOODS AND THE CONTROL EQUIPMENT.

2. LABEL INDIVIDUAL BRANCHES.

B. HOW MANY HOODS ARE CONNECTED TO THE DUCTWORK? 3

C. 1. ARE ALL HOODS CURRENTLY IN USE? YES ✓ NO ___

2. IF NO, MARK UP SKETCH TO SHOW WHICH ARE/ARE NOT CONNECTED.

D. PHYSICAL INSPECTION

1. WHICH BRANCHES DID YOU INSPECT? (LIST) All

2. NOTE THE APPEARANCE OF ANY BRANCH WHICH APPEARS TO BE IN POOR CONDITION (DENTS, RUST, HOLES, ETC.)

Ductwork outside bldg. is rusted

3. NOTE THE NUMBER AND CONDITION OF ANY BENDS, ELBOWS AND TRANSITION PIECES WHICH ARE IN POOR CONDITION

all inside are good

4. DO ANY PIECES OF DUCTWORK APPEAR NEWER THAN OTHERS? YES ✓ NO ___ (IF YES, NOTE WHERE ON SKETCH)

5. WHY WAS DUCTWORK CHANGED? fire in duct insulation

6. DO ANY SECTIONS OF THE DUCTWORK APPEAR VULNERABLE TO BEING HIT BY A MOVING CART, FORKLIFT, CRANE, ETC.? YES ___ NO ✓ (IF YES, NOTE ON SKETCH)

7. HOW OFTEN ARE DUCTS INSPECTED FOR MATERIAL (POLYMERS, RESINS, ETC.) BUILDUP ON THE INSIDE? 1 PER 6 months

---

(continued)

TABLE 3-3 (continued)

E. DAMPERS

1. ARE DAMPERS USED TO ISOLATE DUCTWORK BRANCHES? YES ✓ NO ___

2. WHERE ARE THE DAMPERS LOCATED? (NOTE ON SKETCH)

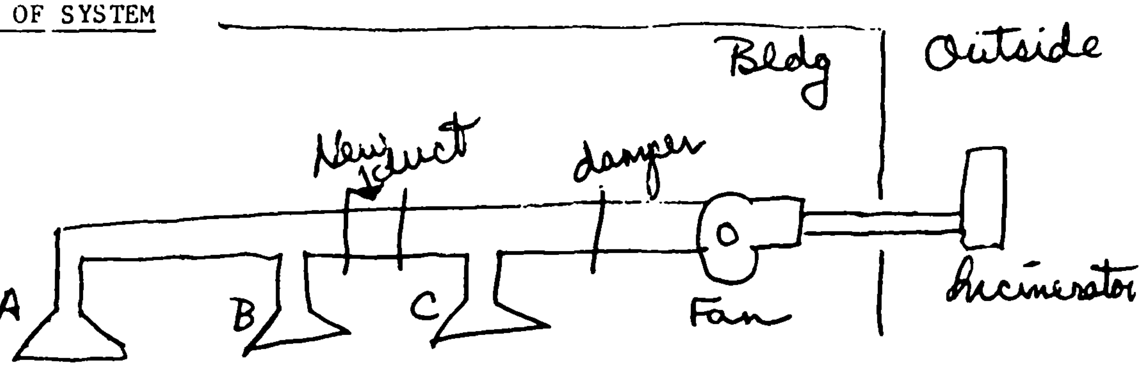
3. WHAT IS EACH DAMPER'S FUNCTION?
EMERGENCY BYPASS ✓
FLOW CONTROL ___
OTHER (SPECIFY) ___

4. IS DAMPER MANUALLY OR AUTOMATICALLY ACTIVATED? Automatic

5. WHAT IS THE POSITION OF EACH DAMPER DURING THE INSPECTION? (0 DEGREES = FULL OPEN, 90 DEGREES = FULL CLOSED) 0°

6. IS EACH DAMPER CLEARLY LABELED? YES ___ NO ✓

II. SKETCH OF SYSTEM



III. GENERAL COMMENTS: some ductwork has resin dripping on outer shell

There are several different types of fans and each has its own relative advantages and disadvantages. Axial fans are generally used to move large quantities of air against very low static pressures, while centrifugal fans are often used in industrial applications to move dust and fume laden air.[12] Regardless of fan design, the volume and the fan static pressure are the two most important items for proper fan selection.

The volume required by the system is that volume which will provide for adequate capture velocity at all collection hoods. This is set by the number of hoods in the system and the volume of air required at each. The static pressure required by the fan is equal to the total resistance of the entire capture and control system, since the fan must overcome this resistance to deliver the required air volume. A fan is, therefore, chosen that delivers the required volume at the required static pressure. As it turns out, the volume and static pressure of any fan are inversely related. That is, as the volume of air moved by the fan increases, its static pressure decreases and vice versa. The exact way in which volume and pressure are related varies with each fan. This means, however, that if you increase the fan volume too much you may no longer be able to overcome the resistance of the system, so there is a practical limit as to how much extra flow a fan can put out and still be effective. What is also important is that, as the system resistance increases, the volume of air moved by the fan decreases. If this happens, the face velocity at each collection hood will decrease, and the VOC emitted may not be captured at the hoods. The increase in system resistance may take place slowly, over a number of months or years, so the decrease in hood capture efficiency may not be noticeable to plant personnel. However, this decrease can happen and it is an item you should be concerned about during your inspection.

Most fans you encounter in a plant will be one of two types: direct driven or belt driven. Direct driven fans are connected directly to the electric motor that drives them. They offer a more compact assembly and assure constant fan speed as they eliminate belt slippage that does occur when belt driven fans are not maintained. Fan speeds are limited to available motor speeds however, and this makes them very inflexible. Certain direct drive fans utilize an adjustable, transmission-like, linkage to provide some amount of adjustment. The fan is still directly linked to the electric motor and to change the fan speed you must change the linkage setting. Belt driven fans are connected to their electric drive motor by means of a belt. This belt gives them the flexibility of a quick change in fan speed without the need to change the electric motor. For this reason belt driven fans are preferred in ventilation systems. The fan speed can be adjusted to account for changes in the number of hoods, or the total air or pressure requirements of the system. The volume of air delivered by a fan is directly proportional to the fan speed; double the fan speed and you double the output volume. Belt driven fans enable plant personnel to adjust the volume of air they need by adjusting the fan speed. However, the electric power consumption increases at a much faster rate than the fan speed, so it is important for plant personnel to closely match fan speed with exact air flow requirements.[13]

Fans are the only part of the capture system that have moving parts. Unlike hoods and ductwork, they require regular inspection, lubrication and maintenance if they are to perform as designed. Your inspection of this part of the system must, therefore, insure that the fans are working well now, that they are regularly maintained and that they show no signs of neglect or lack of maintenance. Check the fan before the motor. Inspect the fan wheel and housing for wear and dust buildup. If possible, observe the fan wheel rotation. It should spin freely with no vibration. Any detectable vibration may indicate a dust buildup on the fan blades, misalignment of the fan and electric motor, or a fan bearing problem. Dust buildup shouldn't be a problem since VOC are gaseous, but check none-the-less. A misalignment problem may be due to improper installation. A fan bearing problem may be caused by misalignment, failure to lubricate the bearings regularly, or a fan belt that is too tight. Bearings will usually overheat before they fail completely, so if you can do so safely, feel the metal housing surrounding the bearing. If it is hot to the touch, it may indicate a problem. Remember you are not here to tell the plant people how to maintain their equipment, you are trying to locate potential problem areas before they cause equipment breakdowns and result in uncontrolled VOC emissions.

Next check the tension of the drive belt. Much like a car fan belt, it should be tight, with a minimal amount of deflection. Slippage by the fan belt will cause the fan to turn slower and hence pull less air. Conversely, if the fan belt is too tight, it may cause a bearing failure. If the fan is not running, closely inspect the belt for cuts and abrasion that may shorten its life. The plant personnel should regularly inspect the fan belt for wear and tear so that they can replace the belt before it breaks completely. Make note of their fan belt inspection schedule.

Finally, check the motor. Put your hand on the motor casing, it should be warm, but not hot to the touch. An overheated motor may also be due to a bearing that is beginning to fail. Request the maintenance schedule for the fan, the fan belt and the motor. The motor bearing should be greased on a regular schedule, usually once per month or once every other month. All moving parts eventually wear down and must be renewed or replaced. The more frequent a moving part is inspected and lubricated, the longer it will last. Note when the motor was last changed and if a spare is kept in stock. Also see if a spare fan belt and fan are maintained in inventory. While there may be no regulatory requirements for spare parts, this information can give clues as to the seriousness of the plant toward equipment operation and maintenance. In general, plant personnel should be encouraged to maintain spares of items such as fan belts and bearings that are not extremely expensive. Such spares will minimize the down time of the capture and control equipment should an equipment breakdown occur. The checklist in Table 3-4 presents important items that must be checked during a fan inspection. A table which summarizes some problems that may arise with fans and the effects that these problems would have on operations or emissions can be found in Appendix D (see Table D-3).

In summary, inspection of a capture system for surface coating VOC emissions is not extremely difficult since the only moving parts are the fan and its associated electric motor. This inspection, however, does require a conscientious, thorough look at every hood, and every branch network of what

TABLE 3-4. CHECKLIST FOR FANS

PLANT XYZ

INSPECTOR J. JONES

DATE 4/12/82

I. TECHNICAL DATA

A. FAN MOTOR

1. MANUFACTURER —

2. RATED HORSEPOWER 75 3. MAXIMUM RPM 196

B. DRIVE

1. DIRECT [✓ BELT] OTHER

2. PULLEY REDUCTION 9:1

C. FAN

1. MANUFACTURER —

2. INSTALLATION DATE 3/76 3. RPM 1760

II. OPERATING AND MAINTENANCE DATA

A. FAN MOTOR

1. NOTICEABLE OVERHEATING? YES [✓ NO]

2. HOW OFTEN IS BEARING INSPECTED? 1 PER month

3. BEARING LAST CHANGED (DATE) 9/81

4. SPARE BEARING KEPT IN STOCK? [✓ YES] NO

5. COMMENTS

B. DRIVE

1. AUDIBLE BELT SLIPPAGE? YES [✓ NO]

2. BELT CONDITION good

(continued)

TABLE 3-4 (continued)

3. HOW OFTEN IS BELT INSPECTED? 1/month

4. WHEN WAS BELT LAST CHANGED? 12/81 LAST ADJUSTED? 2/82

5. SPARE BELT IN STOCK? YES ✓ NO ____

6. COMMENTS triple belts

C. FAN

1. NOTICEABLE FAN VIBRATION? No

2. FAN BLADE CONDITION good

3. HOW OFTEN IS BEARING INSPECTED? 1 PER 3 months

4. BEARING LAST CHANGED 9/81

5. SPARE BEARING KEPT IN STOCK? YES ✓ NO ____

6. DAMPER INSTALLED AT FAN INLET? YES ____ NO ✓

7. DAMPER POSITION ____________ % OPEN

8. FAN STATIC PRESSURES: INLET 7psi OUTLET 3psi

9. CONTINUOUSLY MEASURED VARIABLES?

   a. FAN SPEED YES ____ NO X

   b. AIR FLOW RATE YES X NO ____

   c. INLET STATIC PRESSURE YES X NO ____

   d. OUTLET STATIC PRESSURE YES X NO ____

III. GENERAL COMMENTS: ____________

can be a large and complex ductwork system, depending on the plant size and the number of individual surface coating stations. The most important aspect of the inspection is insuring that the VOC are captured by the hoods as they are emitted. Proportionately more time and effort should be spent inspecting the individual hoods. If a VOC capture problem is detected here, then the rest of the inspection should be spent attempting to determine the cause of the problem--is it the type and position of the hood? The physical condition of the ductwork? Or the speed and condition of the fan? A problem in only one branch of an entire duct network can usually be traced to that ductwork and/or its damper. If no problems at all are encountered, then the remainder of the inspection can be devoted to insuring all systems are tight and well maintained.

3.2.2 Control Devices

3.2.2.1 Introduction--

A surface coating operation emission control system is comprised of two portions; the emission capture system and the emission control device. Capture systems, their various components, and inspection procedures are discussed in Subsection 3.2.1. During your inspection of the hoods, ductwork, and fans associated with the capture system, you will have undoubtedly noted the location of the control device. This subsection describes the control devices you are likely to encounter during inspections of surface coating process emission control systems and provides procedures for conducting a thorough evaluation of the operation and maintenance of these control devices.

Control devices applicable to coating operations include:

- carbon adsorbers,
- incinerators,
- condensers, and
- absorbers.

The type of control device used is often a function of VOC vapor stream properties, such as:

- organics type and concentration,
- temperature,
- flow rate,
- humidity, and
- particulate concentration.

Adsorbers, especially carbon adsorbers, and incinerators, both direct-flame and catalytic, are the most frequently installed control devices in add-on control systems for the reduction of VOC emissions at surface coating facilities. These devices are, therefore, thoroughly discussed in this subsection. Condensation and absorption devices can also be used to control VOC emissions from surface coating processes. However, relatively few of these devices have actually been installed at surface coating facilities.

Carbon adsorption can be used to reclaim solvents from the vapor phase for reuse in a coating process. Adsorption is feasible for low temperature, low particulate concentration vapor streams which contain single solvents.

Incineration is a method of oxidizing the VOC. Two types of incinerators are used to control coatings emissions; direct-flame and catalytic. Direct-flame incineration involves heating a vapor stream close to its combustion temperature and then igniting the vapor in an afterburner. Catalytic incineration makes use of a catalyst bed to allow combustion at significantly lower temperatures. Organic materials are adsorbed on the catalyst surface resulting in higher concentrations and subsequently faster combustion.

Condensers consists of refrigeration units in which vapor streams are chilled to a temperature below the VOC condensation point. Absorbers rely on the principles of selective solubility. Vapor containing organic solvents is passed into a tower countercurrent to a liquid solvent stream. The liquid absorbs the organics and passes out of the column. The solvent must then be thermally stripped of the dissolved organics before reuse.

When reviewing the suggested procedures for inspecting these control devices, you should keep in mind the safety precautions noted earlier. The chances of being exposed to extreme temperatures or high concentrations of VOC are much greater near the control device than anywhere else in the control system. Although a procedure may use the word "feel," it does not necessarily imply "touch." If you are checking for extreme hot or cold, you can "feel" the heat, or lack thereof, simply by placing your hand close to the equipment without actually touching it. Likewise, when checking for "smell," don't put your nose (and therefore your face) in the direct line of an exhaust or emission source. Rather, start about an arm's length away and try to "wave" the air around the source toward your nose with your hand or a notebook or clipboard. If you must get closer, do so slowly, making sure that you won't be "surprised" by a strong odor or high temperature.

3.2.2.2 Incinerators--

Due to their versatility in handling all types of VOC at a broad range of concentrations, incinerators have gained widespread use for control of VOC emissions in the surface coating industry. These devices are sometimes called afterburners. Incinerators destroy the VOC by thermally oxidizing the combustible organic vapors to water vapor and carbon dioxide. This complete combustion process is usually assisted by the addition of an auxiliary fuel, such as natural gas.

Gaseous or fume incinerators, of the type used to oxidize VOC vapors, are simple and straightforward. Most resemble cylindrical chambers with the VOC vapors and auxiliary fuel fed into one end, and the hot combustion gases exiting the other. Some units use separate burners for the VOC vapors and the auxiliary fuel while others mix the two streams in one burner. Often the VOC vapors are preheated by passing them through a heat recovery section located in the hot (outlet) end. If you are unsure of the exact configuration, ask for an explanation of the flow of the VOC into and out of the incinerator.

Gaseous or fume incinerators come in two basic types: direct flame and catalytic. Direct flame units rely on high temperatures, in the 1200-1500°F range, to oxidize the VOC.[14] To reach these high temperatures, direct flame incinerators burn substantial amounts of auxiliary fuel. In addition, the entire incinerator system must be built stronger than catalytic types to withstand these high temperatures. Catalytic incinerators, on the other hand, operate at much lower temperatures, usually in the 500-900°F range.[15] Oxidation of the VOC in these units is carried out on the surface of the catalyst. A catalyst is a material which changes the rate of the reaction but is not consumed in the process. Commercial catalysts used for the incineration of gaseous mixtures usually consist of platinum and paladium in small quantities on some type of alumina support. This support may take the form of a honeycomb, spheres, short rots, etc., which provide a large surface area in a relatively small volume on which the VOC can burn.[15] The catalyst system has an advantage over direct flame incineration in that it operates at lower temperatures and thus saves fuel. However, the catalyst may be expensive, it has a usual life span of 3 to 5 years and is subject to fouling by a variety of chemicals as well as dust and dirt. Its effectiveness in oxidizing VOC emissions is reduced as the catalyst becomes fouled and/or is gradually deactivated. There is no "best" incineration system and the selection of a direct flame versus a catalytic incinerator is usually a personal and/or economic choice.

The effective incineration of any solid, liquid or vapor, such as VOC, requires that the three T's of combustion, Temperature, Time and Turbulence, be met. The temperature at which the incinerator operates must be high enough to completely oxidize the VOC. Once this temperature is known, it is set on the incinerator control panel. If the incinerator temperature falls below this point, auxiliary fuel is combusted to increase the temperature. The minimal acceptable incinerator temperature will usually be set in the operating permit. Make sure you know this temperature before you visit the plant, and verify that the incinerator is operating at least at this temperature for it is the single most important variable that affects incinerator performance.

The time the VOC spends in the high temperature incinerator environment is called its residence time. This time must be long enough to allow all of the VOC to completely combust. If the residence time is too short, then some of the VOC may pass out of the incinerator without being burned. Residence time is designed into an incinerator by the design air flow rate and the volume of the incinerator chamber. The only variable here is the air flow rate and it can only change if the fan speed changes. Too much air flow will decrease the residence time while too little will increase it. Your inspection should insure that the fan is operating as it was designed and approved by your agency, and not any faster, for this could lead to VOC emissions.

Finally, turbulence is important in incineration systems to insure good mixing of the VOC, the combustion air and the auxiliary fuel. Good mixing is required so that each molecule of VOC is contacted with oxygen for combustion. If turbulence is insufficient, then some VOC may pass through the incinerator without being burned. Turbulence is applied to an incinerator by the action of the combustion air, the VOC and the auxiliary fuel as they are injected into the incinerator at the burners. It is not easily checked, but will only vary if any of these flows change dramatically.

Both direct flame and catalytic incinerators are components of an entire incineration system which includes auxiliary fuel, combustion air and VOC feed systems, auxiliary gas or oil burners, combustion control equipment, the incinerator combustion chamber, its refractory lining, and a heat exchanger (if installed). This system is presented graphically in Figure 3-4. Your inspection must cover all of these items, since a failure in any subsystem can affect the ability of the entire incineration system to completely combust the VOC vapors. A review of the individual subsystems will help point out potential problems that may arise.

Air Supply Fan--This fan supplies the air needed for combustion of the auxiliary fuel and/or the VOC. Its function may be combined with the auxiliary fuel and/or the VOC feed lines. Too much air supplied to the incinerator is inefficient and will result in shorter retention times and potentially cause incomplete combustion of the VOCs, while too little air will give longer retention times but may affect the air/VOC mixing and cause localized pockets of oxygen starvation. You need to check the same items mentioned for fans in the capture system. These include material buildup and/or coating of the fan blades, excessive fan vibration, looseness of the fan belt, material integrity of the fan blades and metal casing, overheating of the electric motor and fan, and motor or fan bearing problems.

VOC Vapor Supply--This is the chief line of concern since it carries the VOC to the incinerator. Leaks in this system will dilute the VOC stream, increase the flow rate and decrease the incinerator efficiency. First check the structural integrity of the ductwork. Look and listen for leaks at the joints and connections. If a filter is installed on this supply line, check when it was last replaced and/or inspected. A separate burner or "gun" may be used to atomize the VOC feed. If possible, check this VOC burner for wear and corrosion. If pressure and/or temperature gauges are installed in the VOC line, record these readings. Ask for and inspect these readings for the last several months. Look for noticeable changes in these measurements and question plant personnel if a wide fluxuation is noticed. Such changes may be early indications of equipment problems and should be addressed before they cause equipment failures.

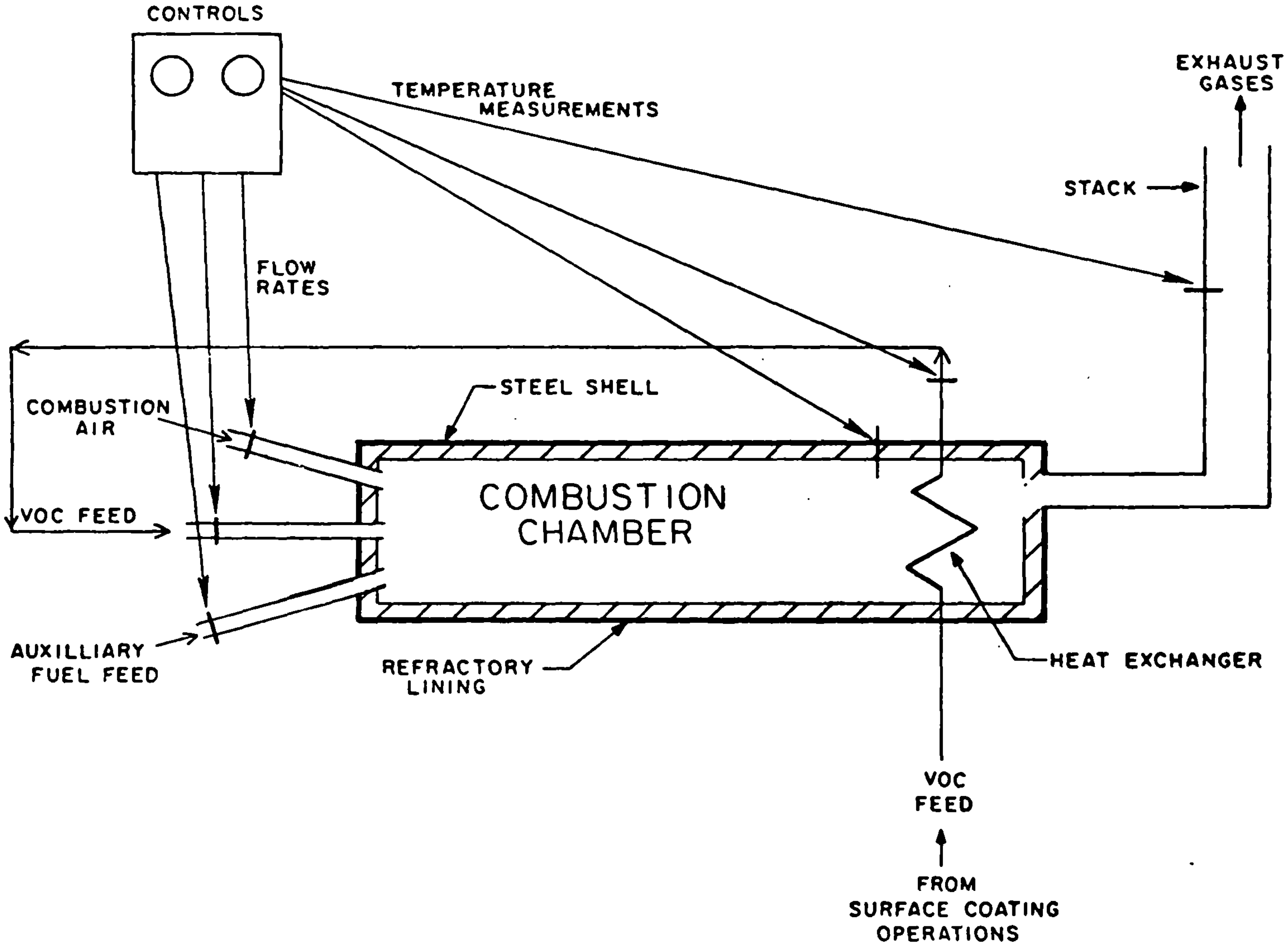


Figure 3-4. Typical incinerator system.

Gas and oil (auxiliary fuel) burners--These systems feed auxiliary fuel, as required, to the incinerator to maintain minimum combustion temperatures. Problems in this area can cause insufficient auxiliary fuel delivery and incomplete fuel combustion. This in turn may lead to low incinerator temperatures and low VOC destruction efficiency. Auxiliary fuel burner tips, especially fuel oil tips, must be inspected for wear and corrosion. The inspection, cleaning and maintenance schedule should be noted and the date of the last burner tip replacement recorded. Gas burners usually require little maintenance. Oil burners are more susceptible to wear, pitting and corrosion, due to the sulfur compounds in the fuel, and are usually serviced and/or cleaned once per week. Note the specific cleaning cycle. The fuel oil supply pump, strainer and/or filters must be inspected for leakage and plugging. Fuel supply pump seals will periodically wear and need replacement. An inspection of the operating logs for the auxiliary fuel system should also be conducted, and discrepancies noted between current and past readings.

Incinerator controls--Most VOC incinerators are automatically controlled. Once turned on, they will go through a preset startup cycle that purges the system with clean air before auxiliary fuel is fed and ignited. Once the unit reaches operating temperature, the VOC vapor stream feed commences. The number and type of incinerator control parameters that are constantly measured and/or recorded will vary from unit to unit. At a minimum, the incinerator operating temperature should be measured and recorded, since this is the only way relative incinerator compliance can be checked on a regular basis. This temperature measurement should be compared with limits set forth in the operating permit to insure the unit is operating as originally approved. Temperature charts for the previous 6 months or since the last inspection should be inspected to insure that the unit maintained its proper temperature range, to note any month by month temperature variations, and to see if the incinerator was operated at all times when the process was in operation. Any inconsistencies uncovered by these checks should be noted. Since there are a wide variety of mechanical and electrical controls commercially available, it is impossible to list specific operating and maintenance instructions for each. The specific O&M instructions that are included with the control panel O&M manual should be followed. Plant personnel should be asked to review O&M procedures for the control panel, such as how often the instruments are calibrated, how often they are cleaned and what type of periodic maintenance, such as lubrication, is regularly conducted.

Refractory--The combustion chamber of the incinerator is normally lined with refractory brick. It acts as an insulation material to prevent the metal body of the incinerator from overheating and warping. If the refractory fails, local hot spots will develop on the surface of the incinerator and this may cause localized metal failure. Refractory is usually inspected once per year, when the incinerator is shut down for annual maintenance. Note the date of this last inspection. Closely inspect the outside of the combustion chamber for telltale signs of refractory failure, such as blistering and/or peeling paint. Check for warpage of the metal surfaces. Insure that all metal to metal joints and connections mate evenly. A hot incinerator surface can be a health and safety risk to the plant operators as well as an early indication of refractory failure.

Catalyst--The use of a catalyst enables catalytic incinerators to be operated at temperatures much lower than direct flame units. However, catalysts have a limited life time and, as they deteriorate, the ability to reduce VOC concentrations decreases. "Poisoning" of the catalyst is due to a number of factors, including chemicals which combine with the catalyst, such as chlorine, fluorine, zinc and lead; masking agents which inhibit the oxidation reactions, including halogen and sulfur compounds; and fouling agents which coat and foul the catalyst, including particulate, oils, carbon and iron oxides. The exact condition of a catalyst can only be judged by a direct physical inspection. Since its condition affects its ability to reduce VOC emission, the catalyst must be inspected by an individual knowledgeable in this area and it must be replaced when it shows signs of deterioration. Find out when the catalyst was last replaced, when it was last inspected and who conducted the inspection. Ask about the condition of the catalyst during this inspection--Did it show signs of plugging, fouling or general deterioration? Was it cleaned or altered? What are the company's plans for replacing the catalyst? If any system variable is measured and recorded downstream of the catalyst, such as stack temperature, review the records for this variable and note any gradual change which may indicate a slow deterioration of the catalyst. Since the catalyst is the single most important item in catalytic incineration systems, close attention must be payed to how and when the catalyst is inspected and maintained.

Heat Exchangers--Many incinerators recover the heat generated in incineration through the use of heat exchangers located at the end of the combustion chamber. These exchangers can be used to heat any one of a number of air and/or water streams. The most common use of a heat exchanger in a VOC incinerator installation is for preheating of the VOC feed stream. This raises the VOC vapor stream temperature close to its ignition temperature and minimizes the amount of auxiliary fuel required for combustion. A breakdown of the heat exchanger can cause the release of unburned VOC by allowing the VOC feed stream to enter the incinerator exhaust, thereby bypassing the incinerator. The physical integrity of the heat exchanger is the most important item that must be checked. The surface of the heat exchanger, and all points where metal is joined by welds, rivets, flanges, etc., must be closely examined. If inlet and/or outlet VOC temperatures are continuously measured and recorded, an examination of this data over several months will indicate unusual fluctuations. Such temperature changes may indicate slow leaks in the system and bypassing of VOC directly into the rear of the combustion chamber and out of the stack. Similarly if the differential pressure across the heat exchanger is measured, fluctuations in this reading may give an early indicate of problems. If such a fluctuation is noticed, plant personnel should be questioned about the frequency of the inspection schedule for the exchanger. It may not be frequent enough and it may not be detailed enough to uncover the problems of leaks and/or holes in the metal surfaces.

The incinerator and all subsystems may be running without problems when the inspection is made. Hopefully this will be the case. The inspection will insure that this condition remains the same by uncovering telltale signs of equipment deterioration. If a potential problem area can be noted and corrected during normal plant maintenance shutdowns, then the VOC emissions that result when an unexpected malfunction occurs can be avoided. Refer to the checklist in Table 3-5 for an item by item description of those variables that must be checked during an incinerator inspection. A table which summarizes some problems that may arise with incinerators and the effects that these problems would have on operations or emissions can be found in Appendix D (see Table D-4).

3.2.2.3 Adsorbers--

Adsorption serves to concentrate solvent vapors for subsequent collection or disposal. Organic vapor-laden exhaust air from a coating process is first pretreated to remove materials which might inhibit efficient adsorber operation. The air stream then passes through the adsorber itself; typically a vessel (called a "bed") containing solid granules of adsorbent. Organic vapors collect on the surface of the granules and the air passes out of the bed. After a period of time, the adsorbent becomes saturated with organic material and its capacity to adsorb additional VOC is substantially reduced. At that time the vapor laden air is routed to a different bed containing unsaturated adsorbent. The saturated bed is stripped of organic material (or "regenerated") so that it can be used again. The organic material stripped from the adsorbent is either recovered for reuse or disposed.

Figure 3-5 contains a flow sheet for a typical adsorption process. Activated carbon is used extensively for adsorptive purposes because of its high surface area to mass ratio. This enables the carbon to adsorb a relatively large amount or organic vapors before it becomes saturated.

Efficient adsorption of VOC is highly dependent on inlet vapor stream conditions. If conditions are not appropriate, adsorption efficiency can be substantially reduced. Key inlet vapor stream control variables include temperature, humidity, pressure, and the presence of solids, liquids and high boiling organics.

Typical pretreatment steps are:[2,6,16]

- temperature adjustment,
- humidity adjustment,
- pressure adjustment, and
- removal of undesired contaminants (e.g., entrained liquids, entrained solids, high boiling organics).

Temperature Adjustment--Typical manufacturer's specifications call for vapor stream temperatures below 100°F (38°C) at the inlet to the bed of adsorbing material. High temperatures (e.g., trom curing oven exhaust) may result in premature desorption, thermal degradation of components, hot spots and bed fires. A cooler or heat exchanger is typically used to reduce stream temperatures to within the design limits.

TABLE 3-5. CHECKLIST FOR INCINERATORS

PLANT XYZ INSPECTOR J. JONES

I. BACKGROUND DATA DATE 4/12/82

A. TYPE OF INCINERATOR: THERMAL ____ CATALYTIC ✓

B. MINIMUM ALLOWED TEMPERATURE ON OPERATING PERMIT 700 °F

C. OPERATING TEMPERATURE DURING INSPECTION 760 °F

D. INSTALLATION DATE 9/80 (retrofit)

II. AIR SUPPLY FAN

A. MAKE ____ B. MODEL NUMBER W-750

C. SPEED 2000 rpm D. RATED FLOW RATE 16,000 cfm

E. FAN VIBRATION? YES ____ NO ✓

F. MATERIAL BUILDUP ON FAN BLADES? YES ____ NO ____ COULD NOT CHECK ✓

G. FAN BELT (IF USED) LOOSE? YES ____ NO ✓

H. FAN/MOTOR BEARING OVERHEATING? YES ____ NO ✓

I. BEARING INSPECTION SCHEDULE: 1 PER 3 months

J. BEARING LUBRICATION SCHEDULE: 1 PER 6 months

K. IS HIGH TEMPERATURE GREASE USED? YES ✓ NO ____

L. COMMENTS: fan housing rusted

III. VOC SUPPLY

A. IS DUCTWORK STRUCTURALLY SOUND? Yes

B. IS VOC PREHEATED? YES ✓ NO ____

C. VOC TEMPERATURE: BEFORE PREHEATER 250°F AFTER PREHEATER 600°F

D. VOC PRESSURE: BEFORE PREHEATER — AFTER PREHEATER —

(continued)

TABLE 3-5 (continued)

E. 1. FILTER INSTALLED? YES ______ NO ✓

2. FILTER LAST INSPECTED? ______ LAST CHANGED ______

F. 1. VOC BURNER: CLEAN? YES ______ NO ______ COULDN'T INSPECT ✓

WORN? YES ______ NO ______ COULDN'T INSPECT ✓

2. VOC BURNER LAST INSPECTED? 9/81 LAST REPLACED? never

G. ADDITIONAL VOC MONITORING DEVICES? (LIST) % LEL sensor

H. COMMENTS ______

IV. AUXILIARY FUEL

A. TYPE: GAS ✓ OIL ______ IF OIL, SULFUR CONTENT ______%

B. FUEL DELIVERY PRESSURE? ______

C. 1. FUEL BURNER: CLEAN? YES ______ NO ______ COULDN'T INSPECT ✓

WORN? YES ______ NO ______ COULDN'T INSPECT ✓

2. FUEL BURNER LAST INSPECTED? 9/81 LAST REPLACED? never

D. FUEL OIL SUPPLY PUMP CONDITION: ______

E. 1. OIL FILTER: LAST INSPECTED? ______ LAST REPLACED? ______

F. COMMENTS: ______

(continued)

TABLE 3-5 (continued)

V. INCINERATOR CONTROLS

A. LIST EACH PARAMETER THAT IS CONTINUOUSLY MONITORED AND/OR RECORDED AND ITS READING DURING THE INSPECTION

PARAMETER	READING
%LEL	~0%
T_{outlet}	830 °F
ΔP	8 in. H_2O

B. 1. DOES INCINERATOR HAVE SHUTOFF CONTROLS FOR:

LOW TEMPERATURE? ______ BURNER FLAME-OUT? ✓
FAN SHUTDOWN? ✓ HIGH VOC CONCENTRATION? ✓

2. ARE THESE [✓ MANUAL] OR AUTOMATIC?

3. ANY ALARMS? YES ✓ NO ____ SPECIFY %LEL Alarm

C. 1. CALIBRATION SCHEDULE FOR CONTROL INSTRUMENTS? YES ✓ NO ____

2. LAST CALIBRATION OF TEMPERATURE RECORDER? 3/82

3. MAINTENANCE/LUBRICATION SCHEDULE FOR INSTRUMENTS? 1/year

4. WHO CONDUCTS THE CALIBRATIONS? contractor

D. COMMENTS: %LEL & temp. at remote don't agree - way off

VI. REFRACTORY

A. 1. TYPE OF REFRACTORY? stainless

2. THICKNESS OF REFRACTORY: 6 INCHES

3. HOW OFTEN IS REFRACTORY CHANGED? 1/year

B. 1. DATE LAST INSPECTED? 11/81

2. INSPECTED BY WHOM? plant

3. ANY PROBLEMS NOTED DURING INSPECTION? warping

(continued)

TABLE 3-5 (continued)

C. NOTICEABLE HOT SPOTS ON OUTER SURFACE OF COMBUSTION CHAMBER? YES ____ NO ✓

D. NOTICEABLE METAL WARPAGE? YES ____ NO ✓

E. METAL CONNECTIONS MATE EVENLY? YES ✓ NO ____

F. COMMENTS: company switching to ceramic

VII. CATALYST

A. 1. CATALYST MATERIAL? DuPont Torvex®

2. DEPTH OF CATALYST BED? 12 INCHES

3. LAST INSPECTION? 3/82

4. INSPECTED BY WHOM? plant

5. CONDITION DURING INSPECTION? good

6. CATALYST CLEANING SCHEDULE 1 PER 4 months

7. HOW OFTEN IS CATALYST CHECKED FOR POISONING? 1 PER year

8. BY WHOM? supplier

9. DATE OF LAST REPLACEMENT? 3/82

10. IS SPARE CATALYST KEPT IN STOCK? YES ✓ NO ____

B. STACK TEMPERATURE MEASUREMENT? YES ✓ NO ____ IF YES: 720 °F

C. COMMENTS: see note at XII.

VIII. HEAT EXCHANGERS

A. SUBSTANCE PREHEATED (VOC, COMBUSTION AIR, WATER) VOC

B. 1. INLET TEMPERATURE 200 °F

2. OUTLET TEMPERATURE 600 °F

3. STACK TEMPERATURE 720 °F

C. PHYSICAL INTEGRITY good

(continued)

TABLE 3-5 (continued)

D. PLANT INSPECTION SCHEDULE 1 PER 6 months

E. COMMENTS:

IX. A. IS INCINERATOR LOCATED OUTSIDE? YES ✓ NO

B. IS EXTERIOR CORRODED?
RUSTED? ✓

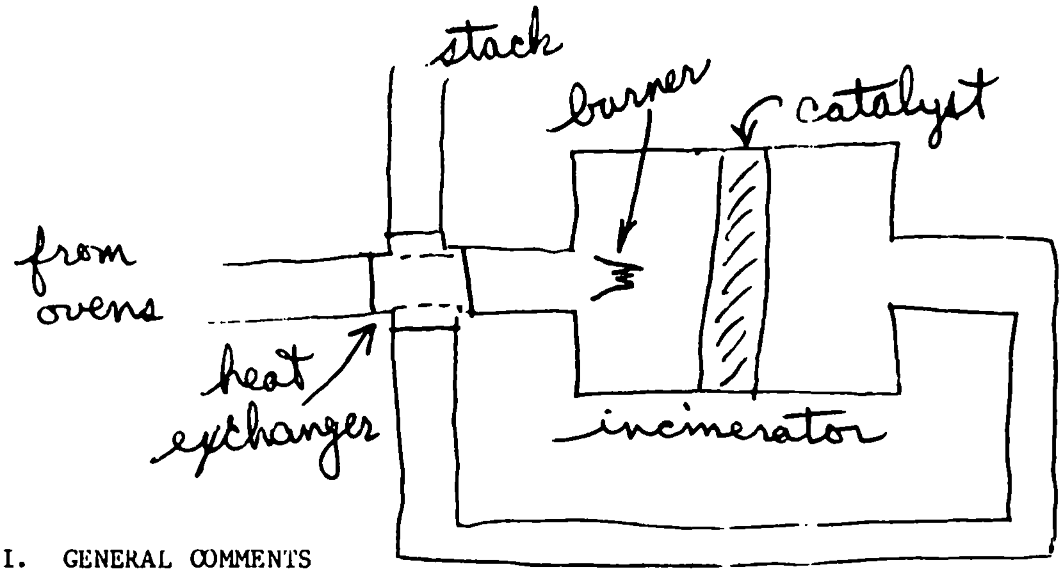
X. OPERATING LOGS

A. ARE OPERATING LOGS KEPT FOR:

AUXILIARY FUEL USAGE? YES ✓ NO
INCINERATOR CONTROLS? YES ✓ NO
CATALYST TEMPERATURES? YES NO ✓
HEAT EXCHANGERS? YES NO ✓

B. IF POSSIBLE, CHECK OPERATING LOGS FOR SIGNIFICANT DEVIATIONS FOR SIGNIFICANT DEVIATIONS FROM DESIGN AND NORMAL OPERATING CONDTIONS

XI. SKETCH OF SYSTEM



XII. GENERAL COMMENTS

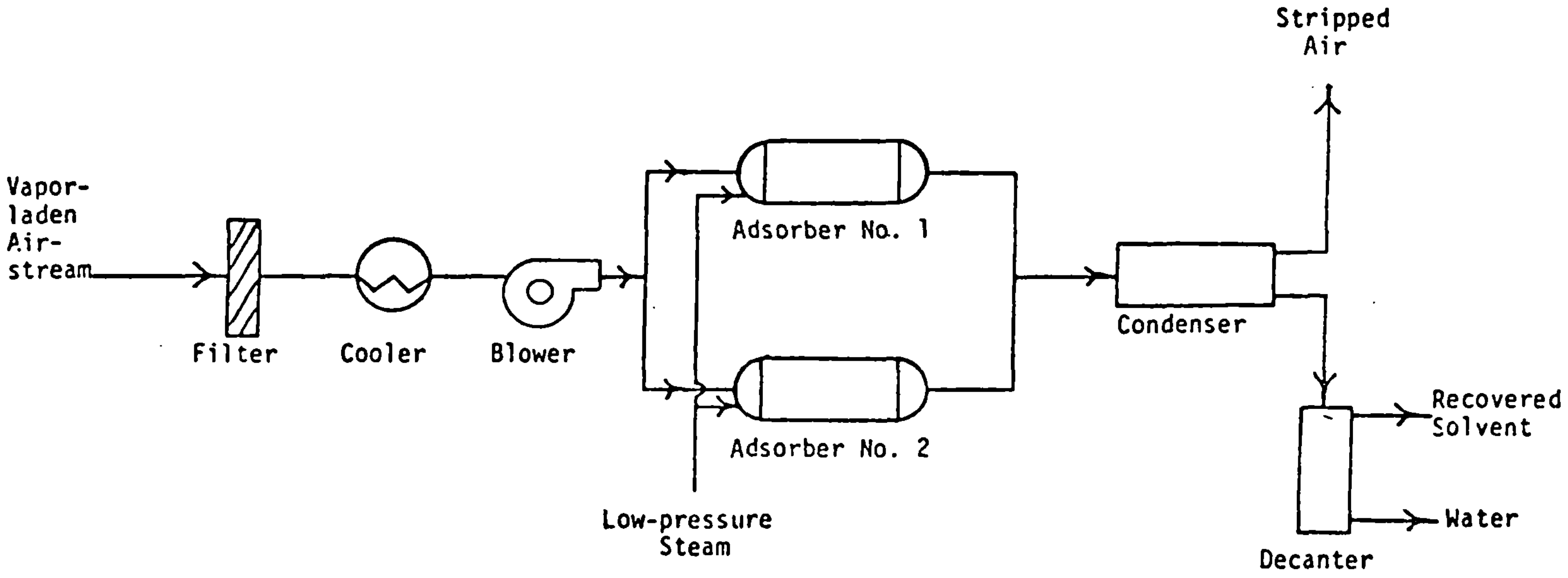


Figure 3-5. Carbon adsorption process.[10]

Humidity Adjustment--Relative humidities of inlet vapor streams should be kept within a specific range. If the relative humidity is higher than 50 percent, water vapor will compete with moderately adsorbable VOC for adsorption sites, thereby reducing operating capacity. Very low relative humidities (typically less than 20 percent) may result in excessive temperatures in the bed; particularly when adsorbing solvents with high heats of adsorption (e.g., ketones), therefore, the humidity must be regulated. Typical methods for adjusting vapor stream humidity include heating, cooling, or addition of dry dilution air.[16,17]

Pressure Adjustment--Adsorption beds are often designed to process large volumes of vapor through a specific depth of carbon. In order to overcome the pressure drop across the bed caused by frictional losses, a blower is usually installed upstream of (before) the adsorption unit. The blower supplies the necessary increase in vapor stream velocity to overcome pressure losses.

Removal of Contaminants--Entrained solids such as dust, dirt and lint must be removed from adsorber inlet streams. Particulate matter can lodge on the carbon and reduce its adsorbing capacity. Solids can also build up in between pieces of carbon reducing vapor flow through the bed and causing excess pressure drop. Devices for removing entrained solids include cloth or fiberglass prefilters. Filters may be either reusable or throw away.[16,17]

Entrained liquids include water droplets and condensed volatile organics. Typical removal methods for entrained liquids include:

- mist eliminators (with cyclone or zigzag baffles)--used for large droplets, or
- small mesh screens--used for small droplets.

High boiling organics should be removed to prevent fouling of the bed. These compounds are difficult to desorb, thus reducing effective bed capacity and carbon life. High boilers may also condense on the prefilter causing an excessive pressure drop. Methods for removal of high boiling organics include condensers and preadsorbers, such as a minibed with disposable carbon, upstream of the main bed.

The adsorption unit serves to concentrate solvent vapors for subsequent collection or disposal. As vapor-laden exhaust from a coating process passes through a vessel containing adsorbent material, organic components are captured at the surface of this material by physical or chemical interaction. When a bed becomes saturated it reaches the "breakthrough" point. This means that the concentration of organic vapors in the air stream exiting the adsorber has reached an unacceptably high level. Exhaust from the coating process is then routed to a parallel bed and the saturated bed is regenerated.[2,6,10,16]

Physical adsorption is achieved through intermolecular forces which attract but do not bind molecules together. Chemical adsorption (or chemisorption) is a result of the actual development of chemical bonds between adsorbent and adsorbate.[17] Once these bonds are formed they are difficult to break using conventional regeneration methods. Chemical adsorbent must usually be discarded, resulting in potentially high operating costs. For this reason, chemisorption is not typically used at surface coating facilities.

Adsorbers can be classified as:[18]

- regenerable,
- nonregenerable,
- fixed bed, and
- continuous.

Regenerable beds are those in which adsorbent capacity can be restored. Regeneration of an adsorber usually involves injecting a heated medium (e.g., steam, air, inert gas) into a saturated bed and stripping organic vapors away from the adsorbent.[17] Another type of regeneration is vacuum desorption which releases adsorbed organics by lowering their partial pressure.[18] Another less common method is thermal regeneration where the saturated bed is heated to volatilize the adsorbed organics and the bed is subsequently purged with inert gas or air.[18] After a bed is regenerated, a residual amount of organics is always left on the adsorbent. This residual is called the "heel."

Nonregenerable beds contain adsorbent which is discarded when it becomes saturated. Nonregenerable and thermally regenerated beds are limited to use in adsorption of low organic concentration streams or in odor control because in these applications the adsorbent does not become saturated until after an extended period.[17]

Fixed bed adsorbers are vessels in which the adsorbent remains stationary and is either adsorbing, regenerating or drying and cooling at a given time. Continuous beds are designed to adsorb, and regenerate at the same time. Example of continuous adsorbers are fluidized beds and concentric beds.[18] Figure 3-6 depicts a fluidized bed adsorption vessel. In these beds saturated adsorbent is removed from the working (adsorbing) section of the vessel to the regenerating section continuously. The adsorbent is then desorbed, cooled, dried and returned to the adsorbing section.[17,19]

Adsorbents can be regenerated in place or removed, regenerated and replaced. Removable beds are typically small. Saturated adsorbent is picked up by the supplier (vendor), heated in a kiln or furnace to drive off adsorbed organics and returned to the coating facility.

After a bed has been regenerated it must be dried (particularly when using steam regeneration) and cooled. Figure 3-7 shows the flow of vapor-laden air, steam and purge air in a typical adsorption system. The purpose of cooling and drying the bed is to reduce the water and heat content of the bed which can affect adsorption efficiency.[17]

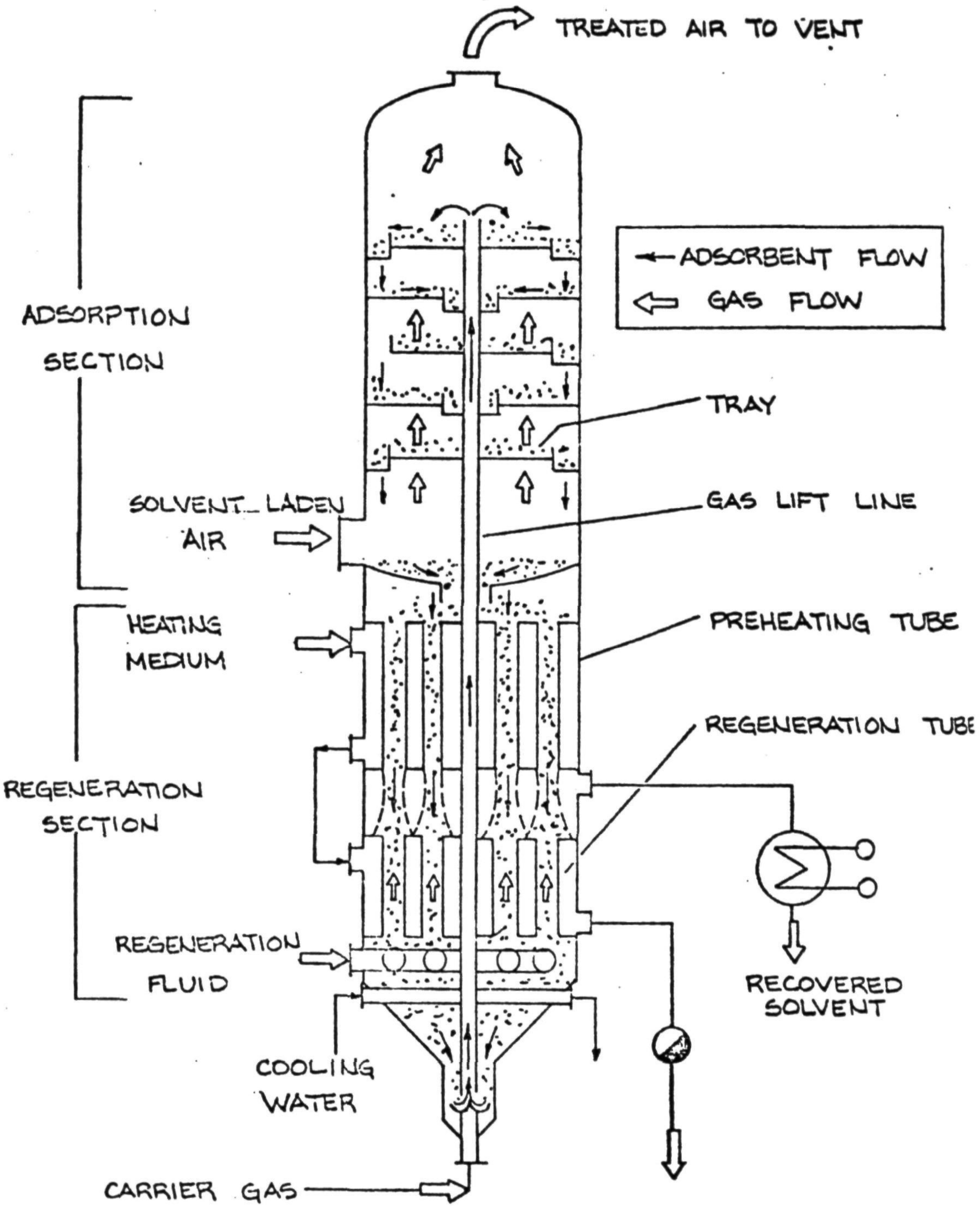


Figure 3-6. Fluidized-bed carbon adsorption system.[16]

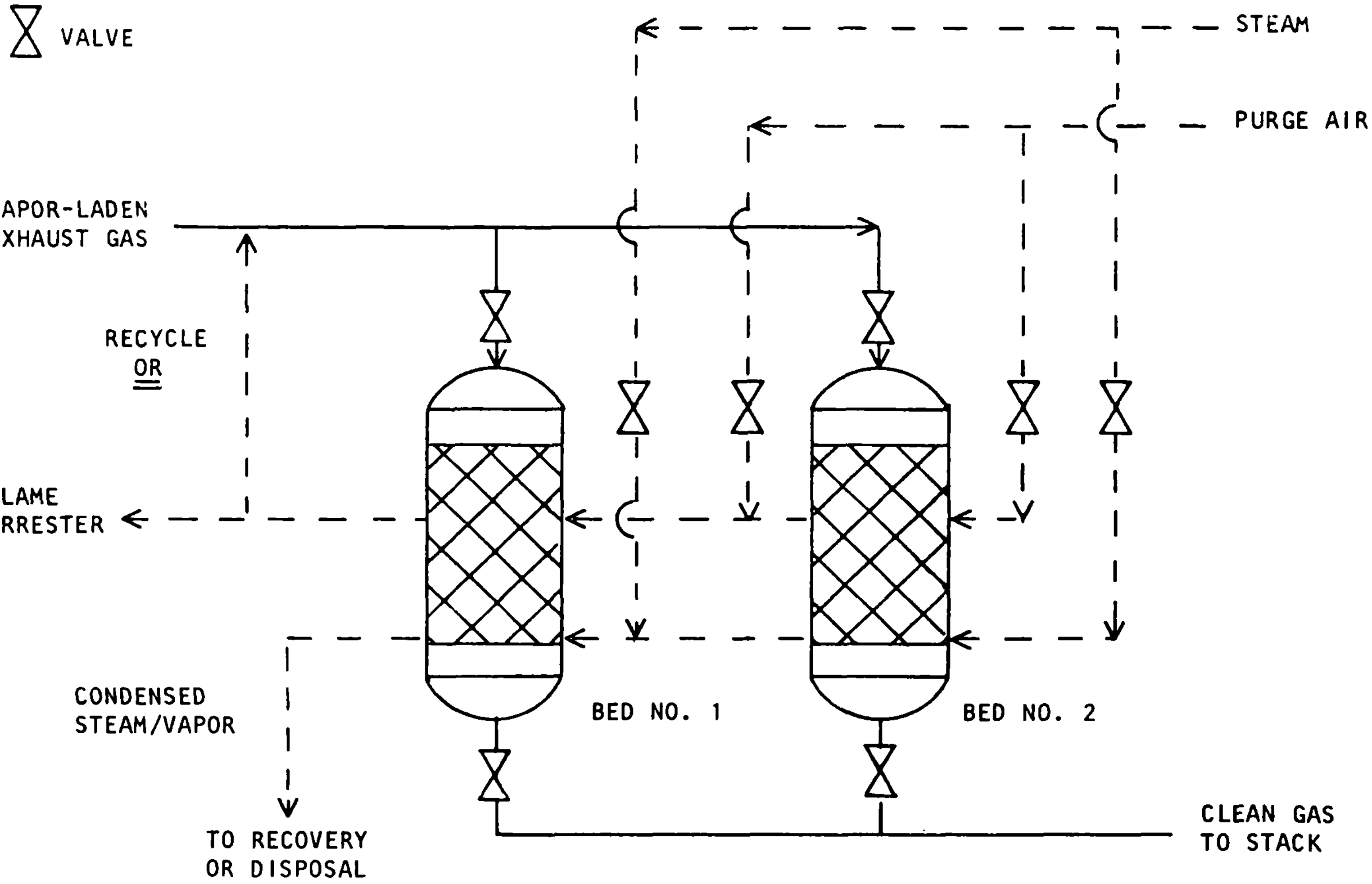


Figure 3-7. Adsorption flow streams.

Dry purge air (which serves as both a cooling and drying agent) is typically blown through a recently regenerated bed. External cooling of the vessel may also be performed. Purge air exiting the vessel is usually routed to the other (adsorbing) bed.

One cycle of an adsorption system, therefore, consists of three periods; adsorption, regeneration, and drying and cooling. The amount of time allowed for each of these periods varies widely among different applications.[18] Figure 3-8 presents the various possibilities of material flow in an adsorption cycle.

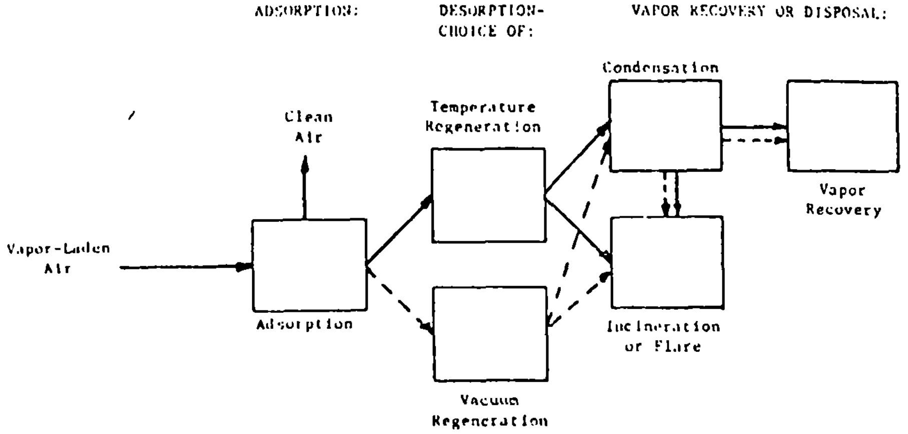


Figure 3-8. Adsorbent regeneration and vapor recovery or disposal alternative.[18]

The most common type of adsorbent used for collection of organic vapors is activated carbon. The carbon comes in several forms including granular, pelletized and powder. Other types of adsorbent media not commonly used in collecting organic vapors include silica gel, activated alumina and molecular sieves.[17,19,20]

The number and configuration of adsorber vessels used in a particular application is a function of air flow rate and cycle time.[18] A minimum of two parallel beds are required; one to adsorb while the other is regenerating, cooling and drying. With three beds, one bed is adsorbing, one is regenerating while the third is cooling and drying. Occasionally vessels are run in series to ensure containment of breakthrough emissions. The initial bed must then be regenerated more frequently than the secondary bed.

Adsorption vessels may be installed vertically or horizontally. Vertical beds are used for low air flow rates and horizontal beds are used in high flow applications. The inlet air stream to a vertical vessel should flow downward from the top to reduce entrainment of carbon particles in the outlet stream.[17] However, fluidized beds require that the air stream flow upward so as to fluidize the adsorption bed.[19]

As stated previously, adsorption of organic vapors is achieved through physical interaction at the molecular level. Some solvents (e.g., ketones) interact chemically with activated carbon. These interactions (hydrolysis, oxidation, halogenation) can release substantial quantities of heat and vessels may have to be externally cooled.[17,19]

The effluent stream which exits the bed during regeneration consists of vapor media (steam, inert gas, air) and desorbed organic vapor. Depending on certain properties of the solvent (e.g., value, number of components, miscibility) the effluent may either be recovered or disposed. If steam regeneration is used the effluent stream is usually condensed and the condensate is separated. If hot air or inert gas is used, the stream is typically incinerated. Other methods of solvent recovery include absorption (wet scrubbing), distillation and secondary adsorption.[18,20] For more information regarding absorption and condensation, see Subsection 3.2.2.4.

Subsequent to condensing, a water and solvent mixture is decanted or distilled, depending on the miscibility of the solvent. Decanting involves pumping the mixture to a tank where the liquid has time to settle and separate into layers. Water and solvents are pumped out of the tank through separate pipes. The water usually goes back to the boiler and the solvent back to the formulation unit. Figure 3-9 shows the flow arrangement in a decanter. Organic vapor may also be recycled to the working adsorber.

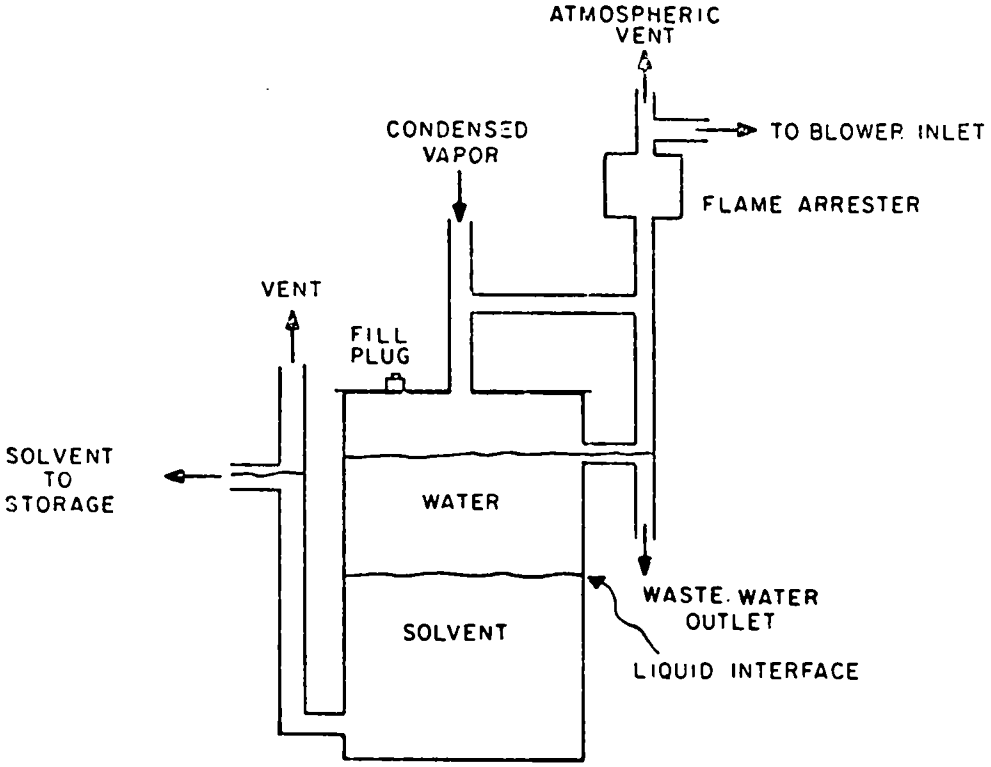


Figure 3-9. Decanter for separating nonmiscible liquids.[18]

Distillation of the water/solvent mixture is performed if the solvent is valuable and cannot be separated by simple decanting. Also, solvents which have stringent purity requirements are distilled to remove contaminants. For additional information on distillation operations see the Chemical Engineers Handbook.

Control systems are used to monitor and adjust process operating conditions. Every control system consists of an instrument for measuring process conditions and a control device for adjusting those conditions. Examples of measuring instruments include:[21]

- thermocouples (temperature),
- manometers (pressure),
- floats (level), and
- flow meters.

Examples of control devices include:

- valves,
- dampers,
- heaters or coolers, and
- pumps or blowers.

The purpose of a measuring instrument is to monitor a specific process parameter (e.g., temperature, pressure, flow rate). The instrument is preset at a value (or range of values) for that parameter. If the actual process value of the parameter deviates from the preset value the instrument signals the control device. The control device then acts to change the process condition in such a way as to return the process variable to its preset value.[21]

Control devices can be either manual or automatic. Manual devices require an operator to activate them. An example is an alarm which signals an operator to adjust process conditions. Automatic control devices rely on a signal from a measuring instrument to be activated. These signals are either mechanical (usually pneumatic) or electronic.[21]

Measurement and control devices are especially important in adsorption systems as they are often used to regulate the frequency with which the bed is regenerated, based on the organic vapor concentration in the effluent stream. When concentration levels reach the preset value corresponding to breakthrough, the bed is regenerated. Another control technique for regenerating saturated adsorption beds is the timed cycle. This method assumes that a bed will reach the breakthrough point after it has been running for a specific amount of time. A timer keeps track of how long the bed has been running and signals for regeneration upon reaching the preset time. Because the timed cycle method assumes a constant air flow rate through the bed and a constant solvent concentration in the air stream, any deviation from these assumed values can result in inefficient adsorber operation.[22] Occasionally, both vapor concentration and timed cycle methods are used simultaneously.[23]

Organic vapor concentrations can be monitored at the inlet of an adsorber as well as the outlet. This is frequently the case in systems with large variations in inlet concentrations. If the concentration of organics is low (i.e., lower than the emission limit for the facility), it can bypass the adsorber and be vented directly to the atmosphere.[22]

The proper calibration of instruments used in control systems is crucial to the operation of an organic vapor collection system. If instruments are not properly calibrated, measurements of process variables become inaccurate. This in turn leads to faulty control of process conditions and potential excess emissions.[21]

√ While the carbon adsorption system may appear more complex and difficult to understand than the other components of the capture and control system, it should be inspected in a similar manner. Each subsystem must be examined individually to insure it is working and maintained, as designed. Above all, the inspector must have a thorough knowledge of what conditions were established for the adsorber on the operating permit so that the field check can verify the key operating parameters that were reviewed and approved by the agency.

First check the physical exterior of the system for corrosion and abrasion. If the metal surfaces are noticeably corroded, determine if this deterioration is located in one spot or is equal across all surfaces. Spot corrosion should be investigated a bit further, since it may be indicative of a hot spot, or some similar localized condition within the adsorber, that is due to the buildup of high organics concentrations and/or a reduced flow rate. This external inspection will also serve to familiarize you with the location of the other adsorber components such as the VOC supply line, the blower motor and fan, the exhaust line, the steam feed line (if steam is used for regeneration), and the piping arrangement used to alternate VOC feed between multiple adsorber beds.

Next check the various feed systems into the adsorber. Inspect the VOC line, looking for holes or corrosion that might allow leakage of room air to dilute the VOC concentration. If this line has a prefilter to screen particulates and other solids that would clog the adsorbent, determine the condition of this filter. When was it last inspected? How frequently is it cleaned and/or replaced and when was this done? Follow the VOC line to the blower which pushes the VOC through the adsorber bed. The blower will consist of an electric motor and a fan. Inspect the condition of the fan blades for corrosion, erosion and buildup. Note any vibration of the fan. Inspect the electric motor. Is the bearing overheating? When was the bearing last inspected? Lubricated? Replaced? Is a spare bearing maintained in stock? Remember a spare parts inventory is not required, but if you ask about spare parts, it will show your concern and may prompt the facility to maintain key items in reserve. At this time, check all valves, damper and cross connections that allow the VOC to be vented to a second adsorber while the first is being regenerated. Look for tight metal to metal connections, and damper and valve positions. Is there a set operating schedule for switching from one adsorber bed to another? Obtain a copy of this operating procedure if you can.

If steam is used to regenerate the adsorbent, inspect the steam feed line, and the VOC/steam return line. The steam feed line should have a steam trap and regulator to insure that excess moisture is removed before the steam is used for regeneration. Excess moisture in the steam can cause a reaction between water and hydrocarbons that may hasten corrosion of the adsorber internals and its use should be avoided. Follow the VOC/steam exhaust line to the condenser and associated organics/water decanter. Inspect both condenser and decanter for corrosion and leakage. If the adsorber is installed outside, check to see that the system has cold weather protection, such as electric heaters and freeze control 'thermostats. Even with such protection, severe winter weather can cause a system malfunction. How often do winter upsets occur? Repeated upsets may require that the adsorber be installed in a weather-proof structure.

If possible, check the level of adsorent. A general loss of adsorbent may occur over time in a bed. If it is not regularly replaced, it will decrease the adsorber control efficiency. Is adsorbent regularly added to the bed? How much is added? How often is this done? Is the adsorbent regularly inspected for deterioration? The adsorbent may lose its effectiveness over time due to poisoning and/or coating of the granules and should be periodically checked. How often is this check done? The entire bed of the adsorber may be replaced on a regular basis and if and when this occurs, you should note this fact. Finally, if you can look inside the adsorber, check for corrosion of the supporting metal framework. Carbon steel and stainless steel are both susceptible to corrosion in the presence of chlorinated hydrocarbons. To prevent this, some adsorber manufacturers line the internals with a protective coating. If such a coating exists, check to see if it is chipped or abraded. Also, inspect to see if the liner is securely bonded to the metal support and if thermal deformation has warped either the liner or its support.

A pump may be installed on the adsorber to transfer condensed organics from the condenser and/or decanter to storage. If such a pump is installed, inspect the pump packing and seals for leakage. Find out when the packing or seal was last replaced. Also check the pump bearing for overheating. When was this bearing last inspected? Lubricated? Replaced?

Now inspect the system controls. Record all continuously monitored variables. Note any devices that are not working. Of special importance is the cycle used to regenerate the adsorber beds. Is this cycle apparent from the control panel? Is it a preset timed schedule or is it determined by the concentration of VOC in the adsorber outlet stream? If it is set by outlet concentration, make special note of this value as well as the current VOC or hydrocarbon reading. If a timed cycle is used, record this cycle. Adsorption systems which use time cycles may experience breakthrough, or emissions of VOC before regeneration, if the facility has changed its formulation to include more organics or if the rate of coating has increased. Obtain the VOC content of the current surface coating formulation and its rate (gallons per hour) of application. Compare these values with those approved by your department. These factors are very important for determining the facility's outlet VOC emissions, so take time to get this data right.

Finally, as part of your control system inspection, check the safety devices used with the adsorber items, including flame arrestors, high bed temperature shutdowns, and safety relief valves that are installed for the safety of the workers and the protection of the equipment. Equipment malfunction and/or poor operating procedures can cause the buildup of VOC in excessive concentrations. This, in turn, can lead to potential fire and/or explosive conditions within the adsorber. Verify the inspection schedule of these safety devices and obtain the date of their last test.

The checklist in Table 3-6 details all of the inspection items that have been discussed in this section. It should be used to record data collected during any adsorber inspection. A table which summarizes some problems that may arise with adsorption units and the effects that these problems would have on operations or emissions can be found in Appendix D (see Table D-5).

3.2.2.4 Absorption and Condensation--

Two control methods which have found limited use in the control of VOC from coating applications are absorption and condensation.[2,9,10] Subsequently, discussion of these methods is limited in this guide. Indepth analyses of absorption and condensation unit operations are available in the literature.

In gas absorption a soluble vapor (such as VOC) is absorbed, by means of liquid in which the vapor is soluble. The vapor is typically carried through the absorber by an inert gas. The solute (VOC) is subsequently recovered from the liquid by distillation. Sometimes the solute is removed from the liquid by bringing the liquid into contact with an inert gas. Such an operation, the reverse of gas absorption, is desorption or gas stripping.[24] Figure 3-10 depicts a typical absorption system with solvent recovery.

A common apparatus used in gas absorption is the packed tower, an example of which is shown in Figure 3-11. The device consists of a cylindrical column, or tower, equipped with a gas inlet and distributing space at the bottom; a liquid inlet and distributor at the top; liquid and gas outlets at the bottom and top, respectively; and a supported mass of inert solid shapes, called tower packing. The inlet solvent is distributed over the top of the packing by the distributor and, in ideal operation, uniformly wets the surfaces of the packing. The solute-containing gas enters the distributing space below the packing and flows upward through the interstices in the packing, countercurrent to the flow of the liquid. The packing provides a large area of contact between the liquid and gas and encourages intimate contact between the phases. The solute is absorbed by the fresh liquid entering the tower and dilute gas leaves the top. The liquid is enriched in solute as it flows down the tower, and concentrated liquid leaves the bottom of the tower through the liquid outlet.[24,25,26]

Many types of tower packing are available including rock, gravel, and coke in various manufactured shapes. The most common type is Raschig rings, which consist of hollow cylinders having an external diameter equal to their length. Other shapes include Berl® saddles, Intalox® saddles, Pall® rings, Hypak®, and spiral-type rings.[19,25]

TABLE 3-6. CHECKLIST FOR ADSORBERS

PLANT ABC

INSPECTOR J. JONES

I. BACKGROUND DATA

DATE 4/15/82

A. MANUFACTURER AIRPOL

B. INSTALLATION DATE 8/78

C. MAKE AND MODEL NUMBER —

D. TYPE OF ADSORBER: FIXED ✓ CONTINUOUS ____

FLUIDIZED BED ____ CONCENTRIC ____

OTHER (SPECIFY) ____

E. REASON FOR INSTALLATION OF ADSORBER: TO MEET EMISSION LIMITS? ____

TO REMOVE ODORS? ✓

F. NUMBER OF BEDS 6

G. BEDS ARE: VERTICAL ____ HORIZONTAL ✓

H. TYPE OF ADSORBENT: THROWAWAY ____ REGENERABLE ✓

ACTIVATED CARBON ✓

OTHER (SPECIFY) ____

I. FORM OF ADSORBENT: GRANULAR ✓ PELLETIZED ____ POWDER ____

J. WHERE IS ADSORBENT REGENERATED? ONSITE ____

OFF-SITE (SPECIFY) ✓ supplier

K. GAS INLET STREAM DATA:

	DESIGN	DURING INSPECTION
FLOW RATE (CFM)	2000	1900
TEMPERATURE (°F)	80-90	110
RELATIVE HUMIDITY	40%	90%
VOC VAPOR CONCENTRATION	50%	50%

(continued)

TABLE 3-6 (continued)

L. NUMBER OF EMISSION POINTS VENTED TO ADSORBER 10

M. TYPE OF EMISSION POINTS VENTED TO ADSORBER ovens, overspray

N. PERCENT VOC IN SURFACE COATING FORMULATION DURING INSPECTION

30%

O. SURFACE COATING APPLICATION RATE ([✓ GAL/HR] LB/HR) 125

II. EXTERIOR CHECK

A. CORROSION/ABRASION EVIDENT? YES ____ NO ✓

B. IF YES, IS IT LOCALIZED? YES ____ NO ____

C. IF LOCALIZED, SKETCH ADSORBER/CORROSION AREAS BELOW.

III. VOC FEED

A. VOC CONTENT OF GAS STREAM ENTERING ADSORBER 50 %

B. IS A PREFILTER INSTALLED? YES ____ NO ✓

C. TYPE OF PREFILTER THROWAWAY ____ FABRIC ____

D. LAST FILTER INSPECTION: ____ REPLACEMENT: ____

IV. BLOWER

A. FAN

1. POSITION OF FAN: ADSORBER INLET ✓ OUTLET ____

2. IS CORROSION EVIDENT? YES ____ NO ✓

3. IS EROSION EVIDENT? YES ____ NO ✓

4. IS BUILD-UP ON FAN BLADES EVIDENT? YES ✓ NO ____

5. IS VIBRATION EVIDENT? YES ____ NO ✓

6. INSPECTION SCHEDULE 1 PER week

(continued)

TABLE 3-6 (continued)

B. MOTOR

1. EVIDENCE OF OVERHEATED BEARING? YES ________ NO ✓

2. INSPECTION SCHEDULE 1 PER week

3. LUBRICATION SCHEDULE when needed PER ________

V. VALVES, DAMPERS

A. ARE ALL VALVES AND DAMPERS LABELED? YES ________ NO ✓

B. IF YES, SKETCH LOCATION AND DESIGNATION BELOW

C. IS THERE A STANDARD OPERATING PROCEDURE (S.O.P.) FOR SWITCHING FROM ONE ADSORBER BED TO ANOTHER? YES ✓ NO ________

D. CAN YOU OBTAIN A COPY OF THIS S.O.P.? YES ________ NO ✓

VI. ADSORBANT REGENERATION

A. TYPE OF REGENERATION: STEAM not known THERMAL ________

INERT GAS (SPECIFY) ________

B. REGENERATION STREAM CONTROL DEVICE:

regeneration done off-site by supplier

INCINERATOR ________ ABSORBER ________

CONDENSER/DECANTER ________

SECONDARY ADSORBER ________

OTHER (SPECIFY) ________

C. REGENERATION INITIATION METHOD:

1. VAPOR CONCENTRATION ________

CONCENTRATION LIMIT ________ PPM

LOCATION OF CONCENTRATION ________

MEASUREMENT DEVICES OUTLET ________

MEASUREMENT DEVICES INLET ________

(continued)

TABLE 3-6 (continued)

2. TIMED CYCLE ____________

LENGTH OF TIME (HOURS) ____________

ADSORPTION ____________ MIN

REGENERATION ____________ MIN

DRYING/COOLING ____________ MIN

TOTAL CYCLE TIME ____________ MIN

3. OTHER (SPECIFY) pressure drop across bed

D. IF STEAM REGENERATION IS USED:

1. HOW OFTEN ARE STEAM TRAPS BLED? ______ PER ______

2. STEAM PRESSURE ____________ PSI

VII. WEATHER PROTECTION

A. ADSORBER INSTALLED OUTSIDE? YES ______ NO ✓

B. ELECTRIC HEATER UTILIZED? YES ______ NO ______

C. FREEZE CONTROL THERMOSTAT UTILIZED? YES ______ NO ______

D. OTHER WEATHER PROTECTION MEASURES? (SPECIFY) ____________

VIII. ADSORBENT

A. 1. IS ADSORBENT REGULARLY INSPECTED FOR DETERIORATION? YES ______ NO ✓

2. HOW OFTEN? ______ PER ______

B. 1. IS MAKE-UP ADSORBENT ADDED TO THE BED ON A REGULAR BASIS? YES ______ NO ✓

2. HOW OFTEN? ______ PER ______

3. HOW MUCH IS ADDED? ____________

(continued)

TABLE 3-6 (continued)

C. 1. IS THE ADSORBENT REGULARLY REPLACED? YES ✓ NO ____

2. HOW OFTEN? 1 PER 6 months

IX. ADSORBER INTERNALS

A. ARE THE INTERNALS LINED WITH A PROTECTIVE COATING? YES ____ NO ✓

B. HOW OFTEN ARE THEY INSPECTED? 1 PER week

CLEANED? 1 PER week

C. IS THE EXTERIOR WARPED DUE TO EXCESSIVE HEAT? YES ____ NO ✓

X. CONDENSED LIQUID

A. IF A CONDENSER/DECANTER IS USED, WHAT IS DONE WITH NONCONDENSIBLES (I.E., THE VAPOR EXITING THE CONDENSER/DECANTER) ____

B. WHAT IS DONE WITH THE CONDENSIBLES? (I.E., DECANTED LIQUID)? ____

C. 1. ARE TRANSFER PUMPS INSTALLED? YES ____ NO ____

2. WHERE ARE THEY LOCATED? ____

3. IS THE PUMP SEAL AND/OR THE PACKING LEAKING? YES ____ NO ____

4. WHEN WAS SEAL AND/OR PACKING LAST REPLACED? ____

D. 1. IS PUMP BEARING OVERHEATING? YES ____ NO ____

2. WHEN WAS BEARING LAST INSPECTED? ____

LUBRICATED? ____

REPLACED? ____

(continued)

TABLE 3-6 (continued)

XI. CONTROLS

A. DOES FACILITY HAVE MONITORS AND/OR RECORDERS FOR (SPECIFY READING)

	PARAMETER	MONITOR	RECORDER	READING
1.	PRESSURE DROP ACROSS BED?	✓		2.4" H_2O
2.	PRESSURE DROP ACROSS PREFILTER?			
3.	VAPOR INLET TEMPERATURE? (°F)	✓		320°F
4.	BED TEMPERATURE? (°F)			
5.	VAPOR OUTLET TEMPERATURE? (°F)			
6.	OTHER (SPECIFY)			
7.	OTHER (SPECIFY)			
8.	OTHER (SPECIFY)			

XII. SAFETY DEVICES INSTALLED

A. FLAME ARRESTOR YES ____ NO ✓

B. HIGH BED TEMPERATURE SHUTDOWN YES ____ NO ✓

C. SAFETY RELIEF VALVE YES ✓ NO ____

D. OTHER ____

E. SAFETY INSPECTION SCHEDULE 1 PER 6 months

XIII.A. IS ADSORBER USED IN SERIES WITH OTHER CONTROL DEVICES?

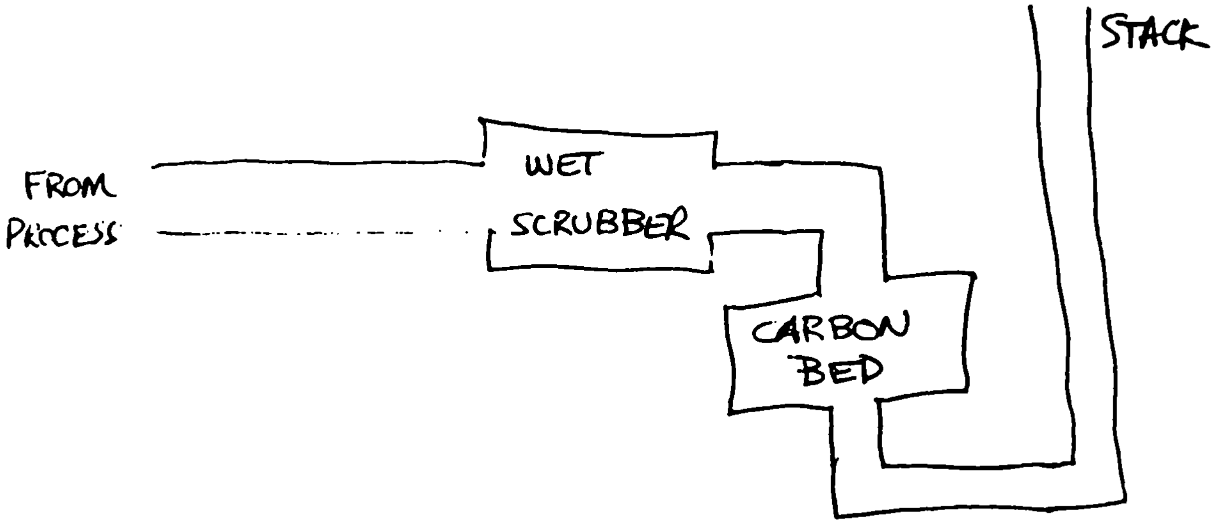
YES ✓ NO ____

B. WHAT KIND(S) Absorber

C. DRAW BELOW THE SEQUENCE OF UNITS

(continued)

XIV. SKETCH SYSTEM--NOTING IMPORTANT DETAILS



COMMENT: Vapor entering adsorber is saturated with water from absorber. This may cause reduced carbon capacity. Also, pressure drop across bed is used to determine when regeneration is necessary. Should check if this is viable technique to reduce VOC emissions.

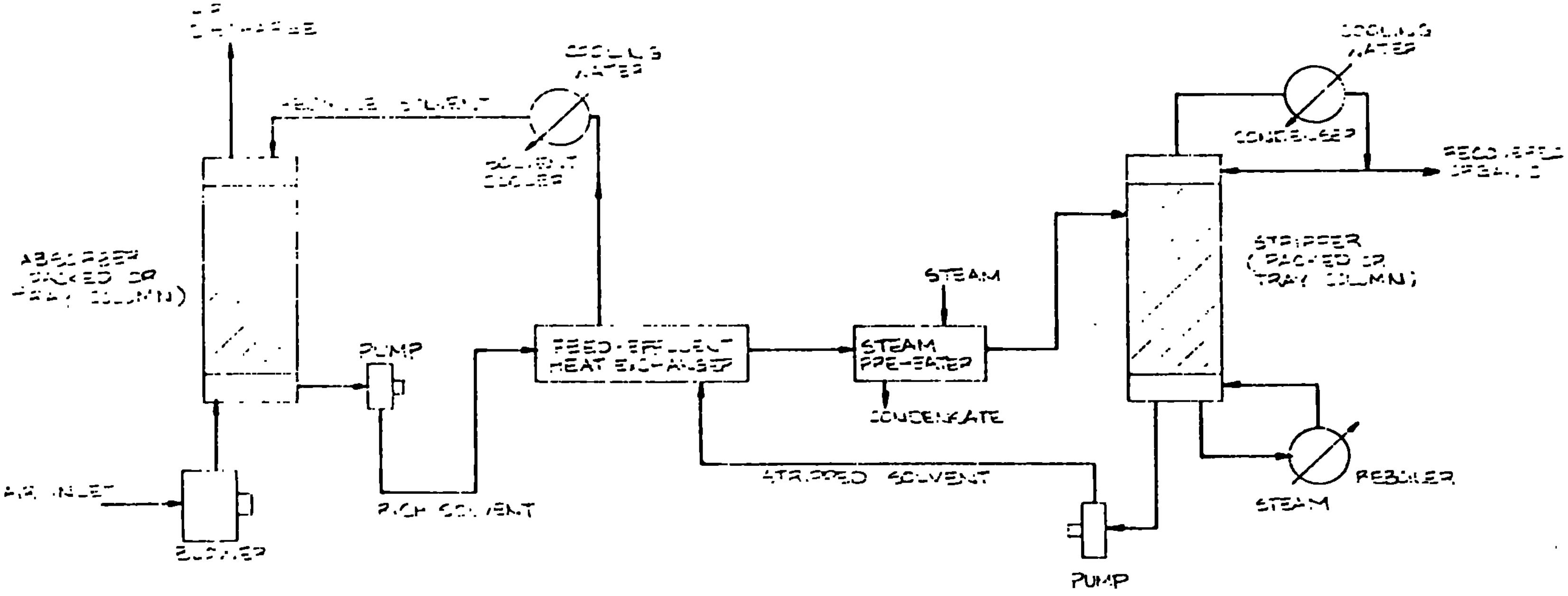


Figure 3-10. Absorption system with stripping tower (solvent recycled to absorber).[16]

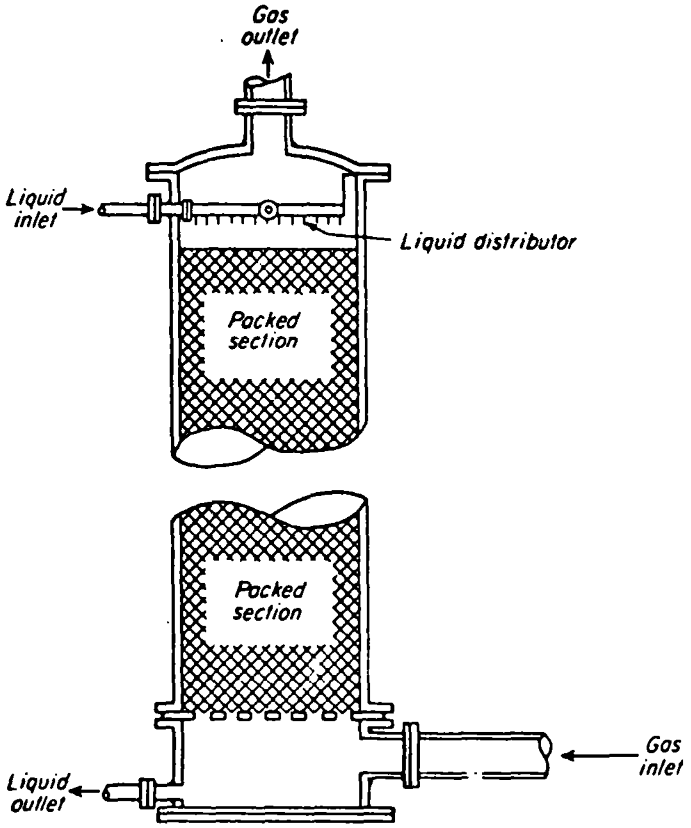


Figure 3-11. Cross section of a packed tower for gas absorption.[24]

In contrast to packed towers, where gas and solvent are in continuous contact throughout the packed bed, plate towers employ stepwise contact by means of a number of trays or plates that are arranged so that the gas is dispersed through a layer of liquid on each plate. Each plate is more or less a separate stage, and the number of plates required is dependent on the difficulty of the mass-transfer operation and the degree of separation required.[24]

The bubble-cap plate is a common type of tray, and most general references deal primarily with it in discussion of plate towers. Other types of plates, including perforated trays and valve trays, may be used in new installations because they are less expensive and their performance is about equal to bubble-cap tray performance.[16]

A schematic section of a bubble-cap tray tower is shown in Figure 3-12. Each plate is equipped with openings (vapor risers) surmounted by bubble caps. The gas rises through the tower and passes through the openings in the plate and through slots in the periphery of the bubble caps which are submerged in liquid. The liquid enters at the top of the tower and then flows across each plate and downward from plate to plate through down spouts. The depth of liquid on the plate and the liquid flow patterns across the plate are controlled by various weir arrangements.[16]

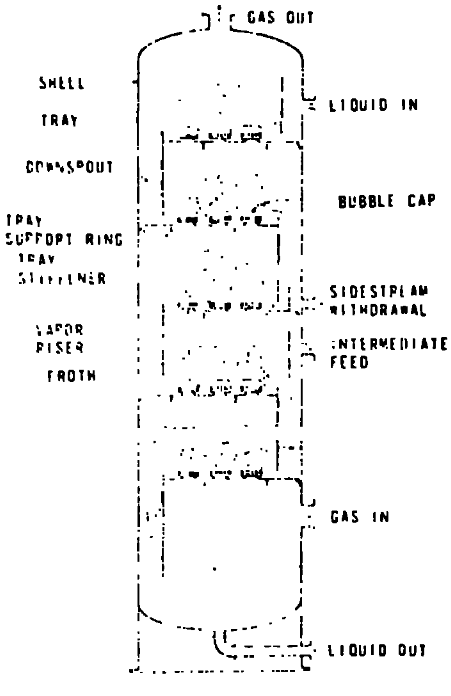


Figure 3-12. Bubble-cap tray tower.[16]

Solvents used for absorption should exhibit the following characteristics:[16]

1. Gas solubility should be high (e.g., solvent and solute should be chemically similar).

2. Relatively low in volatility.

3. Noncorrosive.

4. Inexpensive.

5. Low viscosity.

6. Relatively nontoxic, nonflammable, and chemically inert.

The initial criteria is that solvent and solute be chemically similar. Therefore, a solvent used to absorb VOC should be organic (polar). Subsequently, criteria 2, 4 and 6 are not met (e.g., organic solvents are highly volatile, expensive, flammable, relatively toxic and often unstable). It is for these reasons that absorption systems are very rarely used in the control of VOC.[27]

Absorbers will fail to work as designed if any of the nozzles become clogged, if the packing and seals of the pumps leak, causing a lack of pressure in the pumps, if the absorber and its associated feed lines corrode or if scale or particulate builds up on the tower packing, reducing its effectiveness. An inspection of this total system should begin with the feed lines into the absorber column and the exhaust lines from it, check the VOC feed line first. Look for any metal deterioration and holes in this line. If a filter is installed on this line, inspect the condition of the filter and obtain the filter inspection and replacement schedules. As shown on Figure 3-10, this inlet stream will usually feed a blower immediately before it enters the absorber. Check the fan and the associated motor for vibration, material build-up on the fan blades, corrosion and erosion. Verify that the motor bearing is not overheating and is regularly inspected and lubricated.

Next inspect the solvent line into the absorber. Leaks in this line would cause the emission of solvents in the absorber room and should be obvious, so verify that this piping is structurally sound. Similarly, inspect the VOC containing solvent line that exits the absorber for structural integrity. Now follow this line to the pump which transfers this fluid to the preheat and/or stripping columns. Inspect this pump for signs of leakage. Insure that the pump motor bearing is not overheating. Finally, inspect the air discharge line from the absorber. The effectiveness of the absorber in reducing VOC emissions is judged by the VOC concentration of this discharge line. It should have a hydrocarbon indicator and recorder or some similar device for measuring VOC concentration. Record this value. It can be compared with the allowable concentration permitted by your agency, and stated in the operating permit. Now focus your attention on the absorber column itself.

Inspect the physical integrity of the column. Look for holes and corrosion on the metal surface. Since there is a positive pressure within the absorber column, any hole will cause solvent and/or VOC vapors to be pushed out the hole. So look for liquid on the metal surfaces. Next ask plant personnel about routine maintenance items. How often are the solvent spray nozzles inspected and cleaned? Scale and particulate buildup in these nozzles can clog them, resulting in an uneven solvent spray. This will decrease the absorber efficiency and lead to increased VOC emissions. Now verify the inspection and cleaning cycle for the absorber packing. Since particulate build-up on the packing can decrease its effectiveness, there should be a set inspection schedule. It should not need to be cleaned very often if the VOC, solvent feed and solvent recirculation lines have filters and strainers, but check the plant's maintenance schedule for this item none-the-less.

Finally, inspect the solvent recirculation line to see if strainers and/or filters are installed. Such cleaning devices will minimize scale and particulate build-up on all internal surfaces which come in contact with the solvent. Strainers and filters should be inspected and cleaned or replaced on a regular basis. Make note of this inspection and servicing cycle. Table 3-7 is a checklist which details the principal items that must be reviewed during an absorber inspection. A table which summarizes some problems that may arise with absorption units and the effects that these problems would have on operations or emissions can be found in Appendix D (see Table D-6).

Condensation is an operation in which one or more volatile components of a vapor mixture are separated from the remaining vapor by cooling the vapor below the condensation temperature of the component to be recovered. In a two-component vapor stream, where one of the components is considered to be noncondensible (e.g., air), condensation occurs when the partial pressure of the condensible component (e.g., VOC) becomes equal to the component's vapor pressure. To achieve this condition, the system pressure may be increased at a given temperature or the temperature of the vapors may be reduced at constant pressure.[24] Figure 3-13 depicts a typical condensation system.

Condensation as an emission control method is often used with auxiliary air pollution control equipment. For example, condensers can be located before (upstream of) absorbers, incinerators, or carbon beds to reduce the VOC load on the more expensive control device. The condenser can also remove vapor components that might adversely affect the operation of other equipment or cause corrosion problems or can be used to simply recover valuable material that would otherwise be destroyed. When condensers are used alone, refrigeration is often employed to obtain the low temperatures necessary for acceptable VOC removal efficiencies.[19]

The suitability of condensation for VOC emission control is generally dependent on the following factors:[16]

- VOC concentration in inlet,
- VOC removal efficiency required,
- recovery value of VOC, and
- condenser size requirements.

TABLE 3-7. CHECKLIST FOR ABSORBERS

PLANT LMN INSPECTOR J. JONES

I. BACKGROUND INFORMATION DATE 4/14/82

A. MANUFACTURER OF UNIT Airpol

B. INTALLATION DATE 8/78 RATED CAPACITY (CFM) 2000

C. RATED EFFICIENCY 95% SOLVENT UTILIZED Water with caustic & wetting agents

D. TYPE OF ABSORBER: PACKED BED ______ FILTER MESH ✓ TRAY ______

OTHER (SPECIFY) ______

E. COMPOSITION OF GAS STREAM ENTERING ABSORBER alcohols & aromatics

F. TYPES AND NUMBER OF EMISSION POINTS VENTED TO ABSORBER 22 spray booths

G. BED CONFIGURATION: VERTICAL ______ HORIZONTAL ✓

II. VOC FEED LINE

A. IS IT STRUCTURALLY SOUND? YES ✓ NO ______

B. 1. HOLES OR CORROSION OBSERVED? YES ______ NO ✓

2. IF YES, SKETCH FEED LINE AND HOLE LOCATION BELOW

C. 1. FILTER INSTALLED ON FEED LINE? YES ______ NO ✓

2. TYPE OF FILTER GLASS ______ PAPER ______

3. INSPECTION SCHEDULE ______ PER ______

4. REPLACEMENT SCHEDULE ______ PER ______

5. DATE OF LAST REPLACEMENT ______

D. FAN

1. FAN ON ABSORBER: INLET? ✓ OUTLET? ______

2. VIBRATION EVIDENT? YES ______ NO ✓

(continued)

TABLE 3-7 (continued)

3. BUILD-UP ON FAN BLADES EVIDENT? YES ✓ NO ______

4. CORROSION EVIDENT? YES ______ NO ✓

5. EROSION EVIDENT? YES ______ NO ✓

6. ARE THERE DAMPERS IN THE SYSTEM? YES ✓ NO ______
(MARK THEIR LOCATION ON SKETCH)

7. FUNCTION OF DAMPERS: EMERGENCY BYPASS ✓ FLOW CONTROL ______
OTHER (SPECIFY) ______

E. MOTOR

1. BEARING OVERHEATED? YES ______ NO ✓

2. BEARING INSPECTED 1 PER 3 months

3. BEARING LUBRICATED 1 PER 3 months

III. SOLVENT INLET AND OUTLET LINES

A. SOLVENT RECIRCULATION RATE 10-20 GAL PER 500 CFM

B. ARE THESE LINES STRUCTURALLY SOUND? YES ✓ NO ______

C. 1. STRAINER ON INLET LINE? YES ______ NO ✓

2. STRAINER INSPECTION SCHEDULE ______ PER ______

3. STRAINER CLEANING SCHEDULE ______ PER ______

D. 1. OUTLET SOLVENT PUMP LEAKING? YES ______ NO ✓

2. PUMP PACKING AND SEALS INSPECTED? YES ✓ NO ______

3. PUMP BEARING OVERHEATING? YES ______ NO ✓

4. PUMP BEARING INSPECTED 1 PER week

IV. ABSORBER AIR DISCHARGE LINE

A. MIST ELIMINATOR USED? YES ✓ PER ______

B. VOC MONITORING/RECORDING DEVICE INSTALLED? YES ______ NO ✓

(continued)

TABLE 3-7 (continued)

C. TYPE OF DEVICE (SPECIFY) ____________

D. VOC OUTLET CONCENTRATION DURING INSPECTION ____________

V. ABSORBER COLUMN

A. COLUMN DIMENSIONS 3 FT x 5 FT x 8 FT

B. EXTERIOR STRUCTURALLY SOUND? YES ✓ NO ____

C. 1. SOLVENT SPRAY NOZZLES INSPECTED 1 PER week

2. SOLVENT SPRAY NOZZLES CLEANED 1 PER week

3. DATE OF LAST CLEANING Saturday

D. 1. TYPE OF PACKING, [✓ FILTER] OR TRAY UTILIZED PVC, fiberglass

2. ABSORBER PACKING TRAY INSPECTED 1 PER week

3. ABSORBER PACKING TRAY CLEANED 1 PER week

4. DATE OF LAST CLEANING Saturday

E. 1. ABSORBER INTERNALS INSPECTED 1 PER week

2. ABSORBER INTERNALS CLEANED 1 PER week

3. DATE OF LAST CLEANING Saturday

F. PRESSURE DROP ACROSS COLUMNS 4" H_2O

G. COMMENTS ____________

VI. SOLVENT RECIRCULATION LINE

A. STRAINERS AND/OR FILTER INSTALLED? YES ✓ NO ____

B. INDICATE LOCATION OF FILTERS ON SKETCH BELOW

C. 1. STRAINERS/FILTERS INSPECTED 1 PER week

2. STRAINERS/FILTERS CLEANED 1 PER week

3. DATE OF LAST CLEANING Saturday

(continued)

TABLE 3-7 (continued)

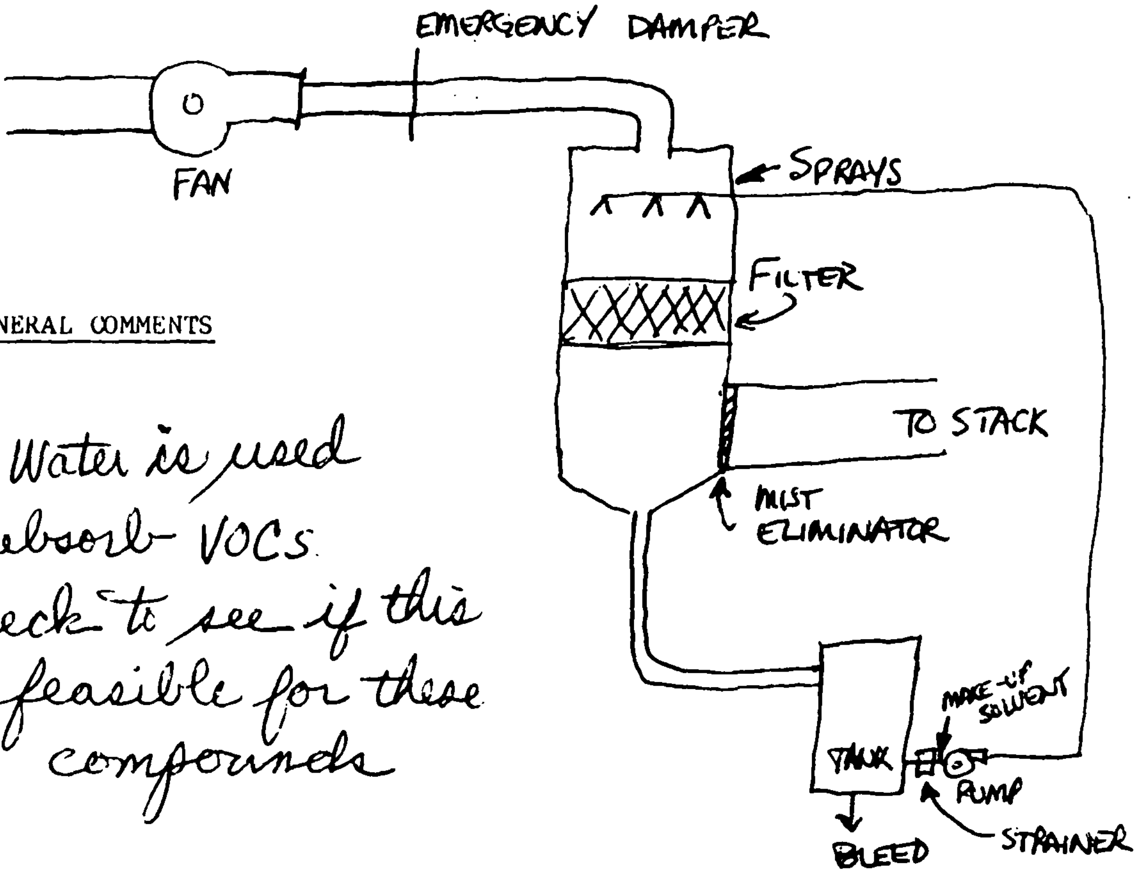
D. IS SOLVENT RECIRCULATION LINE BLED? YES ✓ NO ______

IF YES, FREQUENCY: continuously PER ______

E. IS SOLVENT STRIPPED (DESORBED)? YES ______ NO ✓

IF YES, HOW? ______ PER ______

VII. SKETCH OF ABSORBER SYSTEM



VIII. GENERAL COMMENTS

Water is used
to absorb VOCs.
Check to see if this
is feasible for these
compounds

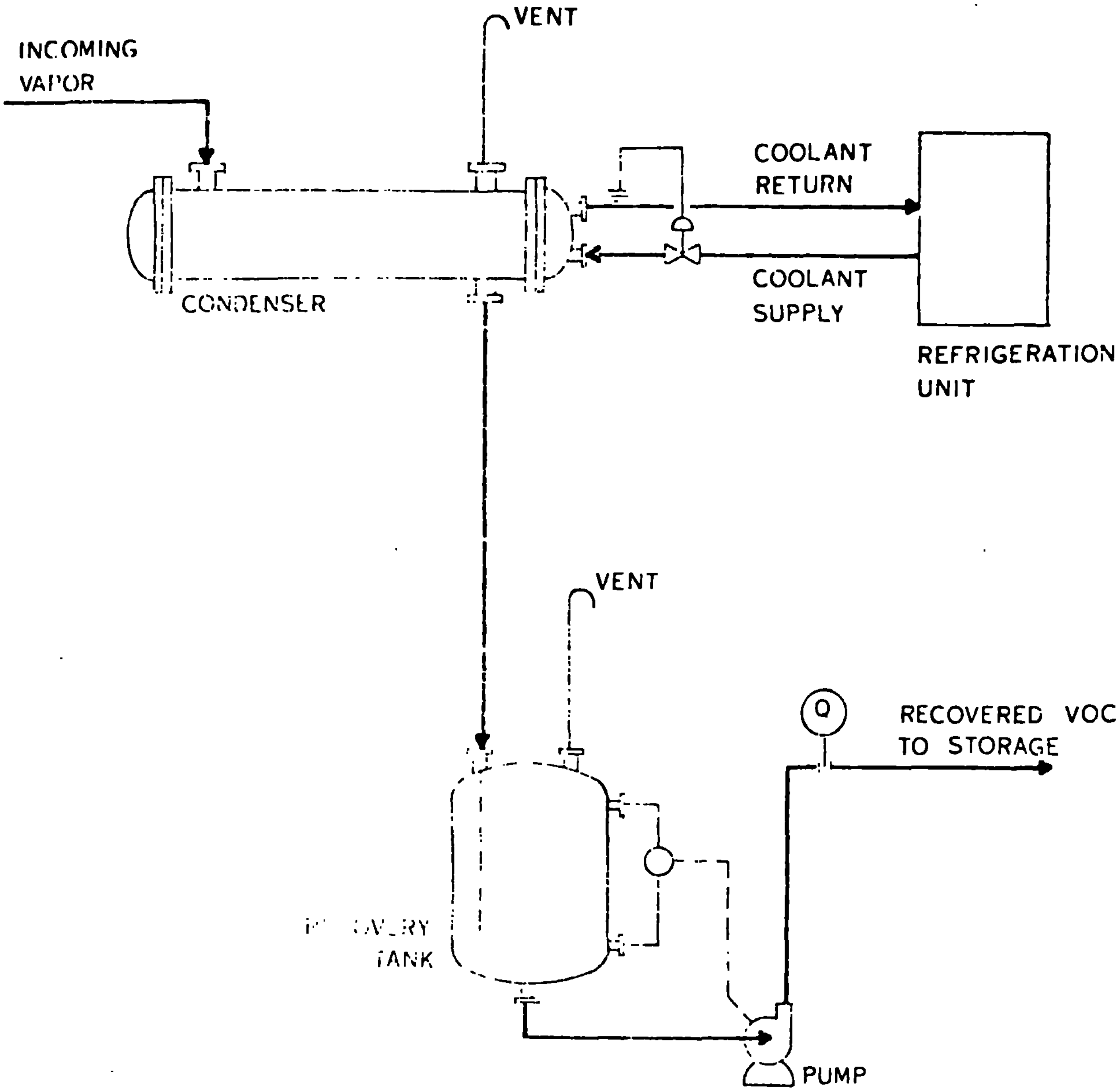


Figure 3-13. Basic surface condenser system.[16]

When a condenser is used to control emissions, it is usually operated at a constant pressure which is typically atmospheric. The two most common types of condensers that operate at atmospheric pressure are surface and contact condensers. Most surface condensers are of the shell and tube type shown in Figure 3-14. The coolant usually flows through the tubes, and the vapors condense on the outside (shell) tube surface. The condensed vapor forms a film on the cool tube and drains away to a collection tank for storage or disposal. The coolant used depends on the temperature required for condensation. Chilled water, brine, and refrigerants are normally used in condensers. Air-cooled surface condensers are also available and are usually constructed with extended surface fins. When the cool air passes over the finned tubes, the vapors condense inside the tubes.[16,28]

In contrast to surface condensers, where the coolant does not contact the vapors or the condensate, contact condensers usually cool the vapor by spraying an ambient-temperature or slightly chilled liquid directly into the gas stream. The coolant is usually water, although in some situations a material used in the process can be used as the coolant. These devices are relatively uncomplicated, as is shown by the typical design in Figure 3-15. Most contact condensers are simple spray chambers that are usually baffled to ensure good contact. The coolant/VOC mixture exiting a contact condenser must be separated if the coolant is to be reused.[19]

Although contact condensers can be highly efficient in removing VOC from a vapor stream, as in vacuum jet service, they can create additional wastewater emission control problems downstream. Unless the VOC-contaminated water discharged from the condenser is treated (e.g., stripped, absorbed, extracted), secondary emissions will result from evaporation. Separation and disposal requirements, along with the high cost of refrigeration, make condensation an unattractive VOC control method.[16]

As seen on Figures 3-13 through 3-15, condensers are relatively simple devices, with an inlet vapor line, an atmospheric vent, a recovered VOC drain line and coolant supply and return lines. Your inspection of this device will therefore concentrate on insuring the physical integrity of these lines, and verifying that the heat transfer surfaces (shell and tube design) or the spray nozzles (contact design) are kept clean and free of scale or other deposits. As discussed, you are more likely to encounter a condenser in conjunction with an adsorber or an absorber than you are to find it alone.

Start your inspection with the VOC feed line. Is it structurally sound, with no signs of leaks or corrosion? Do all metal to metal connections, such as flanges, mate properly with no observable leakage of VOC? Does this line have a filter on it for removing particulates and other contaminants? If so, gather the relevant filter data.

Next check the atmospheric vent line. This line may have some form of hydrocarbon analyzer on it to measure outlet VOC emissions. If it does, record the type of device, and the current reading. Also check the plant records for the readings of the previous 6 months, noting any wide fluxuations that may indicate an O&M problem. If the vent line is near ground level, note if there is an observable odor. Such an odor may be indicative of a poorly

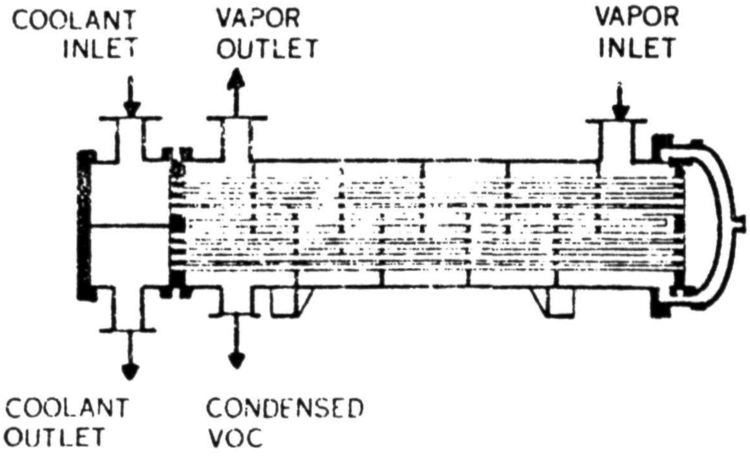


Figure 3-14. Shell and tube surface condenser.[16]

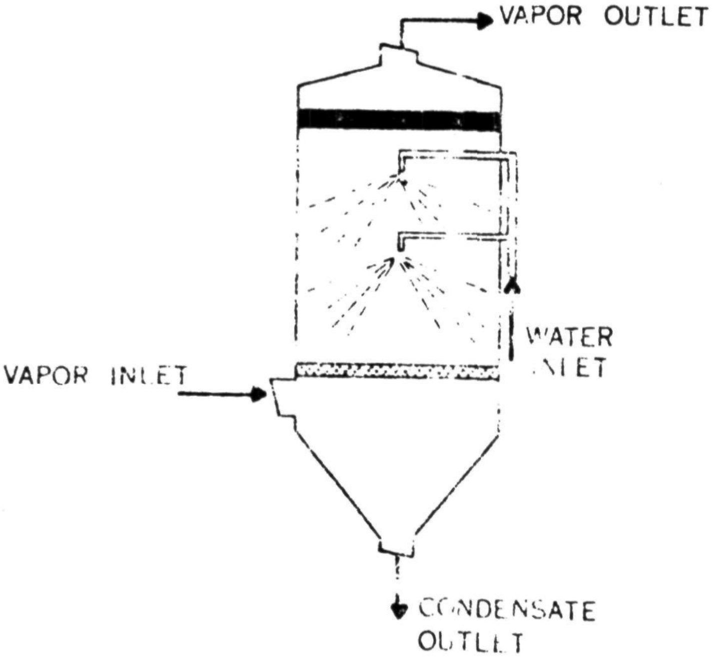


Figure 3-15. Contact condenser.[16]

operating condenser, although you should not draw this conclusion without checking back in your office the allowable emission rate and the odor threshold for the VOC in use at the facility.

Now inspect the recovered VOC drain line. Is it structurally sound with no signs of leakage or corrosion? Where does this line drain? How is this drain tank emptied? Where does the VOC go from the drain tank? The flow of condensed VOC from the condenser to the drain tank and on to final storage should involve only a few lines and a liquid transfer pump. Take time to follow this flow, and check each line and the pump for leakage.

Return to the condenser and inspect the coolant supply and return lines and the refrigeration unit that is associated with them. For contact condensers, this refrigeration system may be connected to the condensate outlet line. As before, first insure that neither supply nor return lines leak. Next verify the type of refrigerant used. Is it checked for impurities on a regular basis? Is make-up refrigerant added regularly? How much is added and how often? Has there been problems with some particular subunit, such as the refrigerant compressor? Failure of the refrigeration unit will cause uncontrolled VOC emissions, so it is important that you verify its reliability.

Now turn your attention to the condenser itself. It will work as designed as long as the VOC and coolant conditions are as specified and there is no fouling of the internal surfaces that might affect heat transfer. To the best extent possible, verify the composition, temperature and pressure of the inlet VOC stream. Check and record the coolant supply temperature and pressure. If these readings are kept by the plant on an operating log, inspect these logs for noticeable changes over the past 6 months. Next inspect the body of the condenser. Does it appear sound or are there signs of leakage and corrosion? How often are the condenser internals inspected? Cleaned? Has any repair work been done in the recent past?

Remember that very often the condenser will have little or no monitoring and recording instrumentation. In this case you will have to investigate some other secondary variable to ascertain how well the condenser is working. For example, if the coolant is being fouled with organics, then this may indicate a tube leak within the condenser. Or if the amount of VOC condensed is monitored and recorded, you should check these records. A decrease in condensed VOC that cannot be explained by process changes may indicate a malfunction with the condenser that is resulting in the release of VOC into the atmosphere. Finally, the condenser may be designed to capture one type of VOC and that substance has since been replaced. Make sure you gather data on VOC use so that you can check this against the type of VOC specified in the facility's submittal to your agency. Table 3-8 is a checklist which provides a complete list of items to be checked during a condenser inspection.

3.2.3 Ultimate Fate of Captured Emissions

The purpose of all the control devices discussed in Section 3.2.2 is to remove the VOC from an exhaust stream and thereby prevent the release of the VOC to the ambient air. With the exception of incinerators which destroy the

TABLE 3-8. CHECKLIST FOR CONDENSERS

PLANT ______________ INSPECTOR ______________

I. BACKGROUND INFORMATION DATE ______________

A. 1. IS THE CONDENSER USED IN CONJUNCTION WITH ANOTHER POLLUTION CONTROL DEVICE? YES ________ NO ________

2. IF YES, WHAT DEVICE ______________________________

3. SKETCH SEQUENCE OF UNITS BELOW

B. TYPE OF CONDENSER: SURFACE ______________ CONTACT ______________

OTHER (SPECIFY) ______________________

C. COOLANT/REFRIGERANT USED ______________________________

II. VOC FEED LINE

A. IS LINE STRUCTURALLY SOUND? YES ________ NO ________

B. ARE ALL CONNECTIONS TIGHT AND NONLEAKING? YES ________ NO ________

C. 1. DOES THIS LINE HAVE A FILTER? YES ________ NO ________

2. IF SO, WHAT TYPE: GLASS ______________ PAPER ______________

OTHER (SPECIFY) ______________________

3. HOW OFTEN IS THE FILTER INSPECTED? ________ PER ________

4. HOW OFTEN IS THE FILTER CLEANED? ________ PER ________

5. WHEN WAS IT LAST CLEANED? ______________________________

III. VOC VENT

A. 1. IS A HYDROCARBON ANALYZER INSTALLED ON THIS VENT? YES ________ NO ________

2. IF SO, WHO IS THE MANUFACTURER AND WHAT IS MODEL NUMBER?

____

____

(continued)

TABLE 3-8 (continued)

3. WHAT IS THE CURRENT READING? ______________________________

4. IS THIS READING KEPT ON A LOG SHEET? YES ________ NO ________

5. COMMENTS ____

____

B. 1. WHAT IS THE APPROXIMATE HEIGHT OF THE VENT LINE? __________ FT

2. COULD YOU DETECT AN ODOR FROM THIS VENT? YES _________ NO _________

3. COMMENTS ____

____

IV. VOC DRAIN LINE

A. IS THE LINE STRUCTURALLY SOUND? YES _________ NO _________

B. 1. DOES THIS LINE DRAIN INTO A RECOVERY TANK? YES _________ NO _________

2. SKETCH THE POSITION OF THE CONDENSER AND THE RECOVERY TANK BELOW

3. IS THE RECOVERY TANK ABOVE GROUND? YES _________ NO _________

4. IF SO, IS IT STRUCTURALLY SOUND WITH NO SIGNS OF CORROSION AND DETERIORATION? YES _________ NO _________

C. 1. WHERE IS THE RECOVERED VOC EVENTUALLY STORED? _______________

2. SKETCH THIS TANK ON THE DIAGRAM BELOW

D. 1. IS A PUMP USED TO TRANSFER THE VOC FROM THE CONDENSER TO THE RECOVERY TANK? YES _________ NO _________

2. FROM THE RECOVERY TANK TO STORAGE? YES _________ NO _________

3. DO EITHER OR BOTH OF THESE PUMPS SHOW SIGNS OF LEAKAGE? YES _________ NO _________

(continued)

TABLE 3-8 (continued)

E. COMMENTS ____

____

V. REFRIGERATION SYSTEM

A. DO BOTH COOLANT SUPPLY AND RETURN LINES APPEAR STRUCTURALLY SOUND WITH NO LEAKAGE OR CORROSION? YES ________ NO ________

B. 1. TYPE OF REFRIGERANT USED ____________________

2. REFRIGERANT CHECKED FOR IMPURITIES ________ PER ________

3. REFRIGERANT LEVEL CHECKED ________ PER ________

4. DATE OF LAST REFRIGERANT ADDITION AND THE QUANTITY ____________________

C. 1. HAS THE REFRIGERATION UNIT HAD ANY PAST OPERATIONAL PROBLEMS? YES ________ NO ________

2. IF SO WHAT WAS THE PROBLEM? ____________________

3. HOW LONG WAS THE UNIT OFF-LINE? ____________________

D. 1. ARE SPARE PARTS KEPT FOR ANY PART OF THE REFRIGERATION SYSTEM? YES ________ NO ________

2. IF SO, WHAT PARTS? ____________________

E. 1. IF A CONTACT CONDENSER IS USED, HOW ARE THE VOC AND WATER SEPARATED? ____________________

2. WHERE IS THE WATER DISPOSED? ____________________

IV. CONDENSER

A. PROPERTIES OF THE INLET VOC STREAM:

TEMPERATURE __________ °F PRESSURE __________

FLOW RATE __________ CFM COMPOSITION (% VOC) __________

(continued)

TABLE 3-8 (continued)

B. WHAT ARE THE INLET COOLANT PROPERTIES

TEMPERATURE ____________ °F PRESSURE ______________

C. 1. CAN YOU INSPECT THE PLANT LOGS FOR THE PAST 6 MONTHS FOR OPERATING VALUES? YES ______ NO ______

2. IF SO, WERE THERE ANY NOTICEABLE DEVIATIONS? YES ______ NO ______

3. COMMENTS ____

____

D. 1. IS THE EXTERNAL SHELL OF THE CONDENSER STRUCTURALLY SOUND? YES ______ NO ______

2. ARE THERE ANY NOTICEABLE LEAKS? YES ______ NO ______

E. 1. IS THE INTERNAL SURFACE OF THE CONDENSER REGULARLY INSPECTED? YES ______ NO ______

2. DATE OF LAST INSPECTION ______________________________

3. IS IT REGULARLY CLEANED? YES ______ NO ______

4. DATE OF LAST CLEANING ______________________________

F. 1. HAS THE CONDENSER HAD A MAJOR OVERHAUL FOR ANY REASON? YES ______ NO ______

2. IF SO, WHY? ____

3. WHEN WAS THIS WORK DONE? ______________________________

VII. COMMENTS

(continued)

TABLE 3-8 (continued)

VIII. SKETCH OF SYSTEM

VOC, the devices remove the VOC vapor from the air stream without really chemically altering them. Once removed from the air stream, the VOC must still be disposed of in a manner that prevents their release to the ambient air. It is therefore extremely important that you find out what the plant does with the VOC that are removed from the control device.

As was touched upon in the discussion of the control devices, some plants will recover and reuse the VOC, others will containerize it and send it to a reclaimer, while some will simply dispose of it. It is the method of disposal that you must be concerned with. Some of the VOC become hazardous waste when disposed and must therefore meet stringent regulations. However, your main concern should be that the VOC are not allowed to evaporate after their removal from control devices at the surface coating facility.

Ask your plant escort about the VOC removal and handling procedures. Inspect any containers that are holding waste VOC. Are they tight enough to prevent leaks or losses by evaporation? Does the plant leave them open until they are full or close them after each use? If they are shipped off-site, obtain the name of the reclaimer or transporter. Some facilities are allowed to put their waste in the sewer system provided that it does not exceed certain concentration limits.

3.3 PROCESS INSPECTION

The procedures for inspecting the emission control system will provide you with an assessment of that system's operation and maintenance relative to it's originally permitted conditions. However, even if the operation and maintenance of the emission control system are found to be satisfactory, it is possible that the emisson rate from the control system is different from the rate permitted. Changes in emission rates can result from changes in the surface coating process operation. Changes in process operation that can effect the emission rate are:

- changes in coating compositions,
- changes in coating application methods,
- changes in coating application rates,
- changes in coating drying/curing methods or rates,
- changes in the material being coated.

Because of the variety and complexity of surface coating processes, a detailed description of inspection methods that would provide a basis for quantifying emission rate changes that would result from process changes is beyond the scope of this document. However, while you are conducting your inspection of the surface coating process emission control system, you should gather some information on the current surface coating operation.

Start your inspection of the surface coating process at the point where the coating is applied to the material being coated (i.e., the applicator). Ask your company escort about the composition of the coating and the application method being used. Find out if they change the types of coatings applied by the applicator. How often are they changed? What are the differences between coatings? Do they buy the coatings from different suppliers?

The compositions of the different coatings are important. The more solvent in a coating the more will enter the control system. Different suppliers may use different solvents that have different evaporation rates. Thus, the amount of solvent evaporated from the applicator versus the curing oven could change and this may require rebalancing of the capture system. Different solvents also exhibit different adsorption, condensation, and absorption characteristics. A control device originally designed for a certain type and amount of solvent may exhibit a different effectiveness of VOC removal if the type of solvent is changed. This is not a problem if the efficiency increases, but an efficiency decrease may result in emissions in excess of permitted conditions. Sometimes it requires only adjustment to a control device operating parameter (temperature, regeneration cycle) to regain effective operation. Ask plant personnel if they change any part of the control system when they change coatings.

Next, observe the material being coated and the coating application method. Make a note of both the coating application method (spray, flow, dip, etc.) and the shape of the material being coated (chairs, fenders, discs, springs, etc.). Ask plant personnel if they have made any changes to the application method recently. Have they changed the rate at which they apply the coating? Can they coat other shapes on the same line? Do they change shapes often? Do they change the application rate for different shapes? What adjustments do they make to the applicator when they change shapes? Do they adjust the control system when they make adjustments to the applicator?

Next observe the drying/curing area of the line. Make a note of the way the coating is dryed/cured onto the material (gas-fired oven, infrared heaters, stacked in room). Many ovens operate continuously with material moved through them on some type of conveyor system. Can the conveyor speed be changed? What circumstances cause it to be changed? Is the temperature of the drying/curing operation monitored? Is it necessary to vary the temperature frequently? Check the physical integrity of the ovens you may see. When ovens are totally enclosed, the capture system will often evacuate them directly. Thus, they should be under negative pressure and fumes should not be observed leaking from the entrance or exit of the ovens. However, a crack or space between oven panels may allow too much air into the oven and overload the capture system. The drying/curing process is important to the quality of the coating and, therefore, the drying/curing equipment is likely to be well maintained.

Because of the diversity of coating process equipment a suggested checklist is not presented, since one that would cover all possibilities would be too cumbersome and a general one would be of little practical value.

Instead, the preceding discussion is intended to inform you of the changes to the surface coating process that can be made and the fact that these changes can influence the control system's ability to perform as originally designed. Plant personnel may, in some cases, be genuinely unaware of the influence that process changes can have on the control system. By asking about process changes you will be able to identify potential changes in emission rates when the information you collect is compared to the original permit conditions.

3.4 PLANT INSPECTION

This document is not intended to provide you with detailed procedures for inspecting all operations at a surface coating facility. However, if your time schedule allows, you should make a brief "walkthrough" inspection of all operating and storage areas of the plant.

Investigate any noise, odor, or fugitive emission problems you may have noted when you conducted your preinspection circumnavigation of the facility. Note the raw material and finished product storage areas. Make a note of noise producing processes or operations, their proximity to the facility property line, and the potential for the noise to reach the nearest off-site receptor. Note operations that are odorous or dust producing and also attempt to evaluate the potential for odors or dust from these sources to leave the plant property.

If the plant operates a boiler you should inspect it for obvious signs of improper operation or malfunction. Another guidance document is available that will provide you with detailed inspection procedures. However, obvious signs of boiler problems are a smoky stack or erratic boiler temperature.

Finally, if during your preinspection file review you noticed a recurring emission problem or citizen complaint, you should inspect that equipment. Make sure that the plant is still taking steps to eliminate recurrance of the past problems.

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5.0 ANNOTATED BIBLIOGRAPHY

In this annotated bibliography, the codes in the columns to the right of each entry indicate the topical areas discussed by the document. The abbreviations used have the meanings described below.

SCP = Surface Coating Process; the document includes information on one or more types of surface coating operations, including coating types.

CS = Capture System; hoods, ductwork, fans.

ACE = Add-on Control Equipment; description of control equipment design and/or operation and maintenance.

I = Incinerator

A = Adsorber

Ab= Absorber

H = Hoods

D = Ductwork

F = Fans

X = Some general information on more than one of the above items

(t) = Text is more theoretical than practical

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Chemical Engineers Handbook, 5th ed. Perry and Chilton. McGraw-Hill, New York (1973). In depth technical information on the theory and design of absorption and adsorption systems. Areas of discussion include mass transfer, solubility, system components and unit design equations and calculations.			A Ab
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APPENDIX A

ABBREVIATIONS

acfm: Actual cubic feet per minute

BID: Background Information Document

Btu: British thermal unit.

CTG: Control Technique Guideline

fpm: Feet per minute.

LEL: Lower Explosive Limit

NSPS: New Source Performance Standard

psia: Pounds per square inch absolute

psig: Pounds per square inch guage

psi: Pounds per square inch

RACT: Reasonably Available Control Technology

VOC: Volatile Organic Compounds

APPENDIX B

GLOSSARY

absorption: The transfer of one or more constituents from a gaseous mixture to a liquid, in which the absorbed material may dissolve physically or react chemically. (Packed, plate, and spray towers are typical absorption devices.)

absorbate: Substance being adsorbed; typically organic vapors.

activated carbon: Highly porous, nonpolar adsorbent produced from bituminous coal.

actual cubic feet per minute: The volume flow per minute of gas at actual conditions of temperature, pressure and composition.

adsorbent: Solid material used to collect vapors and liquid by molecular interaction.

adsorption: Removal of impurities from a gas stream by concentration of the impurities on the surface of a solid or liquid. (Commercial adsorbents have a large surface area per unit weight.)

aerosol: An assemblage of small particles, solid or liquid, suspended in air. The diameter of the particles may vary from 100 microns down to 0.01 micron or less, e.g., dust, fog, smoke.

afterburner: A final burner stage that removes undesirable volatile matter through incineration.

air cleaner: A device designed for the purpose of removing atmospheric airborne impurities such as dusts, gases, vapors, fumes and smokes. (Air cleaners include air washers, air filters, electrostatic precipitators and charcoal filters.)

air filter: An air cleaning device to remove light particulate loadings from normal atmospheric air before introduction into the building. Usual range: loadings up to 3 grains per thousand cubic feet (0.003 grains per cubic foot). Note: Atmospheric air in heavy industrial areas and in-plant air in many industries have higher loadings than this and dust collectors are then indicated for proper air cleaning.

Background Information Document: (also denoted as BID) A technical document, developed by the Environmental Protection Agency, pertinent to an emission source category, which examines the technical and economic impacts of imposing a New Source Performance Standard on the subject emission source category.

balancing by dampers: Method for designing local exhaust system ducts using adjustable dampers to distribute airflow after installation.

balancing by static pressure: Method for designing local exhaust system ducts by selecting the duct diameters that generate the static pressure to distribute airflow without dampers.

bed: Vessel containing supported inert solid shapes for adsorption or absorption.

bed fire: Combustion occurring in adsorption beds caused by excessive heat buildup and organic concentrations above the lower explosive limit.

brake horsepower: The horsepower actually required to drive a fan. This includes the energy losses in the fan and can be determined only by actual test of the fan. (This does not include the drive losses between motor and fan.)

breakthrough: Point at which concentration of organic vapors in gas stream exiting adsorption bed exceeds a preset emission limit.

capture system: The equipment (including hoods, ducts, fans, etc.) used to capture, contain, or transport a pollutant to a control device.

capture velocity: The air velocity at any point in front of the hood or at the hood opening necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the hood.

coating line: One or more apparatus or operations which include a coating applicator, flash-off area, and oven wherein a surface coating is applied, dried, and/or cured.

contaminant: Anything added to the environment that causes a deviation from the mean geochemical composition. (Same as pollutant.)

controls: Measurement and instrumentation devices used to monitor and adjust process conditions.

Control Technique Guideline: (also denoted as CTG) A technical document, developed by the Environmental Protection Agency, pertinent to an emission source category, which examines the technical and economic feasibility of imposing various emission control equipment or emission limit requirements on existing sources.

convection: The motion resulting in a fluid from the differences in density and the action of gravity. In heat transmission this meaning has been extended to include both forced and natural motion or circulation.

cycle time: Amount of time it takes for an adsorption system to adsorb, regenerate, cool and dry.

dampers: Adjustable sources of airflow resistance used to distribute airflow in a ventilation system.

decant: Gravity separation of immiscible liquids (e.g., water and organics.)

desorb: (See Regenerate.)

differential pressure: The difference in static pressure between two locations.

duct: A conduit used for conveying air at low pressures.

dust: Small solid particles formed by the breaking up of larger particles.

effluent: A discharge or emission of a fluid.

emission: The discharge or release, whether directly or indirectly, of air pollutants into the ambient air from any source.

entrainment: Bulk diffusive carryover of solid or liquid particles in a gaseous stream.

fan static pressure: The pressure added to the system by the fan. It equals the sum of pressure losses in the system minus the velocity pressure in the air at the fan inlet.

flange: A rim or edge added to a hood to reduce the quantity of air entering the hood from behind the hood.

flue gas: Gaseous emissions discharged through a flue or stack.

formulation: Coating mixture containing various ingredients blended to meet particular specifications.

friction loss: The pressure loss due to friction.

fumes: Small solid particles formed by the condensation of vapors of solid materials.

gases: Formless fluids which tend to occupy an entire space uniformly at ordinary temperatures and pressures.

heel: Amount of residual organic material left in adsorption bed after regeneration, cooling and drying.

hood: A shaped inlet designed to capture contaminated air and conduct it into the exhaust dust system.

hood, canopy: A hood that is located over a source of emissions.

hood, capturing: A hood with sufficient airflow to reach outside of the hood to draw in contaminants.

hood, enclosing: A hood that encloses the contaminant source.

hood, lateral: See hood, capturing.

hood, receiving: A hood sized and located to catch a stream of contaminants or contaminated air directed at the hood.

hood, slot: A hood consisting of a narrow slot leading into a plenum chamber under suction used to distribute air velocity along the length of the slot.

hood entry loss: The pressure from turbulence and friction as air enters the ventilation system.

hood static pressure: The suction of static pressure in a duct near a hood. It represents the suction that is available to draw air into the hood.

hot spot: Area in an adsorption bed where inadequate ventilation has led to heat buildup.

humidity, relative: The ratio of the actual partial pressure of the water vapor in a space to the saturation pressure of pure water at the same temperature.

inch of water: A unit of pressure equal to the pressure exerted by a column of liquid water 1 in. high at a standard temperature.

incineration: Combustion of solid, liquid or gaseous wastes under controlled conditions.

inclined manometer: A manometer that amplifies the vertical movement of a water column through the use of an inclined leg.

inert gas: Common purge material.

lower explosive limit (LEL): The lower limit of flammability or explosibility of a gas or vapor at ordinary ambient temperatures expressed as percent of gas or vapor in the air by volume.

manometer: An instrument for measuring pressure; essentially a U-tube partially filled with a liquid, usually water, mercury or a light oil, so constructed that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

minimum design duct velocity: Minimum air velocity required to move the particulates in the air stream.

mists: Small droplets of materials that are ordinarily liquid at normal temperature and pressure.

New Source Performance Standards: (also denoted as NSPS) An emission control equipment requirement or an emission limit promulgated by the Environmental Protection Agency and applicable to all new sources in an identified emission source category unless a more stringent state standard applies.

organics: Chemical substances containing carbon atoms. Beside water, most substances used in coating applications are organic.

oxidants and ozone: In air pollution technology, ozone and oxidants are the result of photochemical reactions between nitrogen oxides and some organic pollutants. The concentrations of ozone and oxidants in the atmosphere are an index of photochemical smog.

particulate: Airborne material that has a relatively fixed shape and volume such as dusts, mists, smokes and fumes.

personal protective equipment: Devices worn by persons to protect against hazards in the environment. Respirators, gloves and ear protectors are examples.

pitot tube: A device for measuring pressure consisting of two concentric tubes arranged to measure total and static pressure.

pressure, atmospheric: The pressure due to the weight of the atmosphere. It is the pressure indicated by a barometer. Standard Atmospheric Pressure or Standard Atmosphere is the pressure of 29.92 inches of mercury.

pressure, static: The potential pressure exerted in all directions by a fluid at rest. For a fluid in motion it is measured in a direction normal to the direction of flow. Usually expressed in inches water gauge when dealing with air. (A measure of the tendancy to either burst or collapse a container.)

pressure, total: The algebraic sum of the velocity pressure and the static pressure (with due regard to sign).

pressure, vapor: The pressure exerted by a vapor. If a vapor is kept in confinement over its liquid so that the vapor can accumulate above the liquid, the temperature being held constant, the vapor pressure approaches a fixed limit called the maximum or saturated, vapor pressure, dependent only on the temperature and the liquid. The term vapor pressure is sometimes used as synonymous with saturated vapor pressure.

pressure, velocity: The kinetic pressure in the direction of flow necessary to cause a fluid at rest to flow at a given velocity. Usually expressed in inches water gauge.

pressure drop: The difference in static pressure measured at two locations in a ventilation system due to friction or turbulence.

pressure loss: Energy lost from a ventilation system through friction or turbulence.

psi: Pounds per square inch. A measure of pressure. 1 psi equals 27.7 inch water gauge or 2.04 inch Hg.

psia: Pounds per square inch aboslute. The absolute pressure without reference to another point. Standard atmospheric pressure is 14.7 psia.

psig: Pounds per square inch gauge. The pressure relative to atmospheric (0 psig equals 14.7 psia).

purge: Removal of residual material by the passing of fluid (typically gas) through a system.

push-pull hood: A hood consisting of an air supply system on one side of the contaminant source blowing across the source and into an exhaust hood on the other side.

Reasonably Available Control Technology: (also denoted as RACT) The lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories.

regenerate: Removal of adsorbate from adsorbent, typically by raising temperature or lowering pressure.

scrubber, gas: Any device in which a contaminant, solid or gaseous, is removed from a gas stream by liquid droplets. (Types include spray towers, packed towers, cyclone scrubbers, jet scrubbers, venturi scrubbers, impingement scrubbers and mechanical scrubbers.)

solute: Soluble component of a vapor stream which is absorbed by a solvent.

solvent: As used in reference to surface coatings, organic materials which are liquid at standard conditions and which are used as dissolvers, viscosity reducers, or cleaning agents.

spent: As used in reference to an adsorbent or absorbent, saturated.

standard air density: The density of air, 0.075 lb/ft^3, at standard conditions.

standard conditions: In industrial ventilation; a temperature of 70°F, 50 percent relative humidity and 29.92 inches of mercury atmospheric pressure.

tachometer: A device for measuring rotating speed.

transport (conveying) velocity: See Minimum Design Duct Velocity.

turbulence loss: The pressure or energy lost from a ventilation system through air turbulence.

turning vanes: Curved pieces added to elbows or fan inlet boxes to direct air and so reduce turbulence losses.

velocity, face: The inward air velocity in the plane of openings into an enclosure.

velometer: A device for measuring air velocity.

ventilation, local exhaust: A system, usually consisting of hoods, ducts, air cleaner and fan, that captures or contains contaminants at their source for removal from the work environment.

ventilation, mechanical: Air movement caused by a fan or other air moving device.

ventilation, natural: Air movement caused by wind, temperature difference or other nonmechanical factors.

valve: An adjustable orifice used to control fluid flow.

vapor: The gaseous form of substances which are normally in the solid or liquid state and which can be changed to these states either by increasing the pressure or decreasing the temperature.

Volatile Organic Compound: (also denoted as VOC) Any organic compound which participates in atmospheric photochemical reaction or is measured by the applicable reference methods specified under any subpart of 40 CFR 60.

APPENDIX C

INSPECTION CHECKLISTS

This appendix contains blank copies of the inspection checklists that were presented as Tables 3-2 through 3-8 in Section 3.0 of this report. They are presented here in a reduced format, but are otherwise identical to those in the text. They are printed on only one side of the page. Thus, they can be readily copies to provide a checklist that is useable in the field and contains a minimum number pages. It is suggested that the backs of each page can be used for additional notes and sketches.

TABLE C-1. CHECKLIST FOR HOODS

PLANT __________

INSPECTOR ____________

DATE ______________

I. PROCESS

A. PROCESS LINE DESIGNATION ______________________________

B. PROCESS EQUIPMENT CONTROLLED BY HOOD ________________________

C. PROCESS IN OPERATION DURING INSPECTION? YES ___ NO ___

D. 1. PROCESS OPERATING AT MAXIMUM CAPACITY? YES ___ NO ___

   2. IF NOT, AT APPROXIMATELY WHAT PERCENT OF CAPACITY? ___%

II. HOOD

A. TYPE OF HOOD: ENCLOSURE ___________ RECEIVING _____________

   CAPTURE ___________ OTHER (DESCRIBE) _________

B. 1. IS THE HOOD STRUCTURALLY SOUND? YES ___ NO ___

   2. IF THERE ARE HOLES, DENTS, ETC., WHERE ARE THEY? ___________

C. 1. DOES THE HOOD HAVE A FILTER? YES ___ NO ___

   2. WHEN WAS IT LAST INSPECTED? __________ LAST CHANGED? _________

III. GENERAL OBSERVATIONS

A. ARE THE VOC EMITTED AT A NOTICEABLE RATE? YES ___ NO ___

B. ARE THERE CROSS-DRAFTS IN THE ROOM? YES ___ NO ___

C. IS THE HOOD WELL POSITIONED TO CAPTURE THE VOC? YES ___ NO ___

D. WHAT IS THE APPROXIMATE DISTANCE FROM THE EMISSION POINT TO THE HOOD OPENING? _____ FT _____ INCHES

E. 1. DOES THE HOOD APPEAR TO HAVE BEEN MODIFIED OR ALTERED IN ANY WAY? YES ___ NO ___

   2. IF YES, HOW? ______________________________

F. 1. DOES THE HOOD CAPTURE THE VOC? YES ___ NO ___

   2. IF NOT, WHAT IS HAPPENING WITH THE VOC? ____________________

G. 1. IS THERE AN ODOR IN THE ROOM? YES ___ NO ___

   2. IF SO, WHERE? ______________________________

   3. DOES IT SEEM TO BE RELATED TO THE HOOD CAPTURE EFFICIENCY? YES ___ NO ___

H. OBSERVATIONS ______________________________

IV. MEASUREMENTS

A. TYPE OF INSTRUMENT USED ______________________________

____

B. WHERE WAS MEASUREMENT(S) TAKEN? (DRAW SKETCH BELOW)

C. INSTRUMENT READING(S) (IF APPLICABLE) ____________________

____

D. OBSERVATIONS ______________________________

V. SKETCH

PROCESS, LOCATION OF HOOD, POSITION OF MEASUREMENT DEVICE

VI. GENERAL COMMENTS:

____

____

TABLE C-2. CHECKLIST FOR INCINERATORS

PLANT ______________ INSPECTOR ______________

I. BACKGROUND DATA DATE ______________

A. TYPE OF INCINERATOR: THERMAL ______________ CATALYTIC ______________

B. MINIMUM ALLOWED TEMPERATURE ON OPERATING PERMIT ______________ °F

C. OPERATING TEMPERATURE DURING INSPECTION ______________ °F

D. INSTALLATION DATE ______________

II. AIR SUPPLY FAN

A. MAKE ______________ B. MODEL NUMBER ______________

C. SPEED ______________ D. RATED FLOW RATE ______________

E. FAN VIBRATION? YES ________ NO ________

F. MATERIAL BUILDUP ON FAN BLADES? YES ______ NO ______ COULD NOT CHECK ______

G. FAN BELT (IF USED) LOOSE? YES ______ NO ______

H. FAN/MOTOR BEARING OVERHEATING? YES ______ NO ______

I. BEARING INSPECTION SCHEDULE: ______________ PER ______________

J. BEARING LUBRICATION SCHEDULE: ______________ PER ______________

K. IS HIGH TEMPERATURE GREASE USED? YES ______ NO ______

L. COMMENTS: ______________

III. VOC SUPPLY

A. IS DUCTWORK STRUCTURALLY SOUND? ______________

B. IS VOC PREHEATED? YES ________ NO ________

C. VOC TEMPERATURE: BEFORE PREHEATER ________ AFTER PREHEATER ________

D. VOC PRESSURE: BEFORE PREHEATER ________ AFTER PREHEATER ________

E. 1. FILTER INSTALLED? YES ______ NO ______

2. FILTER LAST INSPECTED? ______________ LAST CHANGED ______________

F. 1. VOC BURNER: CLEAN? YES ______ NO ______ COULDN'T INSPECT ______________

WORN? YES ______ NO ______ COULDN'T INSPECT ______________

2. VOC BURNER LAST INSPECTED? ________ LAST REPLACED? ________

G. ADDITIONAL VOC MONITORING DEVICES? (LIST) ______________

H. COMMENTS ______________

IV. AUXILIARY FUEL

A. TYPE: GAS ________ OIL ________ IF OIL, SULFUR CONTENT ________ %

B. FUEL DELIVERY PRESSURE? ______________

C. 1. FUEL BURNER: CLEAN? YES ______ NO ______ COULDN'T INSPECT ______________

WORN? YES ______ NO ______ COULDN'T INSPECT ______________

2. FUEL BURNER LAST INSPECTED? ________ LAST REPLACED? ________

D. FUEL OIL SUPPLY PUMP CONDITION: ______________

E. 1. OIL FILTER: LAST INSPECTED? ________ LAST REPLACED? ________

F. COMMENTS: ______________

V. INCINERATOR CONTROLS

A. LIST EACH PARAMETER THAT IS CONTINUOUSLY MONITORED AND/OR RECORDED AND ITS READING DURING THE INSPECTION

PARAMETER	READING
______________	______________
______________	______________
______________	______________

B. 1. DOES INCINERATOR HAVE SHUTOFF CONTROLS FOR:

LOW TEMPERATURE? ______________ BURNER FLAME-OUT? ______________

FAN SHUTDOWN? ______________ HIGH VOC CONCENTRATION? ______________

2. ARE THESE MANUAL OR AUTOMATIC?

3. ANY ALARMS? YES ______ NO ______ SPECIFY ______________

C. 1. CALIBRATION SCHEDULE FOR CONTROL INSTRUMENTS? YES ______ NO ______

2. LAST CALIBRATION OF TEMPERATURE RECORDER? ______________

3. MAINTENANCE/LUBRICATION SCHEDULE FOR INSTRUMENTS? ______________

4. WHO CONDUCTS THE CALIBRATIONS? ______________

D. COMMENTS: ______________

TABLE C-2 (continued).

VI. REFRACTORY

A. 1. TYPE OF REFRACTORY? ____________

2. THICKNESS OF REFRACTORY: ________ INCHES

3. HOW OFTEN IS REFRACTORY CHANGED? ____________

B. 1. DATE LAST INSPECTED? ____________

2. INSPECTED BY WHOM? ____________

3. ANY PROBLEMS NOTED DURING INSPECTION? ____________

C. NOTICEABLE HOT SPOTS ON OUTER SURFACE OF COMBUSTION CHAMBER?
YES ____ NO ____

D. NOTICEABLE METAL WARPAGE? YES ____ NO ____

E. METAL CONNECTIONS MATE EVENLY? YES ____ NO ____

F. COMMENTS: ____________

VII. CATALYST

A. 1. CATALYST MATERIAL? ____________

2. DEPTH OF CATALYST BED? ________ INCHES

3. LAST INSPECTION? ____________

4. INSPECTED BY WHOM? ____________

5. CONDITION DURING INSPECTION? ____________

6. CATALYST CLEANING SCHEDULE ______ PER ______

7. HOW OFTEN IS CATALYST CHECKED FOR POISONING? ______ PER ______

8. BY WHOM? ____________

9. DATE OF LAST REPLACEMENT? ____________

10. IS SPARE CATALYST KEPT IN STOCK? YES ____ NO ____

B. STACK TEMPERATURE MEASUREMENT? YES ____ NO ____ IF YES: ______ °F

C. COMMENTS: ____________

VIII. HEAT EXCHANGERS

A. SUBSTANCE PREHEATED (VOC, COMBUSTION AIR, WATER) ____________

B. 1. INLET TEMPERATURE ____________ °F

2. OUTLET TEMPERATURE ____________ °F

3. STACK TEMPERATURE ____________ °F

C. PHYSICAL INTEGRITY ____________

D. PLANT INSPECTION SCHEDULE ____________ PER ____________

E. COMMENTS: ____________

IX. A. IS INCINERATOR LOCATED OUTSIDE? YES ____ NO ____

B. IS EXTERIOR CORRODED? ________
RUSTED? ________

X. OPERATING LOGS

A. ARE OPERATING LOGS KEPT FOR:

AUXILIARY FUEL USAGE? YES ____ NO ____
INCINERATOR CONTROLS? YES ____ NO ____
CATALYST TEMPERATURES? YES ____ NO ____
HEAT EXCHANGERS? YES ____ NO ____

B. IF POSSIBLE, CHECK OPERATING LOGS FOR SIGNIFICANT DEVIATIONS FOR SIGNIFICANT DEVIATIONS FROM DESIGN AND NORMAL OPERATING CONDTIONS

XI. SKETCH OF SYSTEM

XII. GENERAL COMMENTS: ____________

____

TABLE C-3. CHECKLIST FOR ADSORBERS

PLANT ____________ INSPECTOR ____________

DATE ____________

I. BACKGROUND DATA

A. MANUFACTURER ____________

B. INSTALLATION DATE ____________

C. MAKE AND MODEL NUMBER ____________

D. TYPE OF ADSORBER: FIXED ____________ CONTINUOUS ____________
FLUIDIZED BED ____________ CONCENTRIC ____________
OTHER (SPECIFY) ____________

E. REASON FOR INSTALLATION OF ADSORBER: TO MEET EMISSION LIMITS? ______
TO REMOVE ODORS? ____________

F. NUMBER OF BEDS ____________

G. BEDS ARE: VERTICAL ______ HORIZONTAL ______

H. TYPE OF ADSORBENT: THROWAWAY ____________ REGENERABLE ____________
ACTIVATED CARBON ____________
OTHER (SPECIFY) ____________

I. FORM OF ADSORBENT: GRANULAR ______ PELLETIZED ______ POWDER ______

J. WHERE IS ADSORBENT REGENERATED? ONSITE ____________
OFF-SITE (SPECIFY) ____________

K. GAS INLET STREAM DATA:

	DESIGN	DURING INSPECTION
FLOW RATE (CFM)	______	____________
TEMPERATURE (°F)	______	____________
RELATIVE HUMIDITY	______	____________
VOC VAPOR CONCENTRATION	______	____________

L. NUMBER OF EMISSION POINTS VENTED TO ADSORBER ____________

M. TYPE OF EMISSION POINTS VENTED TO ADSORBER ____________

N. PERCENT VOC IN SURFACE COATING FORMULATION DURING INSPECTION
____

O. SURFACE COATING APPLICATION RATE (GAL/HR, LB/HR) ____________
____

II. EXTERIOR CHECK

A. CORROSION/ABRASION EVIDENT? YES ______ NO ______

B. IF YES, IS IT LOCALIZED? YES ______ NO ______

C. IF LOCALIZED, SKETCH ADSORBER/CORROSION AREAS BELOW.

III. VOC FEED

A. VOC CONTENT OF GAS STREAM ENTERING ADSORBER ____________ %

B. IS A PREFILTER INSTALLED? YES ______ NO ______

C. TYPE OF PREFILTER THROWAWAY ______ FABRIC ______

D. LAST FILTER INSPECTION: ____________ REPLACEMENT: ____________

IV. BLOWER

A. FAN

1. POSITION OF FAN: ADSORBER INLET ______ OUTLET ______
2. IS CORROSION EVIDENT? YES ______ NO ______
3. IS EROSION EVIDENT? YES ______ NO ______
4. IS BUILD-UP ON FAN BLADES EVIDENT? YES ______ NO ______
5. IS VIBRATION EVIDENT? YES ______ NO ______
6. INSPECTION SCHEDULE ______ PER ______

B. MOTOR

1. EVIDENCE OF OVERHEATED BEARING? YES ______ NO ______
2. INSPECTION SCHEDULE ______ PER ______
3. LUBRICATION SCHEDULE ______ PER ______

V. VALVES, DAMPERS

A. ARE ALL VALVES AND DAMPERS LABELED? YES ______ NO ______

B. IF YES, SKETCH LOCATION AND DESIGNATION BELOW

C. IS THERE A STANDARD OPERATING PROCEDURE (S.O.P.) FOR SWITCHING FROM ONE ADSORBER BED TO ANOTHER? YES ______ NO ______

TABLE C-3 (continued).

D. CAN YOU OBTAIN A COPY OF THIS S.O.P.? YES ________ NO ________

VI. ADSORBANT REGENERATION

A. TYPE OF REGENERATION: STEAM ________ THERMAL ________

INERT GAS (SPECIFY) ________

B. REGENERATION STREAM CONTROL DEVICE:

INCINERATOR ________ ADSORBER ________

CONDENSER/DECANTER ________

SECONDARY ADSORBER ________

OTHER (SPECIFY) ________

C. REGENERATION INITIATION METHOD:

1. VAPOR CONCENTRATION ________

CONCENTRATION LIMIT ________ PPM

LOCATION OF CONCENTRATION ________

MEASUREMENT DEVICES OUTLET ________

MEASUREMENT DEVICES INLET ________

2. TIMED CYCLE ________

LENGTH OF TIME (HOURS) ________

ADSORPTION ________ MIN

REGENERATION ________ MIN

DRYING/COOLING ________ MIN

TOTAL CYCLE TIME ________ MIN

3. OTHER (SPECIFY) ________

D. IF STEAM REGENERATION IS USED:

1. HOW OFTEN ARE STEAM TRAPS BLED? ________ PER ________

2. STEAM PRESSURE ________ PSI

VII. WEATHER PROTECTION

A. ADSORBER INSTALLED OUTSIDE? YES ________ NO ________

B. ELECTRIC HEATER UTILIZED? YES ________ NO ________

C. FREEZE CONTROL THERMOSTAT UTILIZED? YES ________ NO ________

D. OTHER WEATHER PROTECTION MEASURES? (SPECIFY) ________

VIII. ADSORBENT

A. 1. IS ADSORBENT REGULARLY INSPECTED FOR DETERIORATION? YES ________ NO ________

2. HOW OFTEN? ________ PER ________

B. 1. IS MAKE-UP ADSORBENT ADDED TO THE BED ON A REGULAR BASIS? YES ________ NO ________

2. HOW OFTEN? ________ PER ________

3. HOW MUCH IS ADDED? ________

C. 1. IS THE ADSORBENT REGULARLY REPLACED? YES ________ NO ________

2. HOW OFTEN? ________ PER ________

IX. ADSORBER INTERNALS

A. ARE THE INTERNALS LINED WITH A PROTECTIVE COATING? YES ____ NO ____

B. HOW OFTEN ARE THEY INSPECTED? ________ PER ________

CLEANED? ________ PER ________

C. IS THE EXTERIOR WARPED DUE TO EXCESSIVE HEAT? YES ____ NO ____

X. CONDENSED LIQUID

A. IF A CONDENSER/DECANTER IS USED, WHAT IS DONE WITH NONCONDENSIBLES (I.E., THE VAPOR EXITING THE CONDENSER/DECANTER) ________

B. WHAT IS DONE WITH THE CONDENSIBLES? (I.E., DECANTED LIQUID)? ________

C. 1. ARE TRANSFER PUMPS INSTALLED? YES ________ NO ________

2. WHERE ARE THEY LOCATED? ________

3. IS THE PUMP SEAL AND/OR THE PACKING LEAKING? YES ________ NO ________

4. WHEN WAS SEAL AND/OR PACKING LAST REPLACED? ________

TABLE C-3 (continued).

D. 1. IS PUMP BEARING OVERHEATED? YES ________ NO ________

2. WHEN WAS BEARING LAST INSPECTED? ____________________

LUBRICATED? ____________________

REPLACED? ____________________

XI. CONTROLS

A. DOES FACILITY HAVE MONITORS AND/OR RECORDERS FOR (SPECIFY READING)

	PARAMETER	MONITOR	RECORDER	READING
1.	PRESSURE DROP ACROSS BED?			
2.	PRESSURE DROP ACROSS PREFILTER?			
3.	VAPOR INLET TEMPERATURE? (°F)			
4.	BED TEMPERATURE? (°F)			
5.	VAPOR OUTLET TEMPERATURE? (°F)			
6.	OTHER (SPECIFY)			
7.	OTHER (SPECIFY)			
8.	OTHER (SPECIFY)			

XII. SAFETY DEVICES INSTALLED

A. FLAME ARRESTOR YES ________ NO ________

B. HIGH BED TEMPERATURE SHUTDOWN YES ________ NO ________

C. SAFETY RELIEF VALVE YES ________ NO ________

D. OTHER ____________________

E. SAFETY INSPECTION SCHEDULE ________ PER ________

XIII. A. IS ADSORBER USED IN SERIES WITH OTHER CONTROL DEVICES?

YES ________ NO ________

B. WHAT KIND(S) ____________________

C. DRAW BELOW THE SEQUENCE OF UNITS

XIV. SKETCH SYSTEM--NOTING IMPORTANT DETAILS

TABLE C-4. CHECKLIST FOR ABSORBERS

PLANT ____________ INSPECTOR ____________

I. BACKGROUND INFORMATION DATE ____________

A. MANUFACTURER OF UNIT ____________

B. INTALLATION DATE ____________ RATED CAPACITY (CFM) ____________

C. RATED EFFICIENCY ____________ SOLVENT UTILIZED ____________

D. TYPE OF ABSORBER: PACKED BED ______ FILTER MESH ______ TRAY ______

OTHER (SPECIFY) ____________

E. COMPOSITION OF GAS STREAM ENTERING ABSORBER ____________

F. TYPES AND NUMBER OF EMISSION POINTS VENTED TO ABSORBER ____________

____

G. BED CONFIGURATION: VERTICAL ________ HORIZONTAL ________

II. VOC FEED LINE

A. IS IT STRUCTURALLY SOUND? YES ________ NO ________

B. 1. HOLES OR CORROSION OBSERVED? YES ________ NO ________

2. IF YES, SKETCH FEED LINE AND HOLE LOCATION BELOW

C. 1. FILTER INSTALLED ON FEED LINE? YES ________ NO ________

2. TYPE OF FILTER GLASS ________ PAPER ________

3. INSPECTION SCHEDULE ________ PER ________

4. REPLACEMENT SCHEDULE ________ PER ________

5. DATE OF LAST REPLACEMENT ____________

D. FAN

1. FAN ON ABSORBER: INLET? ________ OUTLET? ________

2. VIBRATION EVIDENT? YES ________ NO ________

3. BUILD-UP ON FAN BLADES EVIDENT? YES ________ NO ________

4. CORROSION EVIDENT? YES ________ NO ________

5. EROSION EVIDENT? YES ________ NO ________

6. ARE THERE DAMPERS IN THE SYSTEM? YES ________ NO ________
(MARK THEIR LOCATION ON SKETCH)

7. FUNCTION OF DAMPERS: EMERGENCY BYPASS ______ FLOW CONTROL ______

OTHER (SPECIFY) ________

E. MOTOR

1. BEARING OVERHEATED? YES ________ NO ________

2. BEARING INSPECTED ________ PER ________

3. BEARING LUBRICATED ________ PER ________

III. SOLVENT INLET AND OUTLET LINES

A. SOLVENT RECIRCULATION RATE ________ GAL PER ________ CFM

B. ARE THESE LINES STRUCTURALLY SOUND? YES ________ NO ________

C. 1. STRAINER ON INLET LINE? YES ________ NO ________

2. STRAINER INSPECTION SCHEDULE ________ PER ________

3. STRAINER CLEANING SCHEDULE ________ PER ________

D. 1. OUTLET SOLVENT PUMP LEAKING? YES ________ NO ________

2. PUMP PACKING AND SEALS INSPECTED? YES ________ NO ________

3. PUMP BEARING OVERHEATING? YES ________ NO ________

4. PUMP BEARING INSPECTED ________ PER ________

IV. ABSORBER AIR DISCHARGE LINE

A. MIST ELIMINATOR USED? YES ________ PER ________

B. VOC MONITORING/RECORDING DEVICE INSTALLED? YES ________ NO ________

C. TYPE OF DEVICE (SPECIFY) ____________

D. VOC OUTLET CONCENTRATION DURING INSPECTION ____________

TABLE C-4 (continued).

V. ABSORBER COLUMN

A. COLUMN DIMENSIONS __________ FT x __________ FT x __________ FT

B. EXTERIOR STRUCTURALLY SOUND? YES __________ NO __________

C. 1. SOLVENT SPRAY NOZZLES INSPECTED __________ PER __________

2. SOLVENT SPRAY NOZZLES CLEANED __________ PER __________

3. DATE OF LAST CLEANING ______________________________

D. 1. TYPE OF PACKING, FILTER OR TRAY UTILIZED __________________

2. ABSORBER PACKING TRAY INSPECTED __________ PER __________

3. ABSORBER PACKING TRAY CLEANED __________ PER __________

4. DATE OF LAST CLEANING ______________________________

E. 1. ABSORBER INTERNALS INSPECTED __________ PER __________

2. ABSORBER INTERNALS CLEANED __________ PER __________

3. DATE OF LAST CLEANING ______________________________

F. PRESSURE DROP ACROSS COLUMNS ______________________________

G. COMMENTS ______________________________

____

VI. SOLVENT RECIRCULATION LINE

A. STRAINERS AND/OR FILTER INSTALLED? YES __________ NO __________

B. INDICATE LOCATION OF FILTERS ON SKETCH BELOW

C. 1. STRAINERS/FILTERS INSPECTED __________ PER __________

2. STRAINERS/FILTERS CLEANED __________ PER __________

3. DATE OF LAST CLEANING ______________________________

D. IS SOLVENT RECIRCULATION LINE BLED? YES __________ NO __________

IF YES, FREQUENCY: __________ PER __________

E. IS SOLVENT STRIPPED (DESORBED)? YES __________ NO __________

IF YES, HOW? __________ PER __________

VII. SKETCH OF ABSORBER SYSTEM

VIII. GENERAL COMMENTS: ______________________________

____

TABLE C-5. CHECKLIST FOR CONDENSERS

PLANT ________ INSPECTOR ________

I. <u>BACKGROUND INFORMATION</u> DATE ________

A. 1. IS THE CONDENSER USED IN CONJUNCTION WITH ANOTHER POLLUTION CONTROL DEVICE? YES ________ NO ________

2. IF YES, WHAT DEVICE ________

3. SKETCH SEQUENCE OF UNITS BELOW

B. TYPE OF CONDENSER: SURFACE ________ CONTACT ________

OTHER (SPECIFY) ________

C. COOLANT/REFRIGERANT USED ________

II. <u>VOC FEED LINE</u>

A. IS LINE STRUCTURALLY SOUND? YES ________ NO ________

B. ARE ALL CONNECTIONS TIGHT AND NONLEAKING? YES ________ NO ________

C. 1. DOES THIS LINE HAVE A FILTER? YES ________ NO ________

2. IF SO, WHAT TYPE: GLASS ________ PAPER ________

OTHER (SPECIFY) ________

3. HOW OFTEN IS THE FILTER INSPECTED? ________ PER ________

4. HOW OFTEN IS THE FILTER CLEANED? ________ PER ________

5. WHEN WAS IT LAST CLEANED? ________

III. <u>VOC VENT</u>

A. 1. IS A HYDROCARBON ANALYZER INSTALLED ON THIS VENT? YES ________ NO ________

2. IF SO, WHO IS THE MANUFACTURER AND WHAT IS MODEL NUMBER?

____

____

3. WHAT IS THE CURRENT READING? ________

4. IS THIS READING KEPT ON A LOG SHEET? YES ________ NO ________

5. COMMENTS ________

____

B. 1. WHAT IS THE APPROXIMATE HEIGHT OF THE VENT LINE? ________ FT

2. COULD YOU DETECT AN ODOR FROM THIS VENT? YES ________ NO ________

3. COMMENTS ________

IV. <u>VOC DRAIN LINE</u>

A. IS THE LINE STRUCTURALLY SOUND? YES ________ NO ________

B. 1. DOES THIS LINE DRAIN INTO A RECOVERY TANK? YES ________ NO ________

2. SKETCH THE POSITION OF THE CONDENSER AND THE RECOVERY TANK BELOW

3. IS THE RECOVERY TANK ABOVE GROUND? YES ________ NO ________

4. IF SO, IS IT STRUCTURALLY SOUND WITH NO SIGNS OF CORROSION AND DETERIORATION? YES ________ NO ________

C. 1. WHERE IS THE RECOVERED VOC EVENTUALLY STORED? ________

2. SKETCH THIS TANK ON THE DIAGRAM BELOW

D. 1. IS A PUMP USED TO TRANSFER THE VOC FROM THE CONDENSER TO THE RECOVERY TANK? YES ________ NO ________

2. FROM THE RECOVERY TANK TO STORAGE? YES ________ NO ________

3. DO EITHER OR BOTH OF THESE PUMPS SHOW SIGNS OF LEAKAGE? YES ________ NO ________

E. COMMENTS ________

V. <u>REFRIGERATION SYSTEM</u>

A. DO BOTH COOLANT SUPPLY AND RETURN LINES APPEAR STRUCTURALLY SOUND WITH NO LEAKAGE OR CORROSION? YES ________ NO ________

B. 1. TYPE OF REFRIGERANT USED ________

2. REFRIGERANT CHECKED FOR IMPURITIES ________ PER ________

3. REFRIGERANT LEVEL CHECKED ________ PER ________

4. DATE OF LAST REFRIGERANT ADDITION AND THE QUANTITY ________

C. 1. HAS THE REFRIGERATION UNIT HAD ANY PAST OPERATIONAL PROBLEMS? YES ________ NO ________

TABLE C-5 (continued).

2. IF SO, WHAT WAS THE PROBLEM ______________________

3. HOW LONG WAS THE UNIT OFF-LINE? ______________________

D. 1. ARE SPARE PARTS KEPT ON ANY PART OF THE REFRIGERATION SYSTEM? YES _______ NO _______

2. IF SO, WHAT PARTS? ______________________

E. 1. IF A CONTACT CONDENSER IS USED, HOW ARE THE VOC AND WATER SEPARATED? ______________________

2. WHERE IS THE WATER DISPOSED? ______________________

IV. CONDENSER

A. PROPERTIES OF THE INLET VOC STREAM:

TEMPERATURE ____________ °F PRESSURE ____________

FLOW RATE ____________ CFM COMPOSITION (% VOC) ____________

B. WHAT ARE THE INLET COOLANT PROPERTIES

TEMPERATURE ____________ °F PRESSURE ____________

C. 1. CAN YOU INSPECT THE PLANT LOGS FOR THE PAST 6 MONTHS FOR OPERATING VALUES? YES _______ NO _______

2. IF SO, WERE THERE ANY NOTICEABLE DEVIATIONS? YES _______ NO _______

3. COMMENTS ______________________

____

D. 1. IS THE EXTERNAL SHELL OF THE CONDENSER STRUCTURALLY SOUND? YES _______ NO _______

2. ARE THERE ANY NOTICEABLE LEAKS? YES _______ NO _______

E. 1. IS THE INTERNAL SURFACE OF THE CONDENSER REGULARLY INSPECTED? YES _______ NO _______

2. DATE OF LAST INSPECTION ______________________

3. IS IT REGULARLY CLEANED? YES _______ NO _______

4. DATE OF LAST CLEANING ______________________

F. 1. HAS THE CONDENSER HAD A MAJOR OVERHAUL FOR ANY REASON? YES _______ NO _______

2. IF SO, WHY? ______________________

3. WHEN WAS THIS WORK DONE? ______________________

VII. COMMENTS: ______________________

____

VIII. SKETCH OF SYSTEM

APPENDIX D

EFFECTS OF CONTROL SYSTEM PROBLEMS

This appendix contains six tables which summarize problems which may arise with various parts of emission control systems and the effects that these problems would have on the operation of and the emissions from a control system.

TABLE D-1. EFFECTS OF PROBLEMS WITH HOODS

Problem	Effect on: Operations	Effect on: Emissions
Holes in hood.	Possible pressure loss in duct.	Fugitive emissions exit through holes in hood.
Plugged filter in hood.	Loss of suction in hood.	Emissions escape without being collected by hood.
Hood poorly positioned to capture emissions.	None	Emissions escape without being collected by hood.

TABLE D-2. EFFECTS OF PROBLEMS WITH DUCTWORK

	Effect on:	
Problem	Operations	Emissions
Corroded, eroded metal ductwork.	Pressure loss in duct.	Pollutant stream diluted with ambient air; decreased capture efficiency resulting in increased emissions.
Ductwork is vunerable to being hit by moving vehicles.	Moving vehicle may damage ductwork, create holes.	Fugitive emissions from holes in ducts.
Buildup of resinous materials inside duct.	Possible reduction in flow area or fire if material is combustible.	Possible damage to duct resulting in fugitive emissions.
Dampers not properly labeled (e.g., open, close).	Operator may confuse damper settings.	Imbalance of airflow in ductwork network reduces capture efficiency at certain hoods and results in increased emissions.
Dampers open at improper time.	None	Room air from unused coating operation dilutes VOC stream, reducing capture efficiency and resulting in increased emissions.

TABLE D-3. EFFECTS OF PROBLEMS WITH FANS

Problem	Effect on: Operations	Emissions
Fan motor, bearing overheating.	Reduced fan efficiency, suction and VOC capture at hoods.	Emissions escape at source without being collected.
Fan imbalance.	Reduced fan efficiency, suction and VOC capture at hoods.	Emissions escape at source without being collected.
Spare parts (bearing, belt) not kept in stock.	System down until spare part can be obtained.	Facility will most likely vent emissions to atmosphere while control system is down.
Belt is slipping, broken.	Fan will not turn at rated rpm.	Emissions escape at source without being collected.
Damper at fan is not open wide enough.	Excessive pressure drop across fan leading to overheating of motor.	Emission escape due to reduced suction.

TABLE D-4. EFFECTS OF PROBLEMS WITH INCINERATOR UNITS

Problem	Effect on: Operations	Effect on: Emissions
Operating temperature lower than stated on permit.	Reduced VOC combustion efficiency.	VOC pass through incinerator without being completely oxidized.
Fan malfunction.	Loss of VOC; excess airflow to incinerator.	Incomplete combustion of VOC resulting in emissions higher than design level.
Vapor stream not preheated.	Additional heat required to raise vapor stream to combustion temperature.	Incomplete combustion.
Burners plugged, worn.	Flame out.	VOC are not combusted.
Incinerator controls not calibrated.	Low temperature, high VOC concentration, fan failure.	VOC not completely combusted.
Incinerator has no controls.	Low temperature, high VOC concentration, fan failure.	VOC not completely combusted.
Improper refractory for high temperatures.	Warping, deformation of metal shell.	Fugitive emissions leaking from incinerator unit.
Fuel filter plugged.	Decreased auxiliary fuel flow.	Incomplete combustion of VOC's.
Catalyst plugged, poisoned.	Inefficient adsorption of VOC on catalyst surface.	Incomplete combustion of VOC.
Catalyst not cleaned, replaced on regular schedule.	Inefficient adsorption of VOC on catalyst surface.	Incomplete combustion of VOC.
Heat exchanger fouled, leaking.	Insufficient preheat of VOC vapor to incinerator.	Excess emissions due to incomplete combustion. VOC may bypass incinerator through leaks.

TABLE D-5. EFFECTS OF PROBLEMS WITH ADSORPTION UNITS

	Effect on:	
Problem	Operations	Emissions
Gradual loss of adsorbent due to entrainment.	Loss of adsorption capacity, premature saturation of bed.	Breakthrough (emission of uncaptured VOC) occurs much sooner.
Regeneration concentration detector/initiator poorly calibrated.	Regeneration will be initiated improperly.	Possible premature breakthrough.
VOC inlet vapor concentration higher than design value.	Adsorbent is prematurely saturated. Also, possible hot spots and bed fires may occur.	Premature breakthrough.
Emergency bypass damper opened.	Loss of vapor stream to adsorber.	Emissions bypass control unit and are vented to atmsophere.
Regeneration steam traps not bled.	Steam becomes saturated (wet).	Bed is saturated with water and cannot adsorb VOC.
Adsorbent not inspected, replaced on regular schedule.	Buildup of particulates, nonregenerable organics on adsorbent may occur.	Premature breakthrough.
Internal vessel liner chipped, abraded.	Eventual corrosion, erosion of vessel walls.	Fugitive emissions exit through vessel walls.
Plugged prefilter.	Exessive pressure drop in vapor line.	Increase in bed exhaust concentrations.
Blower (fan) failure (e.g., bearings, belt, motor).	Reduced flow to adsorber.	Increase in bed exhaust concentrations.
Inlet vapor stream relative humidity >50%.	Water vapor competes with VOC for adsorption sites.	Breakthrough occurs much sooner.
Nonregenerable compounds present in inlet vapor stream.	Bed fouling, less adsorption capacity.	Breakthrough occurs much sooner.

(continued)

TABLE D-5 (continued)

Problem	Effect on: Operations	Emissions
Corrosion in adsorber.	Pressure loss in bed.	Fugitive emissions from adsorber vessel.
Vapor stream inlet temperature higher than design value.	Revaporization of low boiling compounds will occur.	Exhaust VOC concentrations higher than design value.
Inlet vapor stream relative humidity <20%.	Potential excess heat buildup in bed.	Breakthrough occurs much sooner.
Highly exothermic solvents (e.g., ketones, phenols) present in inlet vapor stream.	Hot spots, bed fires may occur resulting in adsorption capacity loss.	Exhaust VOC concentrations in excess of emission limits.
Condensibles transfer pump leaking.	Leaking condensed organics.	Vaporization of leaked organics.
Control system poorly maintained.	Poorly controlled system.	Potential excess concentrations of VOC in adsorber exhaust stream.

TABLE D-6. EFFECTS OF PROBLEMS WITH ABSORPTION UNITS

	Effect on:	
Problem	Operations	Emissions
Incorrect solvent used in absorber (e.g., water used to absorb VOC).	Incomplete absorption of immiscible vapor.	VOC pass through bed with negligible control.
Plugged prefilter on vapor inlet.	Excess pressure drop in vapor inlet line.	Possible increase in exhaust VOC concentrations.
Fan failure.	Reduced vapor flow through vessel, poor gas/liquid contact.	Exhaust VOC concentration exceeds design limit.
Plugged solvent recirculation line strainer.	Reduced liquid flow to absorber.	Exhaust VOC concentration exceeds design limit.
Solvent recirculation pump leaking or overheating.	Reduced liquid flow to absorber.	Exhaust VOC concentration exceeds design limit.
Bypass damper open.	Vapor stream bypasses absorber.	VOC vented directly to atmosphere.
Solvent spray nozzles plugged.	Poor solvent distribution in absorber.	Exhaust VOC concentration exceeds design limit.
Packing trap plugged or fouled.	Excess pressure drop through vessel, poor gas/liquid contact.	Exhaust VOC concentration exceeds design limit.
Stripping column temperature too low.	Absorbed VOC not fully desorbed from solvent.	Exhaust VOC concentration exceeds design limit.
Solvent recirculation line not bled frequently enough.	Buildup of VOC in solvent results in reduced solvent absorption capacity.	Exhaust VOC concentration exceeds design limit.