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Environmental Protection  
Agency

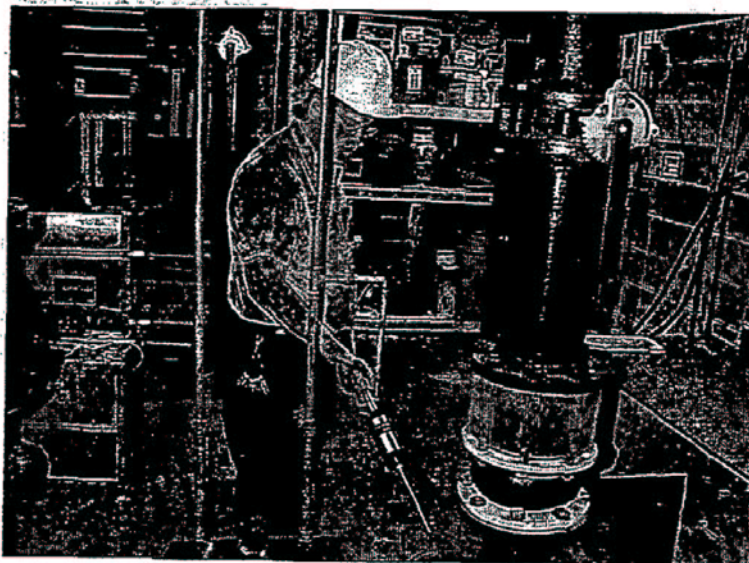
Enforcement and  
Compliance Assurance  
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EPA/305/B-98/011  
December 1998



# **Inspection Manual: Federal Equipment Leak Regulations for the Chemical Manufacturing Industry**

## **Volume II: Chemical Manufacturing Industry Regulations**



**EPA Office of Compliance  
Chemical, Commercial  
Services, and Municipal  
Division**

**Appendices D - H**

**APPENDIX D**  
**REGULATED EQUIPMENT<sup>1</sup>**

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<sup>1</sup>Source: Handbook: Control Techniques for Fugitive VOC Emissions from Chemical Process Facilities, Chapter 3, EPA/625/R-93/005, Office of Research and Development, Cincinnati, OH, 45268, March 1994.



## Chapter 3 Regulated Equipment

Equipment leak standards are designed to control emissions of VOCs and VHAPs from regulated equipment through the application of work practices and equipment practices. The work practice most commonly applied to control equipment leaks is the LDAR program, which is discussed in detail in Section 2.2.4.2. Subsequent chapters address the monitoring, recordkeeping, and reporting requirements of implementing a LDAR program under NSPS or NESHAP standards. In this chapter, regulated equipment is reviewed to illustrate how monitoring programs are applied to specific pieces of equipment.

Equipment practices include the use of specific types of components, equipment design standards or specifications, and operational standards for certain types of equipment. Equipment practices are evaluated using performance standards that provide a basis for monitoring or substantiating the effectiveness of such control practices. Equipment practices, briefly summarized in Section 2.2.4.3, are addressed in greater detail in this chapter.

A general set of equipment is covered by all of the equipment leak standards. Some equipment is covered only by specific standards. For example, product accumulator vessels are covered only by the equipment leak standards for benzene. Also, the vinyl chloride fugitive emission standards cover additional sources (loading and unloading lines, agitators, slip gauges, opening of equipment, and in-process wastewater). Except for agitators, however, the emissions from these sources generally are not considered "equipment leaks." The equipment leak standards also identify requirements for closed-vent systems and control devices that may be used to comply with the regulations.

### 3.1 Pumps

Pumps are used extensively in the SOCOMI and petroleum refinery industries, as well as in natural gas processing plants, for moving organic fluids. The most widely used pump is the centrifugal pump. Other types of pumps that also may be used are the positive-displacement, reciprocating and rotary

action, and special canned-motor and diaphragm pumps (U.S. EPA, 1990).

Chemicals transferred by pumps can leak at the point of contact between the moving shaft and stationary casing. To isolate the pump's interior from the atmosphere, all pumps, except the seal-less type (canned-motor and diaphragm), require a seal at the point where the shaft penetrates the housing. The most commonly used seals in these pumps are packed and mechanical (U.S. EPA, 1980a).

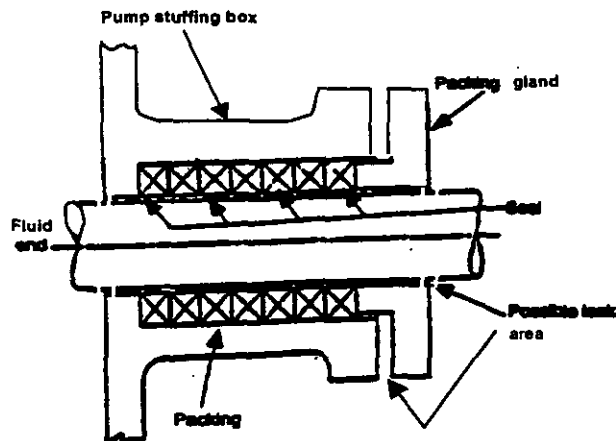


Figure 3-1. Diagram of simple packed seal (U.S. EPA, 1980b).

#### 3.1.1 Packed Seals

Packed seals can be used on both reciprocating and rotary action pumps. A packed seal consists of a cavity ("stuffing box") in the pump casing filled with special packing material that is compressed with a packing gland to form a seal around the shaft. A simple packed seal is illustrated in Figure 3-1. To prevent buildup of frictional heat, lubrication is required. A sufficient amount of liquid (either the liquid being pumped or another liquid that is injected) must be allowed to flow between the packing and the shaft to provide the necessary lubrication. If this packing and/or the shaft seal face degrade after a period of usage, organic compounds can leak to the atmosphere.

### 3.1.2 Single Mechanical Seals

Mechanical seals, limited in application to pumps with rotating shafts, can be single or dual. Basic designs of mechanical seals vary, but all have a lapped seal face between a stationary element and a rotating seal ring (Ramsden, 1978). In a single mechanical seal application, the rotating-seal ring and stationary element faces are lapped to a very high degree of flatness to maintain contact over their shared surface area (Figure 3-2). The faces are held together by a combination of pressure supplied by a spring and the pump pressure transmitted through the liquid that is being pumped. An elastomer seals the rotating face to the shaft. The stationary face is sealed to the stuffing box with another elastomer or gasket. As with packed seals, the faces must be lubricated; however, because of the mechanical seal's construction, much less lubrication is needed. Again, if the seal becomes imperfect because of wear, the organic compounds being pumped can leak between the seal faces and can be emitted to the atmosphere.

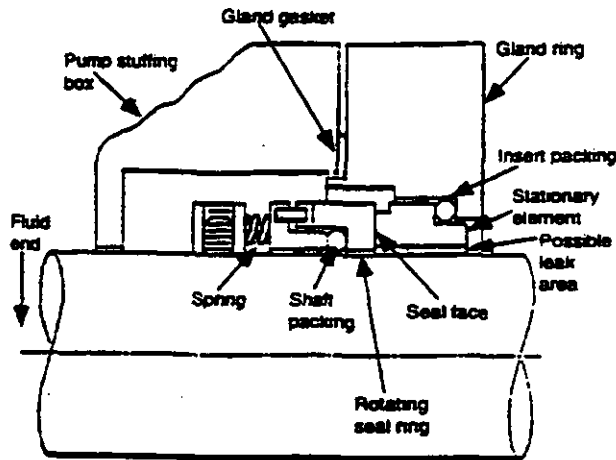


Figure 3-2. Diagram of basic single mechanical seal (U.S. EPA, 1980b).

### 3.1.3 Dual Mechanical Seals

Dual mechanical seals (Figure 3-3) can be arranged back to back, in tandem, or face to face. In the back-to-back arrangement, the two seals form a closed cavity. A barrier fluid, such as water or seal oil, is circulated through the cavity. Because the barrier fluid surrounds the dual seal and lubricates both sets of seal faces, the heat transfer and seal life characteristics of this dual seal are much better than those of the single seal. In order for the seal to

function, the barrier fluid must be at a pressure greater than the operating pressure of the stuffing box. As a result, some barrier fluid will leak across the seal faces. Liquid leaking across the inboard face will enter the stuffing box and mix with the process liquid. Barrier fluid going across the outboard face will exit to the atmosphere. Therefore, the barrier fluid must be compatible with the process liquid and with the environment (Ramsden, 1978, p. 99).

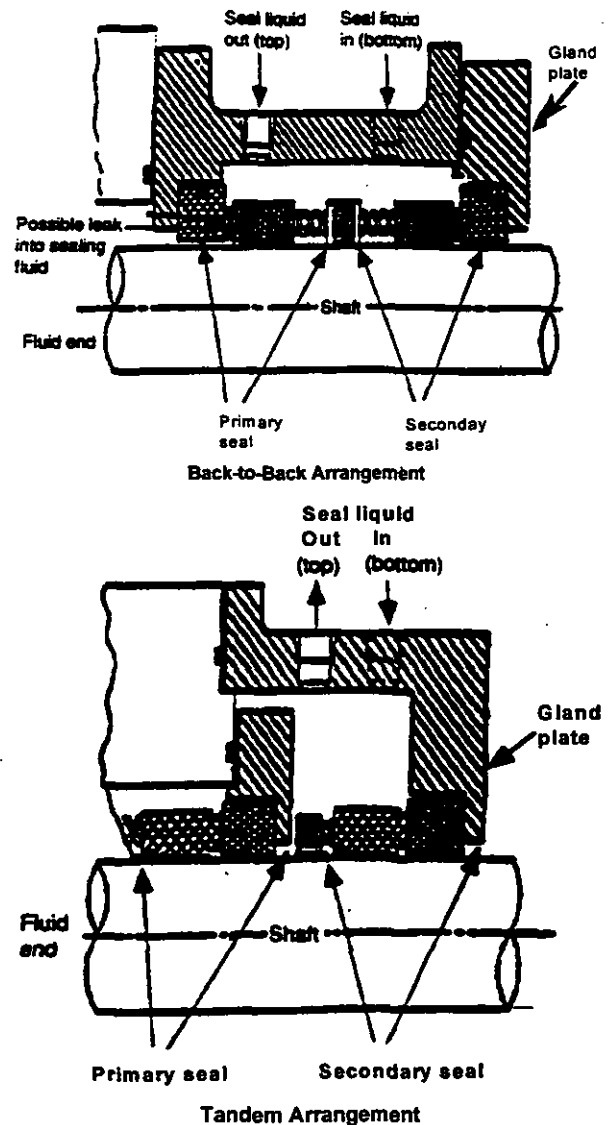


Figure 3-3. Typical arrangements of dual mechanical pump seals (U.S. EPA, 1984).

In a tandem dual mechanical seal arrangement, the seals face the same direction, and the secondary seal provides a backup for the primary seal. A seal flush is used in the stuffing box to remove the heat generated by friction. As with the back-to-back seal arrangement, the cavity between the two tandem seals is filled with a barrier fluid. The barrier fluid, however, is at a pressure lower than that in the stuffing box. Therefore, any leakage will be from the stuffing box into the seal cavity containing the barrier fluid. Since this liquid is routed to a closed reservoir, process liquid that leaks into the seal cavity also will be transferred to the reservoir. At the reservoir, the process liquid could vaporize and be emitted to the atmosphere. To ensure that VOCs or VHAPs do not leak from the reservoir, the reservoir can be vented to a control device.

Another arrangement of dual seals is face to face. In this configuration, two rotating faces are mated with a common stationary barrier. Barrier fluid may be provided at higher or lower pressures than in the stuffing box. As in the tandem arrangement, if the barrier fluid is at a lower pressure than in the stuffing box, the barrier fluid reservoir may require venting to a control device.

### 3.1.4 Seal-less Pumps

The seal-less pump includes canned-motor and diaphragm pumps. In canned-motor pumps (Figure 3-4), the cavity housing, the motor rotor, and the pump casing are interconnected. As a result, the motor bearings run in the process liquid and all shaft

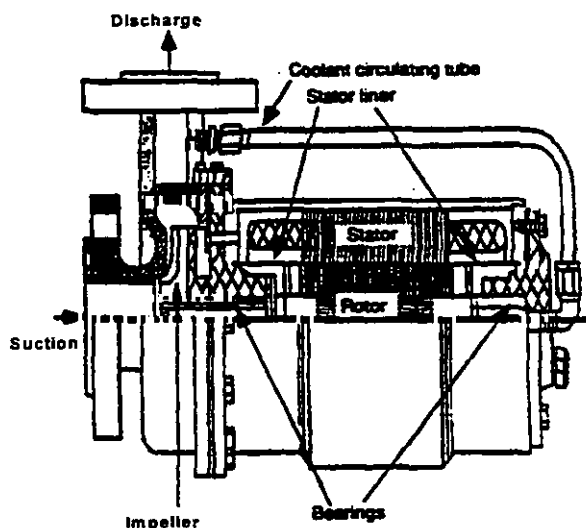


Figure 3-4. Diagram of seal-less canned-motor pump (U.S. EPA, 1990, P. 2-11).

seals are eliminated. Because the process liquid is the bearing lubricant, abrasive solids cannot be tolerated. Canned-motor pumps are used widely for handling organic solvents, organic heat transfer liquids, light oils, and many toxic or hazardous liquids. Canned-motor pumps also are used when leakage is an economic problem (Perry and Chilton, 1978, p. 6-8).

Diaphragm pumps (Figure 3-5) perform similarly to piston and plunger pumps. The driving member, however, is a flexible diaphragm fabricated of metal, rubber, or plastic. The primary advantage of this arrangement is that no packing and shaft seals are exposed to the process liquid, which is an important asset when handling hazardous or toxic liquids.

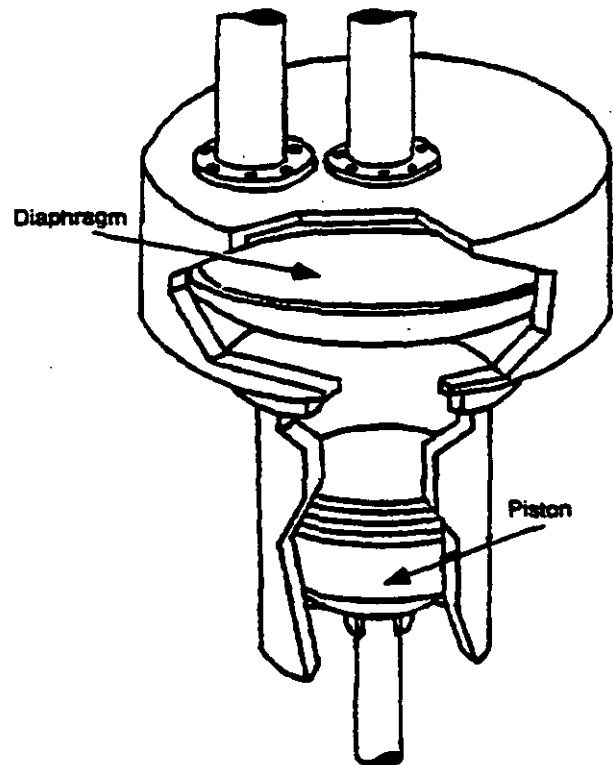


Figure 3-5. Diagram of diaphragm pump (U.S. EPA, 1990, p. 2-13).

## 3.2 Compressors

In the industries affected by these standards, centrifugal, reciprocating, and rotary compressors are used. The centrifugal compressor uses a rotating element or series of elements containing curved blades to increase the pressure of a gas by centrifugal force. Reciprocating and rotary compressors increase pressure by confining the gas

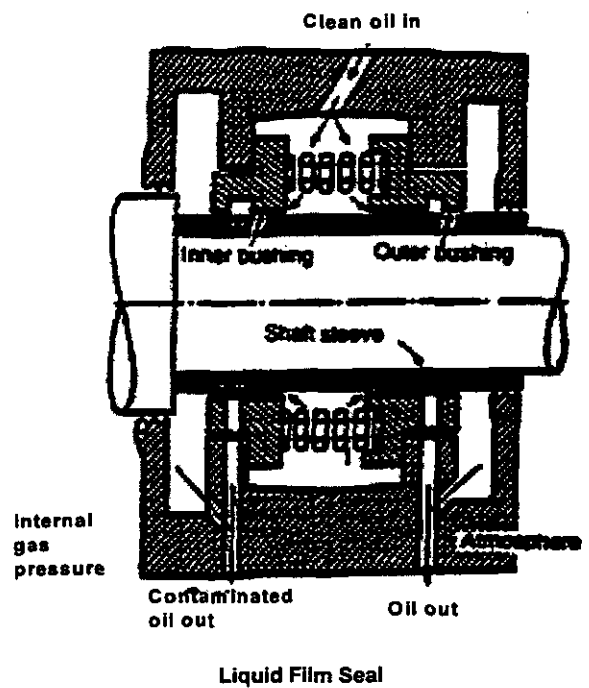
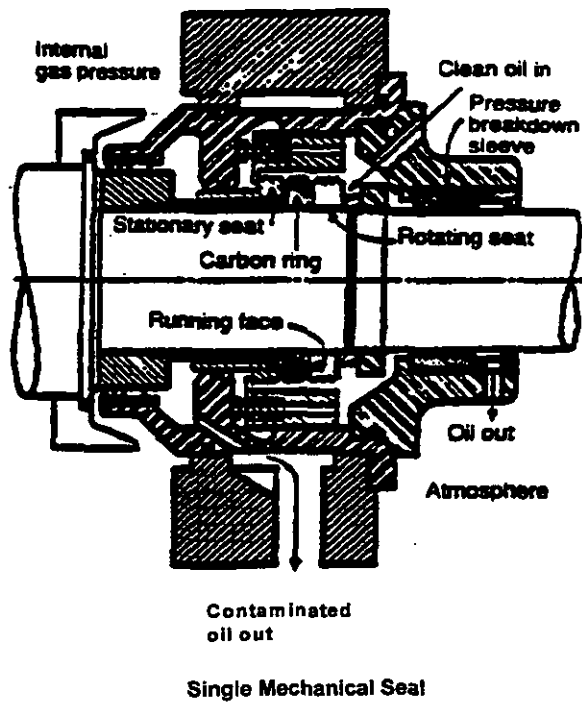
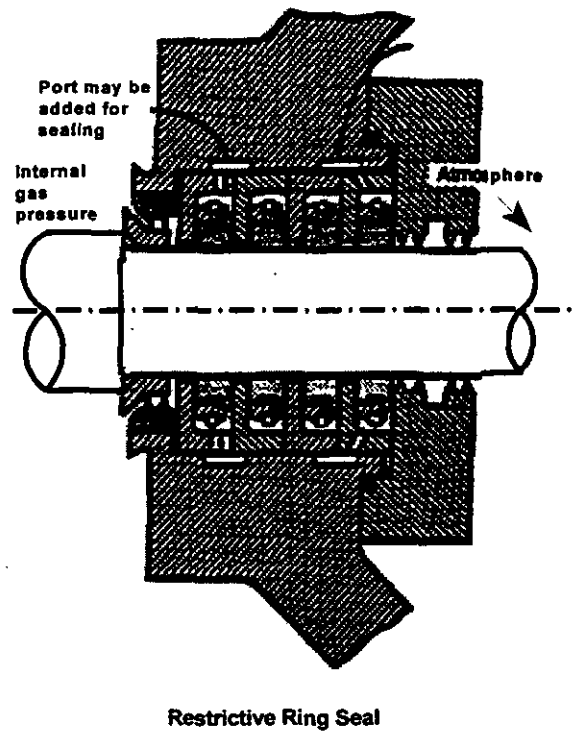
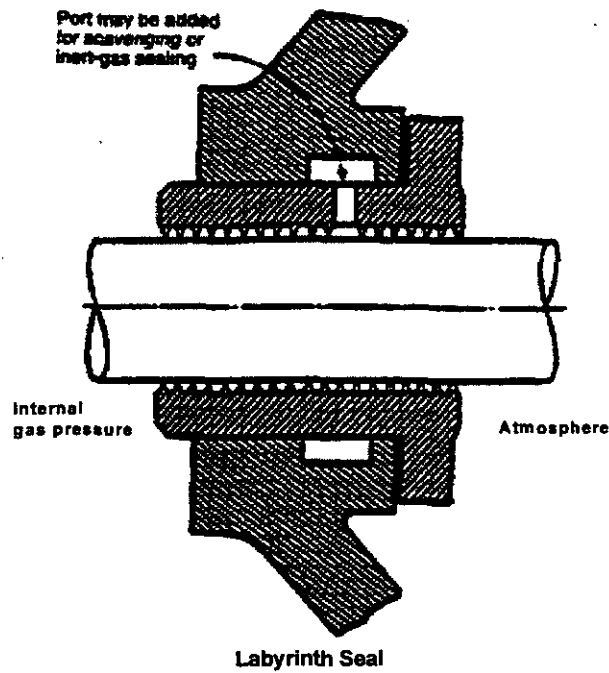


Figure 3-6. Typical designs of mechanical compressor seals (Ramsden, 1978, p.99).

in a cavity and progressively decreasing the volume of the cavity. Reciprocating compressors usually use a piston and cylinder arrangement, while rotary compressors use rotating elements such as lobed impellers or sliding vanes.

As with pumps, seals are required to prevent leakage from compressors. Rotary shaft seals for compressors may be labyrinth, restrictive carbon rings, mechanical contact, or liquid film. Figure 3-6 is an illustration of typical designs of these four types of seals. All of these seals are leak restriction devices, but none of them completely eliminates leakage. To respond to leakage, many compressors are equipped with ports in the seal area that evacuate collected gases.

### 3.2.1 Labyrinth

The labyrinth seal is composed of a series of close tolerance, interlocking "teeth" that restrict the flow of gas along the shaft. Many variations in "tooth" design and materials of construction are available. Although labyrinth seals as a group have the largest leak potential of the different types, properly applied variations in tooth configuration and shape can reduce leakage by up to 40 percent over a straight-pass-type labyrinth (Nelson, 1977).

### 3.2.2 Carbon Rings

Restrictive carbon ring seals consist of multiple stationary carbon rings with close shaft clearances. These seals may be operated dry with a sealing fluid or with a buffer gas. Restrictive ring seals can achieve lower leak rates than can the labyrinth type.

### 3.2.3 Mechanical

Mechanical contact seals are a common type of seal for rotary compressor shafts and are similar to the mechanical seals described for pumps. In this type of seal, the clearance between the rotating and stationary elements is reduced to zero, and oil or another suitable lubricant is supplied to the seal faces. Mechanical seals can achieve the lowest leak rates of the types discussed here, but they are not suitable for all processing.

### 3.2.4 Packed

Packed seals are used for reciprocating compressor shafts. As with pumps, the packing in the stuffing box is compressed with a gland to form a seal. Packing used on reciprocating compressor shafts is

often of the "chevron" or netted V type. To ensure operating safety, the area between the compressor seals and the compressor motor (distance piece) normally is enclosed and vented outside of the compressor building. If hydrogen sulfide is present in the gas, then the vented vapors are flared normally.

Reciprocating compressors can use a metallic packing plate and nonmetallic partially compressible material (i.e., Graffoil, Teflon) or oil wiper rings to seal shaft leakage to the distance piece. Nevertheless, some leakage into the distance piece may occur.

### 3.2.5 Liquid Film Seals

In addition to having seal types like those used for pumps, centrifugal compressors can be equipped with a liquid-film seal. The seal is a film of oil that flows between the rotating shaft and the stationary gland. The oil that leaves the compressor from the pressurized system side is under the system internal gas pressure and is contaminated with the gas. When this contaminated oil is returned to the open oil reservoir, process gas and entrained VOCs and VHAPs can be released to the atmosphere.

## 3.3 Pressure Relief Devices

Engineering codes require the use of pressure-relieving devices or systems in applications where

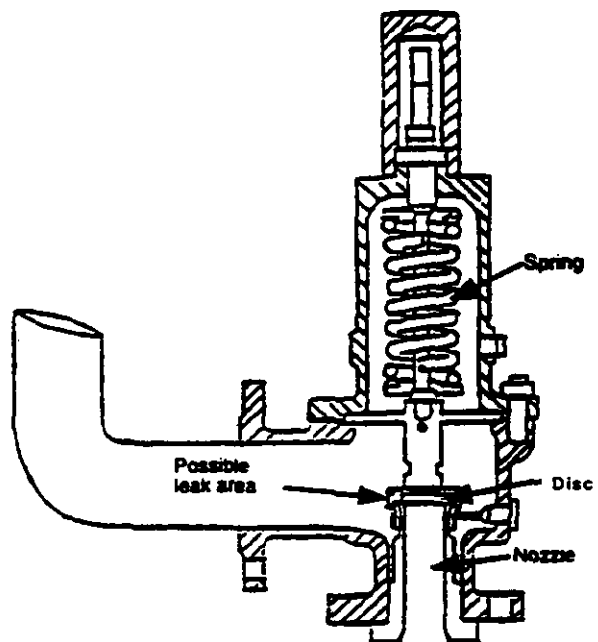


Figure 3-7. Diagram of a spring-loaded relief valve (U.S. EPA, 1990, p.2-16).



the process pressure may exceed the maximum allowable working pressure of the vessel. The pressure relief valve is the most common type of pressure-relieving device used. Typically, relief valves are spring-loaded (see Figure 3-7) and designed to open when the system pressure exceeds a set pressure, allowing the release of vapors or liquids until the system pressure is reduced to its normal operating level. When the normal pressure is re-attained, the valve reseats, and a seal is again formed. The seal is a disc on a seat, and a leak through this seal is a potential source of VOC and VHAP fugitive emissions. The potential causes of leakage from relief valves are "simmering or popping" (a condition that occurs when the system pressure comes close to the set pressure of the valve); improper reseating of the valve after a relieving operation; and corrosion or degradation of the valve seat (U.S. EPA, 1980a, p. 3-3).

Rupture discs also may be used to relieve pressure in process units (see Figure 3-8). These discs are made of a material that ruptures when a set pressure is exceeded, thus allowing the system to depressurize. The advantage of a rupture disc is that the disc seals tightly and does not allow any

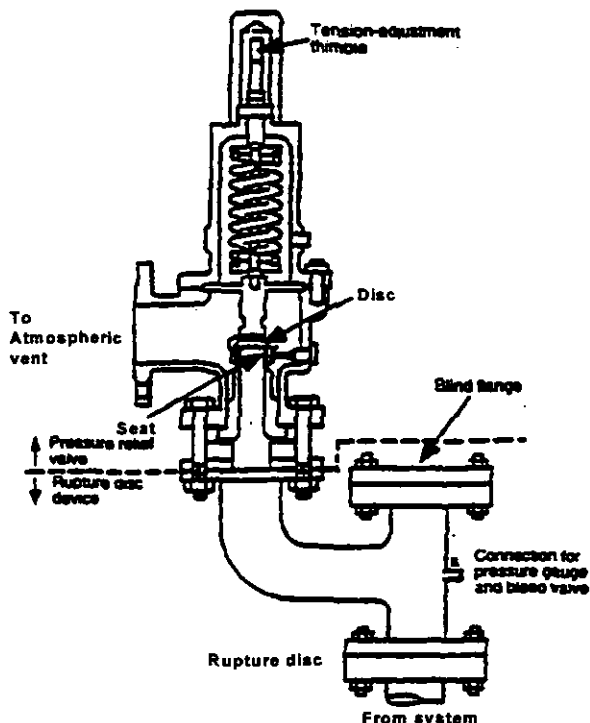


Figure 3-8. Typical design of a pressure relief valve mounted on a rupture disc device (Ramsden, 1978, p.99)

VOC or VHAP to escape from the system during normal operations. When the disc ruptures, however, the system will depressurize until atmospheric conditions are obtained, unless the disc is used with a pressure relief valve.

### 3.4 Sampling Connections

Process unit operations are checked periodically by routine analysis of feedstocks and products. To obtain representative samples for these analyses, sampling lines first must be purged. If the flushing liquid is not controlled, it could be drained onto the ground or into a process drain where it would evaporate and release VOCs or VHAPs to the atmosphere. Closed-loop sampling systems control the purged process fluid by returning it directly to the process line, collecting and recycling the fluid, or transporting the fluid to a control device. These sampling system controls typically allow zero VOC or VHAP emissions to the atmosphere. Two closed-loop sampling systems are illustrated in Figure 3-9.

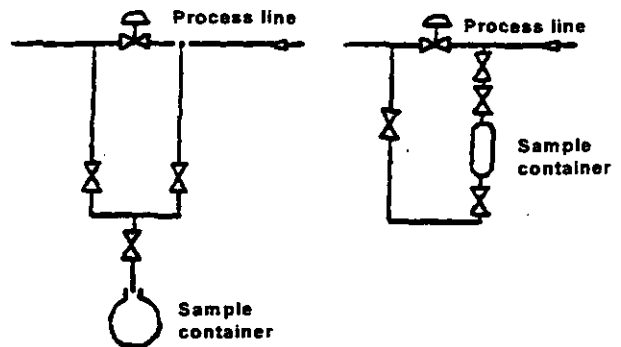


Figure 3-9. Diagram of two closed-loop sampling systems (Ramsden, 1978, p. 99).

### 3.5 Open-ended Lines or Open Valves

Some valves are installed in a system so that they function with the downstream line open to the atmosphere. Open-ended lines, which are used mainly in intermittent service for sampling and venting, include purge, drain, and sampling lines. Some open-ended lines are needed to preserve product purity. Normally, these are installed between multi-use product lines to prevent products from collecting in cross-tie lines during valve seat leakage. A faulty valve seat or incompletely closed valve would result in leakage through the valve, releasing fugitive VOC or VHAP emissions to the atmosphere.

Operational requirements specify that open-ended valves or lines be equipped with a cap, blind flange, plug, or second valve. The purpose of the cap, blind flange, plug, or second valve is to seal the open end at all times, except during operations requiring process fluid flow through the open-ended valve or line.

If a second valve is used, the open-ended line or valve is to be operated so that the valve on the process fluid end is closed before the second valve is closed. If a double block-and-bleed system is being used, the bleed valve or line may remain open during operations that require venting the line between the block valves. At all other times, the open end of the bleed valve or line must be sealed (again, except during operations requiring process fluid flow through the open-ended line or valve).

### 3.6 Process Valves

One of the most common pieces of equipment affected by these standards is the process valve. Commonly used types are control, globe, gate, plug, ball, relief, and check valves (see Figures 3-10 and 3-11). All except the relief valve (see Section 3.3) and check valve are activated through a valve stem, which may have either a rotational or linear motion, depending on the design. The valve stem requires a seat to isolate the process fluid inside the valve from the atmosphere. The possibility of a leak through this seal makes it a potential source of fugitive emissions. Since a check valve has no stem or subsequent packing gland, it is not considered a potential source of fugitive emissions.

The stem can be sealed to prevent leakage by using a packing gland or O-ring seals. Valves that require the stem to move in and out with or without rotation must use a packing gland. Conventional packing glands are suited for a wide variety of packing material. The most common are various types of braided asbestos that contain lubricants. Other packing materials include graphite, graphite-impregnated fibers, and tetrafluorethylene polymer. The packing material used depends on the valve application and configuration. These conventional packing glands can be used over a range of operating temperatures, but at high pressures, these glands must be quite tight to obtain a good seal (Templeton, 1971).

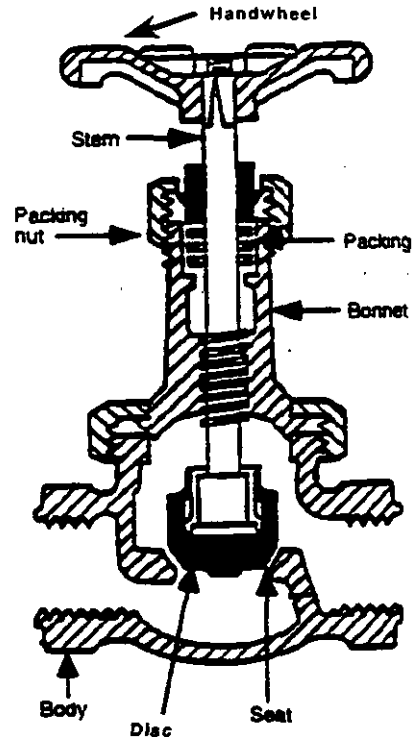


Figure 3-10. Diagram of a globe valve with a packed seal (U.S. EPA, 1980b).

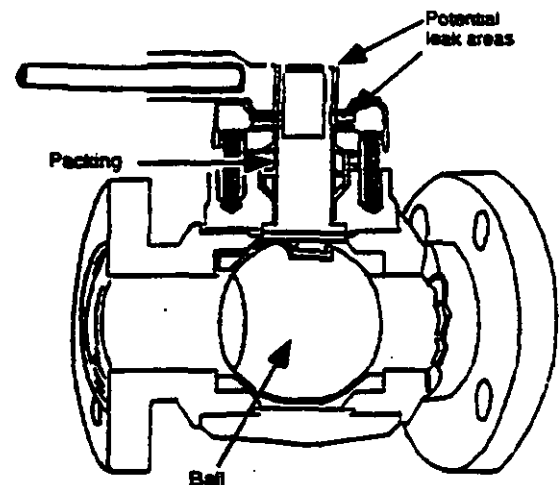


Figure 3-11. Diagram of a ball valve (U.S. EPA, 1990, p. 2-21).

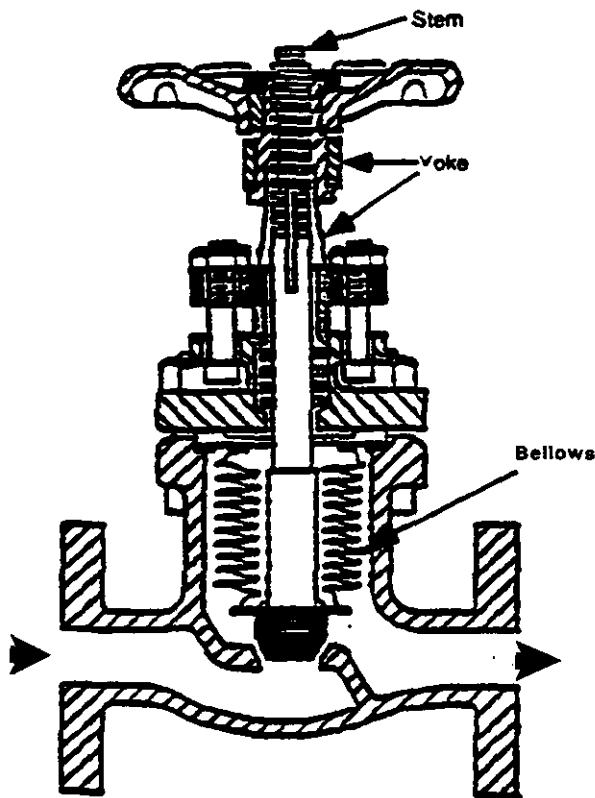


Figure 3-12. Diagram of a sealed bellows valve (U.S. EPA, 1990, p. 2-23).

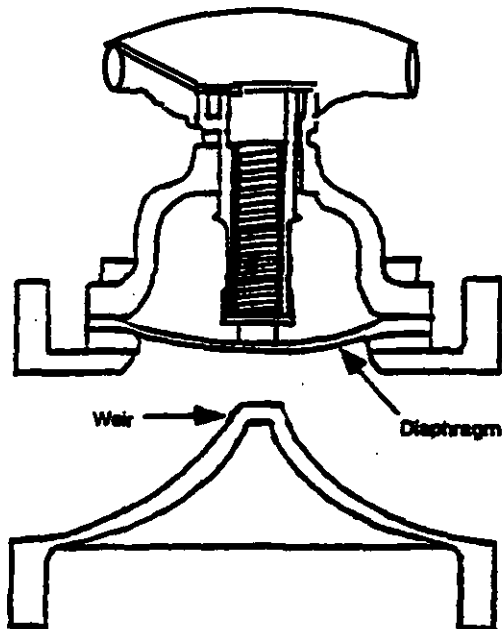


Figure 3-13. Diagram of a weir diaphragm seal (U.S. EPA, 1990, p. 2-24).

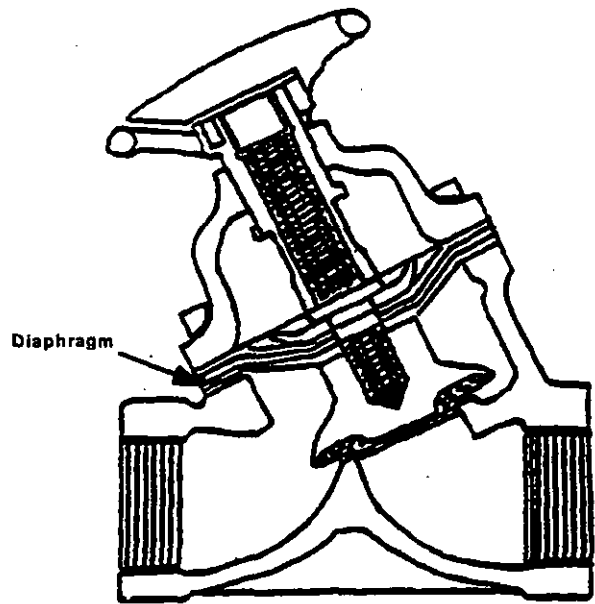


Figure 3-14. Diagram of a bonnet diaphragm seal (U.S. EPA, 1990, p. 2-24).

Elastomeric O-rings also are used for sealing process valves. These O-rings provide good sealing, but are not suitable if sliding motion occurs through the packing gland. These seals are used rarely in high pressure service, and operating temperatures are limited by the seal material.

Bellows seals are more effective for preventing process fluid leaks than is the conventional packing gland or any other gland-seal arrangement. This type of seal incorporates a formed metal bellows that makes a barrier between the disc and bonnet joint (see Figure 3-12). The bellows is the weak point of this type of system, and service life can be quite variable. Consequently, this type of seal normally is backed up with a conventional packing gland and often is fitted with a leak detector in case of failure.

A diaphragm may be used to isolate the working parts of the valve and the environment from the process liquid. Illustrated in Figures 3-13 and 3-14 are two types of diaphragm seals. The diaphragm also may be used to control the flow of the process fluid. In this design, a compressor component pushes the diaphragm toward the valve bottom, throttling the flow. The diaphragm and compressor are connected in a manner so that separating them is impossible under normal working conditions. When the diaphragm reaches the valve bottom, it seats firmly against the bottom, forming a leak-proof

seal. This configuration is recommended for fluids containing solid particles and for medium-pressure service. Depending on the diaphragm material, this type of valve can be used at temperatures up to 205°C and in severe acid solutions. If the seal fails, however, a valve using a diaphragm seal can become a source of fugitive emissions (Pikulik, 1978, pp. 3-23 and 3-24).

### 3.7 Flanges and Other Connectors

Flanges are bolted, gasket-sealed junctions used wherever pipes or other equipment such as vessels, pumps, valves, and heat exchangers may require isolation or removal. Connectors are all other nonwelded fittings that serve a similar purpose to flanges, which also allow bends in pipes (elbows), joining two pipes (couplings), or joining three or four pipes (tees or crosses). Connectors typically are threaded.

Flanges may become fugitive emissions sources when leakage occurs because of improperly chosen gaskets or poorly assembled flanges. The primary cause of flange leakage is thermal stress, which causes deformation of the seal between the flange faces. Threaded connectors may leak if the threads become damaged or corroded or if tightened without sufficient lubrication or torque. LDAR programs are the principal control technique for flanges and other connectors.

### 3.8 Product Accumulator Vessels

The background information document for the proposed benzene standards (U.S. EPA, 1980b) states that product accumulator vessels include overhead and bottoms receiver vessels used with fractionation columns and product separator vessels used in series with reactor vessels to separate reaction products. Accumulator vessels can be vented directly to the atmosphere or indirectly through a blowdown drum or vacuum system. When an accumulator vessel contains benzene and vents to the atmosphere, benzene emissions can occur. This equipment is covered only by the benzene equipment leak standards.

The benzene standards require each product accumulator vessel to be equipped with a closed-vent system capable of capturing and transporting any leakage from the vessel to a control device. Acceptable control devices include vapor recovery

systems, enclosed combustion devices, or flares. These control systems are described in Section 3.10.

### 3.9 Agitators

Agitators are used to stir or blend chemicals. Like pumps and compressors, agitators may leak organic chemicals at the point where the shaft penetrates the casing. Consequently, seals are required to minimize fugitive emissions. Four seal arrangements commonly are used with agitators: compression packing (packed seal), mechanical seals, hydraulic seals, and lip seals. Packed seals for agitators are very similar in design and application to packed seals for pumps (Ramsey and Zoller, 1976).

Although mechanical seals are more costly than the other three types of seals, they offer a greatly reduced leakage rate to offset their higher cost. Furthermore, the maintenance frequency of mechanical seals is one-half to one-fourth that of packed seals. At pressures greater than 1,140 kPa (150 psig), the leakage rate and maintenance frequency are so superior that the use of packed seals on agitators is rare. As with packed seals, the mechanical seals for agitators are similar in design and application to the mechanical seals for pumps.

The hydraulic seal, which is the simplest and least used agitator shaft seal, has an annular cup attached to the process vessel that contains a liquid that is in contact with an inverted cup attached to the rotating agitator shaft. The primary advantage of this seal is that it is a noncontact seal. Use of this seal, however, is limited to low temperatures and pressures and very small pressure fluctuations. In addition, organic chemicals may contaminate the seal liquid and then be released into the atmosphere as fugitive emissions.

A lip seal can be used on a top-entering agitator as a dust or vapor seal. The sealing element is a spring-loaded elastomer. Lip seals are relatively inexpensive and easy to install. Once the seal has been installed, the agitator shaft rotates in continuous contact with the lip seal. Pressure limits of the seal are 2 to 3 psig because it operates without lubrication, and operating temperatures are limited by the characteristics of the elastomer. Fugitive emissions can be released through this seal when the seal wears excessively or the

operating pressure surpasses the pressure limits of the seal.

### 3.10 Closed-Vent Systems and Control Devices

A closed-vent system can be used to collect and dispose of gaseous VOC emissions from seal oil degassing vents, pump and compressor seal leakage, relief valve leakage, and relief valve discharges because of over-pressure operation. A closed-vent system consists of piping connectors, flame arrestors, and, if necessary, flow-inducing devices. Closed-vent systems are designed and operated so that all VOC emissions are transported to a control device without leakage to the atmosphere.

Several types of control devices can be used to dispose of VOC and VHAP emissions captured in the closed-vent system. Incineration, carbon adsorption, and condensation are three control methods that typically are applied. Control efficiencies of the three methods are dependent on specific operating characteristics and the types of emissions being generated. Typically, enclosed combustion devices (boilers, process heaters, and thermal and catalytic incinerators) can achieve better than 95 percent destruction efficiencies. The key parameters affecting destruction efficiency are residence time and temperature. Carbon adsorption systems can achieve 95 to 99 percent control efficiency through proper design and operation, while condensation systems can achieve capture efficiencies of 90 percent or more.

Flares commonly found at plants subject to these standards include steam-assisted, air-assisted, non-assisted, ground, and dual-flare systems. Certain flares have demonstrated destruction efficiencies equal to those of enclosed combustion devices provided certain design specifications (heat content and exit velocity) are met (U.S. EPA, 1985).

### 3.11 References

When an NTIS number is cited in a reference, that document is available from:

National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
703-487-4650

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**APPENDIX E**

**METHOD 21 (40 CFR 60, APPENDIX A)**





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**EMISSION MEASUREMENT TECHNICAL INFORMATION CENTER  
NSPS TEST METHOD**

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(EMTIC M-21, 2/9/93)

**Method 21 - Determination of Volatile Organic Compound Leaks**

**1. APPLICABILITY AND PRINCIPLE**

**1.1 Applicability.** This method applies to the determination of volatile organic compound (VOC) leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

**1.2 Principle.** A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it must meet the specifications and performance criteria contained in Section 3. A leak definition concentration based on a reference compound is specified in each applicable regulation. This procedure is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rate from individual sources.

**2. DEFINITIONS**

**2.1 Leak Definition Concentration.** The local VOC concentration at the surface of a leak source that indicates that a VOC emission (leak) is present. The leak definition is an instrument meter reading based on a reference compound.

**2.2 Reference Compound.** The VOC species selected as an instrument calibration basis for specification of the leak definition concentration. (For example, if a leak definition concentration is 10,000 ppm as methane, then any source emission that results in a local concentration that yields a meter reading of 10,000 on an instrument meter calibrated with methane would be classified as a leak. In this example, the leak definition is 10,000 ppm, and the reference compound is methane.)

**2.3 Calibration Gas.** The VOC compound used to adjust the instrument meter reading to a known value. The calibration gas is usually the reference compound at a known concentration approximately equal to the leak definition concentration.

**2.4 No Detectable Emission.** The total VOC concentration at the surface of a leak source that indicates that a VOC emission (leak) is not present. Since background VOC concentrations may exist, and to account for instrument drift and imperfect reproducibility, a difference between the source surface concentration and the local ambient concentration is determined. A difference based on the meter readings of less than a concentration

corresponding to the minimum readability specification indicates that a VOC emission (leak) is not present. (For example, if the leak definition in a regulation is 10,000 ppm, then the allowable increase in surface concentration versus local ambient concentration would be 500 ppm based on the instrument meter readings.)

**2.5 Response Factor.** The ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

**2.6 Calibration Precision.** The degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

**2.7 Response Time.** The time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

### **3. APPARATUS**

#### **3.1 Monitoring Instrument.**

##### **3.1.1 Specifications**

- a. The VOC instrument detector shall respond to the compounds being processed. Detector types which may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption, and photoionization.
- b. The instrument shall be capable of measuring the leak definition concentration specified in the regulation.
- c. The scale of the instrument meter shall be readable to + or - 5 percent of the specified leak definition concentration.
- d. The instrument shall be equipped with a pump so that a continuous sample is provided to the detector. The nominal sample flow rate shall be 0.1 to 3.0 liters per minute.
- e. The instrument shall be intrinsically safe for operation in explosive atmospheres as defined by the applicable U.S.A. standards (e.g., National Electrical Code by the National Fire Prevention Association).
- f. The instrument shall be equipped with a probe or probe extension for sampling not to exceed 1/4 in. in outside diameter, with a single end opening for admission of sample.

### **3.1.2 Performance Criteria.**

- a. The instrument response factors for the individual compounds to be measured must be less than 10.
- b. The instrument response time must be equal to or less than 30 seconds. The response time must be determined for the instrument configuration to be used during testing.
- c. The calibration precision must be equal to or less than 10 percent of the calibration gas value.
- d. The evaluation procedure for each parameter is given in Section 4.4.

### **3.1.3 Performance Evaluation Requirements.**

- a. A response factor must be determined for each compound that is to be measured, either by testing or from reference sources. The response factor tests are required before placing the analyzer into service, but do not have to be repeated at subsequent intervals.
- b. The calibration precision test must be completed prior to placing the analyzer into service, and at subsequent 3-month intervals or at the next use whichever is later.
- c. The response time test is required before placing the instrument into service. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required before further use.

### **3.2 Calibration Gases.**

The monitoring instrument is calibrated in terms of parts per million by volume (ppm) of the reference compound specified in the applicable regulation. The calibration gases required for monitoring and instrument performance evaluation are a zero gas (air, less than 10 ppm VOC) and a calibration gas in air mixture approximately equal to the leak definition specified in the regulation. If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within + or - 2 percent accuracy, and a shelf life must be specified. Cylinder standards must be either reanalyzed or replaced at the end of the specified shelf life. Alternatively, calibration gases may be prepared by the user according to any accepted gaseous preparation procedure that will yield a mixture accurate to within + or - 2 percent. Prepared standards must be replaced each day of use unless it can be demonstrated that degradation does not occur during storage.

Calibrations may be performed using a compound other than the reference compound if a conversion factor is determined for that alternative compound so that the resulting

meter readings during source surveys can be converted to reference compound results.

## 4. PROCEDURES

**4.1 Pretest Preparations.** Perform the instrument evaluation procedure given in Section 4.4 if the evaluation requirement of Section 3.1.3 have not been met.

**4.2 Calibration Procedures.** Assemble and start up the VOC analyzer according to the manufacturer's instructions. After the appropriate warmup period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value. (Note: If the meter readout cannot be adjusted to the proper value, a malfunction of the analyzer is indicated and corrective actions are necessary before use.)

### 4.3 Individual Source Surveys.

**4.3.1 Type I - Leak Definition Based on Concentration.** Place the probe inlet at the surface of the component interface where leakage could occur. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. If the maximum observed meter reading is greater than the leak definition in the applicable regulation, record and report the results as specified in the regulation reporting requirements. Examples of the application of this general technique to specific equipment types are:

a. Valves - Leaks usually occur at the seal between the stem and the housing. Place the probe at the interface where the stem exits the packing and sample the stem circumference and the flange periphery. Survey valves of multipart assemblies where a leak could occur.

b. Flanges and Other Connections - Place the probe at the outer edge of the flange-gasket interface and sample the circumference of the flange.

c. Pump or Compressor Seals - If applicable, determine the type of shaft seal. Perform a survey of the local area ambient VOC concentration and determine if detectable emissions exist as described above.

d. Pressure Relief Devices - For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere.

e. Process Drains - For open drains, place the probe inlet as near as possible to the

center of the area open to the atmosphere. For covered drains, locate probe at the surface of the cover and traverse the periphery.

f. Open-ended Lines or Valves - Place the probe inlet at approximately the center of the opening of the atmosphere.

g. Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices - If applicable, observe whether the applicable ducting or piping exists. Also, determine if any sources exist in the ducting or piping where emissions could occur before the control device. If the required ducting or piping exists and there are no sources where the emissions could be vented to the atmosphere before the control device, then it is presumed that no detectable emissions are present. If there are sources in the ducting or piping where emissions could be vented or sources where leaks could occur, the sampling surveys described in this section shall be used to determine if detectable emissions exist.

h. Access door seals - Place the probe inlet at the surface of the door seal interface and traverse the periphery.

**4.3.2 Type II - "No Detectable Emission".** Determine the ambient concentration around the source by moving the probe randomly upwind and downwind around one to two meters from the source. In case of interferences, this determination may be made closer to the source down to no closer than 25 centimeters. Then move the probe to the surface of the source and measure as in 4.3.1. The difference in these concentrations determines whether there are no detectable emissions. When the regulation also requires that no detectable emissions exist, visual observations and sampling surveys are required. Examples of this technique are: (a) Pump or Compressor Seals - Survey the local area ambient VOC concentration and determine if detectable emissions exist. (b) Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices - Determine if any VOC sources exist upstream of the device. If such ducting exists and emissions cannot be vented to the atmosphere upstream of the control device, then it is presumed that no detectable emissions are present. If venting is possible sample to determine if detectable emissions are present.

### **4.3.3 Alternative Screening Procedure.**

**4.3.3.1** A screening procedure based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources that do not have continuously moving parts, that do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that do not have open areas to the atmosphere that the soap solution cannot bridge, or that do not exhibit evidence of liquid leakage. Sources that have these conditions present must be surveyed using the instrument technique of Section 4.3.1 or 4.3.2.

**4.3.3.2** Spray a soap solution over all potential leak sources. The soap solution may be a commercially available leak detection solution or may be prepared using concentrated detergent and water.

A pressure sprayer or squeeze bottle may be used to dispense the solution. Observe the potential leak sites to determine if any bubbles are formed. If no bubbles are observed, the source is presumed to have no detectable emissions or leaks as applicable. If any bubbles are observed, the instrument techniques of Section 4.3.1 or 4.3.2 shall be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

**4.4 Instrument Evaluation Procedures.** At the beginning of the instrument performance evaluation test, assemble and start up the instrument according to the manufacturer's instructions for recommended warmup period and preliminary adjustments.

**4.4.1 Response Factor.**

**4.4.1.1** Calibrate the instrument with the reference compound as specified in the applicable regulation. For each organic species that is to be measured during individual source surveys, obtain or prepare a known standard in air at a concentration of approximately 80 percent of the applicable leak definition unless limited by volatility or explosivity. In these cases, prepare a standard at 90 percent of the standard saturation concentration, or 70 percent of the lower explosive limit, respectively. Introduce this mixture to the analyzer and record the observed meter reading. Introduce zero air until a stable reading is obtained. Make a total of three measurements by alternating between the known mixture and zero air. Calculate the response factor for each repetition and the average response factor.

**4.4.1.2** Alternatively, if response factors have been published for the compounds of interest for the instrument or detector type, the response factor determination is not required, and existing results may be referenced. Examples of published response factors for flame ionization and catalytic oxidation detectors are included in the Bibliography.

**4.4.2 Calibration Precision.** Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

**4.4.3 Response Time.** Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. Measure the time from switching to when 90 percent of the final stable reading is attained. Perform this test sequence three times and record the results. Calculate the average response time.

## 5. BIBLIOGRAPHY

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**APPENDIX F**

**CHEMICAL MANUFACTURING PROCESSES  
SUBJECT TO HON STANDARDS  
(40 CFR 63, SUBPART H)**



**TABLE 1 TO SUBPART F - SYNTHETIC ORGANIC CHEMICAL MANUFACTURING INDUSTRY  
CHEMICALS**

<b>Chemical Name<sup>a</sup></b>	<b>CAS Number<sup>b</sup></b>	<b>Group</b>
Acenaphthene	83329	V
Acetal	105577	V
Acetaldehyde	75070	II
Acetaldol	107891	II
Acetamide	60355	II
Acetanilide	103844	II
Acetic acid	64197	II
Acetic anhydride	108247	II
Acetoacetanilide	102012	III
Acetone	67641	I
Acetone cyanohydrin	75865	V
Acetonitrile	75058	I
Acetophenone	98862	I
Acrolein	107028	IV
Acrylamide	79061	I
Acrylic acid	79107	IV
Acrylonitrile	107131	I
Adiponitrile	111693	I
Alizarin	72480	V
Alkyl anthraquinones	008	V
Allyl alcohol	107186	I
Allyl chloride	107051	IV
Allyl cyanide	109751	IV
Aminophenol sulfonic acid	0010	V
Aminophenol (p-)	123308	I
Aniline	62533	I
Aniline hydrochloride	142041	III
Anisidine (o-)	90040	II
Anthracene	120127	V
Anthraquinone	84651	III

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Azobenzene	103333	I
Benzaldehyde	100527	III
Benzene	71432	I
Benzenedisulfonic acid	98486	I
Benzenesulfonic acid	98113	I
Benzil	134816	III
Benzilic acid	76937	III
Benzoic acid	65850	III
Benzoin	119539	III
Benzonitrile	100470	III
Benzophenone	119619	I
Benzotrichloride	98077	III
Benzoyl chloride	98884	III
Benzyl acetate	140114	III
Benzyl alcohol	100516	III
Benzyl benzoate	120514	III
Benzyl chloride	100447	III
Benzyl dichloride	98873	III
Biphenyl	92524	I
Bisphenol A	80057	III
Bis(Chloromethyl)Ether	542881	I
Bromobenzene	108861	I
Bromoform	75252	V
Bromonaphthalene	27497514	IV
Butadiene (1,3-)	106990	II
Butanediol (1,4-)	110634	I
Butyl acrylate (n-)	141322	V
Butylene glycol (1,3-)	107880	II
Butyrolactone	96480	I
Caprolactam	105602	II
Carbaryl	63252	V
Carbazole	86748	V

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Carbon disulfide	75150	IV
Carbon tetrabromide	558134	II
Carbon tetrachloride	56235	I
Carbon tetrafluoride	75730	II
Chloral	75876	II
Chloroacetic acid	79118	II
Chloroacetophenone (2-)	532274	I
Chloroaniline (p-)	106478	II
Chlorobenzene	108907	I
2-Chloro-1,3-butadiene (Chloroprene)	126998	II
Chlorodifluoroethane	25497294	V
Chlorodifluoromethane	75456	I
Chloroform	67663	I
Chloronaphthalene	25586430	IV
Chloronitrobenzene (m-)	121733	I
Chloronitrobenzene (o-)	88733	I
Chloronitrobenzene (p-)	100005	I
Chlorophenol (m-)	108430	II
Chlorophenol (o-)	95578	II
Chlorophenol (p-)	106489	II
Chlorotoluene (m-)	108418	III
Chlorotoluene (o-)	95498	III
Chlorotoluene (p-)	106434	III
Chlorotrifluoromethane	75729	II
Chrysene	218019	V
Cresol and cresylic acid (m-)	108394	III
Cresol and cresylic acid (o-)	95487	III
Cresol and cresylic acid (p-)	106445	III
Cresols and cresylic acids (mixed)	1319773	III
Cumene	98828	I
Cumene hydroperoxide	80159	I
Cyanoacetic acid	372098	II

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Cyclohexane	110827	I
Cyclohexanol	108930	I
Cyclohexanone	108941	I
Cyclohexylamine	108918	III
Cyclooctadienes	29965977	II
Decahydronaphthalene	91178	IV
Diacetoxy-2-Butene (1,4-)	0012	V
Diaminophenol hydrochloride	137097	V
Dibromomethane	74953	V
Dichloroaniline (mixed isomers)	27134276	I
Dichlorobenzene (p-)	106467	I
Dichlorobenzene (m-)	541731	I
Dichlorobenzene (o-)	95501	I
Dichlorobenzidine (3,3'-)	91941	I
Dichlorodifluoromethane	75718	I
Dichloroethane (1,2-) (Ethylene dichloride) (EDC)	107062	I
Dichloroethyl ether (bis(2-chloroethyl)ether)	111444	I
Dichloroethylene (1,2-)	540590	II
Dichlorophenol (2,4-)	120832	III
Dichloropropene (1,3-)	542756	II
Dichlorotetrafluoroethane	1320372	V
Dichloro-1-butene (3,4-)	760236	II
Dichloro-2-butene (1,4-)	764410	V
Diethanolamine (2,2'-Iminodiethanol)	111422	I
Diethyl sulfate	64675	II
Diethylamine	109897	IV
Diethylaniline (2,6-)	579668	V
Diethylene glycol	111466	I
Diethylene glycol dibutyl ether	112732	I
Diethylene glycol diethyl ether	112367	I
Diethylene glycol dimethyl ether	111966	I
Diethylene glycol monobutyl ether acetate	124174	I

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Diethylene glycol monobutyl ether	112345	I
Diethylene glycol monoethyl ether acetate	112152	I
Diethylene glycol monoethyl ether	111900	I
Diethylene glycol monohexyl ether	112594	V
Diethylene glycol monomethyl ether acetate	629389	V
Diethylene glycol monomethyl ether	111773	I
Dihydroxybenzoic acid (Resorcylic acid)	27138574	V
Dimethylbenzidine (3,3'-)	119937	II
Dimethyl ether	115106	IV
Dimethylformamide (N,N-)	68122	II
Dimethylhydrazine (1,1-)	57147	II
Dimethyl sulfate	77781	I
Dimethyl terephthalate	120616	II
Dimethylamine	124403	IV
Dimethylaminoethanol (2-)	108010	I
Dimethylaniline (N,N')	121697	III
Dinitrobenzenes (NOS) <sup>c</sup>	25154545	I
Dinitrophenol (2,4-)	51285	III
Dinitrotoluene (2,4-)	121142	III
Dioxane (1,4-) (1,4-Diethyleneoxide)	123911	I
Dioxolane (1,3-)	646060	I
Diphenyl methane	101815	I
Diphenyl oxide	101848	I
Diphenyl thiourea	102089	III
Diphenylamine	122394	III
Dipropylene glycol	110985	I
Di-o-tolylguanidine	97392	III
Dodecanedioic acid	693232	I
Dodecyl benzene (branched)	123013	V
Dodecyl phenol (branched)	121158585	V
Dodecylaniline	28675174	V
Dodecylbenzene (n-)	121013	I



Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Dodecylphenol	27193868	III
Epichlorohydrin (1-chloro-2,3-epoxypropane)	106898	I
Ethanolamine	141435	I
Ethyl acrylate	140885	II
Ethylbenzene	100414	I
Ethyl chloride (Chloroethane)	75003	IV
Ethyl chloroacetate	105395	II
Ethylamine	75047	V
Ethylaniline (N-)	103695	III
Ethylaniline (o-)	578541	III
Ethylcellulose	9004573	V
Ethylcyanoacetate	105566	V
Ethylene carbonate	96491	I
Ethylene dibromide (Dibromoethane)	106934	I
Ethylene glycol	107211	I
Ethylene glycol diacetate	111557	I
Ethylene glycol dibutyl ether	112481	V
Ethylene glycol diethyl ether (1,2-diethoxyethane)	629141	I
Ethylene glycol dimethyl ether	110714	I
Ethylene glycol monoacetate	542596	V
Ethylene glycol monobutyl ether acetate	112072	I
Ethylene glycol monobutyl ether	111762	I
Ethylene glycol monoethyl ether acetate	111159	I
Ethylene glycol monoethyl ether	110805	I
Ethylene glycol monohexyl ether	112254	V
Ethylene glycol monomethyl ether acetate	110496	I
Ethylene glycol monomethyl ether	109864	I
Ethylene glycol monoethyl ether	002	V
Ethylene glycol monophenyl ether	122996	I
Ethylene glycol monopropyl ether	2807309	I
Ethylene oxide	75218	I
Ethylenediamine	107153	II

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Ethylenediamine tetraacetic acid	60004	V
Ethylenimine (Aziridine)	151564	II
Ethylhexyl acrylate (2-isomer)	103117	II
Fluoranthene	206440	V
Formaldehyde	50000	I
Formamide	75127	II
Formic acid	64186	II
Fumaric acid	110178	I
Glutaraldehyde	111308	IV
Glyceraldehyde	367475	V
Glycerol	56815	II
Glycine	56406	II
Glyoxal	107222	II
Hexachlorobenzene	118741	II
Hexachlorobutadiene	87683	II
Hexachloroethane	67721	II
Hexadiene (1,4-)	592450	II
Hexamethylenetetramine	100970	I
Hexane	110543	V
Hexanetriol (1,2,6-)	106694	IV
Hydroquinone	123319	I
Hydroxyadipaldehyde	141311	V
Isobutyl acrylate	106638	V
Isobutylene	115117	V
Isophorone	78591	IV
Isophorone nitrile	0017	V
Isophthalic acid	121915	III
Isopropylphenol	25168063	III
Linear alkylbenzene	— <sup>d</sup>	I
Maleic anhydride	108316	I
Maleic hydrazide	123331	I

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Malic acid	6915157	I
Metanilic acid	121471	I
Methacrylic acid	79414	V
Methanol	67561	IV
Methionine	63683	I
Methyl acetate	79209	IV
Methyl acrylate	96333	V
Methyl bromide (Bromomethane)	74839	IV
Methyl chloride (Chloromethane)	74873	IV
Methyl ethyl ketone (2-butanone)	78933	V
Methyl formate	107313	II
Methyl hydrazine	60344	IV
Methyl isobutyl carbinol	108112	IV
Methyl isobutyl ketone (Hexone)	108101	IV
Methyl isocyanate	624839	IV
Methyl mercaptan	74931	IV
Methyl methacrylate	80626	IV
Methyl phenyl carbinol	98851	II
Methyl tert-butyl ether	1634044	V
Methylamine	74895	IV
Methylaniline (N-)	100618	III
Methylcyclohexane	108872	III
Methylcyclohexanol	25639423	V
Methylcyclohexanone	1331222	III
Methylene chloride (Dichloromethane)	75092	I
Methylene dianiline (4,4'-isomer)	101779	I
Methylene diphenyl diisocyanate (4,4'-) (MDI)	101688	III
Methylionones (a-)	79696	V
Methylpentynol	77758	V
Methylstyrene (a-)	98839	I
Naphthalene	91203	IV
Naphthalene sulfonic acid (a-)	85472	IV

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Naphthalene sulfonic acid (b-)	120183	IV
Naphthol (a-)	90153	IV
Naphthol (b-)	135193	IV
Naphtholsulfonic acid (1-)	567180	V
Naphthylamine sulfonic acid (1,4-)	84866	V
Naphthylamine sulfonic acid (2,1-)	81163	V
Naphthylamine (1-)	134327	V
Naphthylamine (2-)	91598	V
Nitroaniline (m-)	99092	II
Nitroaniline (o-)	88744	I
Nitroanisole (o-)	91236	III
Nitroanisole (p-)	100174	III
Nitrobenzene	98953	I
Nitronaphthalene (1-)	86577	IV
Nitrophenol (p-)	100027	III
Nitrophenol (o-)	88755	III
Nitropropane (2-)	79469	II
Nitrotoluene (all isomers)	1321126	III
Nitrotoluene (o-)	88722	III
Nitrotoluene (m-)	99081	III
Nitrotoluene (p-)	99990	III
Nitroxylyene	25168041	V
Nonylbenzene (branched)	1081772	V
Nonylphenol	25154523	V
Octene-1	111660	I
Octylphenol	27193288	III
Paraformaldehyde	30525894	I
Paraldehyde	123637	II
Pentachlorophenol	87865	III
Pentaerythritol	115775	I
Peracetic acid	79210	II
Perchloromethyl mercaptan	594423	IV

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Phenanthrene	85018	V
Phenetidine (p-)	156434	III
Phenol	108952	III
Phenolphthalein	77098	III
Phenolsulfonic acids (all isomers)	1333397	III
Phenyl anthranilic acid (all isomers)	91407	III
Phenylenediamine (p-)	106503	I
Phloroglucinol	108736	III
Phosgene	75445	IV
Phthalic acid	88993	III
Phthalic anhydride	85449	III
Phthalimide	85416	III
Phthalonitrile	91156	III
Picoline (b-)	108996	II
Piperazine	110850	I
Propiolactone (beta-)	57578	I
Propionaldehyde	123386	IV
Propionic acid	79094	I
Propylene carbonate	108327	V
Propylene dichloride (1,2-dichloropropane)	78875	IV
Propylene glycol	57556	I
Propylene glycol monomethyl ether	107982	I
Propylene oxide	75569	I
Pyrene	129000	V
Pyridine	110861	II
p-tert-Butyl toluene	98511	III
Quinone	106514	III
Resorcinol	108463	I
Salicylic acid	69727	III
Sodium methoxide	124414	IV

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Sodium phenate	139026	III
Stilbene	588590	III
Styrene	100425	I
Succinic acid	110156	I
Succinonitrile	110612	I
Sulfanilic acid	121573	III
Sulfolane	126330	II
Tartaric acid	526830	I
Terephthalic acid	100210	II
Tetrabromophthalic anhydride	632791	III
Tetrachlorobenzene (1,2,4,5-)	95943	I
Tetrachloroethane (1,1,2,2-)	79345	II
Tetrachloroethylene (Perchloroethylene)	127184	I
Tetrachlorophthalic anhydride	117088	III
Tetraethyl lead	78002	IV
Tetraethylene glycol	112607	I
Tetraethylenepentamine	112572	V
Tetrahydrofuran	109999	I
Tetrahydronaphthalene	119642	IV
Tetrahydrophthalic anhydride	85438	II
Tetramethylenediamine	110601	II
Tetramethylethylenediamine	110189	V
Tetramethyllead	75741	V
Toluene	108883	I
Toluene 2,4 diamine	95807	II
Toluene 2,4 diisocyanate	584849	II
Toluene diisocyanates (mixture)	26471625	II
Toluene sulfonic acids	104154	III
Toluenesulfonyl chloride	98599	III
Toluidine (o-)	95534	II
Trichloroaniline (2,4,6-)	634935	III
Trichlorobenzene (1,2,3-)	87616	V

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Trichlorobenzene (1,2,4-)	120821	I
Trichloroethane (1,1,1-)	71556	II
Trichloroethane (1,1,2-) (Vinyl trichloride)	79005	II
Trichloroethylene	79016	I
Trichlorofluoromethane	75694	I
Trichlorophenol (2,4,5-)	95954	I
(1,1,2-) Trichloro (1,2,2-) trifluoroethane	76131	I
Triethanolamine	102716	I
Triethylamine	121448	IV
Triethylene glycol	112276	I
Triethylene glycol dimethyl ether	112492	I
Triethylene glycol monoethyl ether	112505	V
Triethylene glycol monomethyl ether	112356	I
Trimethylamine	75503	IV
Trimethylcyclohexanol	933482	IV
Trimethylcyclohexanone	2408379	IV
Trimethylcyclohexylamine	34216347	V
Trimethylolpropane	77996	I
Trimethylpentane (2,2,4-)	540841	V
Tripropylene glycol	24800440	V
Vinyl acetate	108054	II
Vinyl chloride (Chloroethylene)	75014	I
Vinyl toluene	25013154	III
Vinylcyclohexene (4-)	100403	II
Vinylidene chloride (1,1-dichloroethylene)	75354	II
Vinyl(N-)-pyrrolidone(2-)	88120	V
Xanthates	140896	V
Xylene sulfonic acid	25321419	III
Xylenes (NOS) <sup>c</sup>	1330207	I
Xylene (m-)	108383	I
Xylene (o-)	95476	I
Xylene (p-)	106423	I

Chemical Name <sup>a</sup>	CAS Number <sup>b</sup>	Group
Xylenols (Mixed)	1300716	V
Xylidene	1300738	III

<sup>a</sup>Isomer means all structural arrangements for the same number of atoms of each element and does not mean salts, esters, or derivatives.

<sup>b</sup>CAS Number = Chemical Abstract Service number.

<sup>c</sup>NOS = not otherwise specified.

<sup>d</sup>No CAS number assigned.



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**APPENDIX G**

**ORGANIC HAP SUBJECT TO HON STANDARDS (SUBPART H)**



**TABLE 2 TO SUBPART F - ORGANIC HAZARDOUS AIR POLLUTANTS**

Chemical Name <sup>a,b</sup>	CAS Number <sup>c</sup>
Acenaphthene	83329
Acetaldehyde	75070
Acetamide	60355
Acetonitrile	75058
Acetophenone	98862
Acrolein	107028
Acrylamide	79061
Acrylic acid	79107
Acrylonitrile	107131
Alizarin	72480
Allyl chloride	107051
Aniline	62533
Anisidine (o-)	90040
Anthracene	120127
Anthraquinone	84651
Benzene	71432
Benzotrichloride	98077
Benzyl chloride	100447
Biphenyl	92524
Bis(chloromethyl)ether	542881
Bromoform	75252
Bromonaphthalene	27497514
Butadiene (1,3-)	106990
Carbon disulfide	75150
Carbon tetrachloride	56235
Chloroacetic acid	79118
Chloroacetophenone (2-)	532274
Chlorobenzene	108907

Chemical Name <sup>a,b</sup>	CAS Number <sup>c</sup>
2-Chloro-,1,3-butadiene (Chloroprene)	126998
Chloroform	67663
Chloronaphthalene	25586430
Chrysene	218019
Cresols and cresylic acids (mixed)	1319773
Cresol and cresylic acid (o-)	95487
Cresol and cresylic acid (m-)	108394
Cresol and cresylic acid (p-)	106445
Cumene	98828
Dichlorobenzene (p-)	106467
Dichlorobenzidine (3,3'-)	91941
Dichloroethane (1,2-) (Ethylene dichloride) (EDC)	107062
Dichloroethylether (Bis(2-chloroethyl)ether)	111444
Dichloropropene (1,3-)	542756
Diethanolamine (2,2'-Iminodiethanol)	111422
Dimethylaniline (N,N-)	121697
Diethyl sulfate	64675
Dimethylbenzidine (3,3'-)	119937
Dimethylformamide (N,N-)	68122
Dimethylhydrazine (1,1-)	58147
Dimethylphthalate	131113
Dimethylsulfate	77781
Dinitrophenol (2,4-)	51285
Dinitrotoluene (2,4-)	121142
Dioxane (1,4-) (1,4-Diethyleneoxide)	123911
1,2-Diphenylhydrazine	122667
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	106898
Ethyl acrylate	140885
Ethylbenzene	100414
Ethyl chloride (Chloroethane)	75003

Chemical Name <sup>a,b</sup>	CAS Number <sup>c</sup>
Ethylene dibromide (Dibromoethane)	106934
Ethylene glycol	107211
Ethylene oxide	75218
Ethylidene dichloride (1,1-Dichloroethane)	75343
Fluoranthene	206440
Formaldehyde	50000
Glycol ethers <sup>d</sup>	
Hexachlorobenzene	118741
Hexachlorobutadiene	87683
Hexachloroethane	67721
Hexane	110543
Hydroquinone	123319
Isophorone	78591
Maleic anhydride	108316
Methanol	67561
Methylbromide (Bromomethane)	74839
Methylchloride (Chloromethane)	74873
Methyl ethyl ketone (2-Butanone)	78933
Methyl hydrazine	60344
Methyl isobutyl ketone (Hexone)	108101
Methyl isocyanate	624839
Methyl methacrylate	80626
Methyl tert-butyl ether	1634044
Methylene chloride (Dichloromethane)	75092
Methylene diphenyl diisocyanate (4,4'-) (MDI)	101688
Methylenedianiline (4,4'-)	101779
Naphthalene	91203
Naphthalene sulfonic acid ( $\alpha$ )	85472
Naphthalene sulfonic acid ( $\beta$ )	120183
Naphthol ( $\alpha$ )	90153
Naphthol ( $\beta$ )	135193

Chemical Name <sup>a,b</sup>	CAS Number <sup>c</sup>
Naphtholsulfonic acid (1-)	567180
Naphthylamine sulfonic acid (1,4-)	84866
Naphthylamine sulfonic acid (2,1-)	81163
Naphthylamine (1-)	134327
Naphthylamine (2-)	91598
Nitronaphthalene (1-)	86577
Nitrobenzene	98953
Nitrophenol (p-)	100027
Nitropropane (2-)	79469
Phenanthrene	85018
Phenol	108952
Phenylenediamine (p-)	106503
Phosgene	75445
Phthalic anhydride	85449
Propiolactone (beta-)	57578
Propionaldehyde	123386
Propylene dichloride (1,2-Dichloropropane)	78875
Propylene oxide	75569
Pyrene	129000
Quinone	106514
Styrene	100425
Tetrachloroethane (1,1,2,2-)	79345
Tetrachloroethylene (Perchloroethylene)	127184
Tetrahydronaphthalene	119642
Toluene	108883
Toluene diamine (2,4-)	95807
Toluene diisocyanate (2,4-)	584849
Toluidine (o-)	95534
Trichlorobenzene (1,2,4-)	120821
Trichloroethane (1,1,1-) (Methyl chloroform)	71556
Trichloroethane (1,1,2-) (Vinyl trichloride)	79005

Chemical Name <sup>a,b</sup>	CAS Number <sup>c</sup>
Trichloroethylene	79016
Trichlorophenol (2,4,5-)	95954
Triethylamine	121448
Trimethylpentane (2,2,4-)	540841
Vinyl acetate	108054
Vinyl chloride (Chloroethylene)	75014
Vinylidene chloride (1,1-Dichloroethylene)	75354
Xylenes (NOS)	1330207
Xylene (m-)	108383
Xylene (o-)	95476
Xylene (p-)	106423

<sup>a</sup> For all Listings above containing the word "Compounds," the following applies: Unless otherwise specified, these listings are defined as including any unique chemical substance that contains the named chemical (i.e., antimony, arsenic) as part of that chemical's infrastructure.

<sup>b</sup> Isomer means all structural arrangements for the same number of atoms of each element and does not mean salts, esters, or derivatives.

<sup>c</sup> CAS Number = Chemical Abstract Service number.

<sup>d</sup> Includes mono- and di- ethers of ethylene glycol, diethylene glycol, and triethylene glycol  
 $R-(OCH_2CH_2)_n-OR'$

where

n = 1, 2, or 3;

R = alkyl or aryl groups; and

R' = R, H, or groups which, when removed, yield glycol ethers with the structure:  $R-(OCH_2CH_2)_n-OH$

Polymers are excluded from the glycol category.



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**APPENDIX H**

**MANUFACTURING PROCESSES AND ORGANIC HAP  
SUBJECT TO HON STANDARDS (SUBPART I)**



## MANUFACTURING PROCESSES AND ORGANIC HAP SUBJECT TO HON STANDARDS (SUBPART I)

### Production Process(es)

### Regulated Emissions

Styrene-butadiene rubber production

Butadiene and styrene

Polybutadiene rubber production

Butadiene

The processes producing the agricultural chemicals:

Butadiene, carbon tetrachloride, methylene chloride, and ethylene dichloride

Captafol™

Captan™

Chlorothalonil

Dacthal

Tordon™ acid

Processes producing the polymers/resins or other chemical products:

Carbon tetrachloride, methylene chloride, tetrachloroethylene, chloroform, and ethylene dichloride

Hypalon™

Oxybisphenoxarsine/

1,3-diisocyanate (OBPA™)

Polycarbonates

Polysulfide rubber

Chlorinated paraffins

Symmetrical tetrachloropyridine

Pharmaceutical production processes using carbon tetrachloride or methylene chloride

Carbon tetrachloride and methylene chloride

**Production Process(es)**

**Regulated Emissions**

Processes producing the polymers/resins or other chemical products:

Butadiene

Methylmethacrylate-butadiene-

styrene resins (MBS)

Butadiene-furfural copolymer

Methylmethacrylate-acrylonitrile-

butadiene-styrene (MABS) resins

Ethylidene norbornene