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# COURSE #380

# INSPECTION TECHNIQUES FOR FUGITIVE VOC EMISSION SOURCES

## Student Manual

EPA 340/1-90-026a
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# Course Module #380

# Inspection Techniques For Fugitive VOC Emission Sources

## Student Manual

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# LECTURE 1

## INTRODUCTION

Upon completion of this course, you will be able to conduct complete and effective Level 2 inspections of air pollution sources subject to fugitive VOC leak detection regulations. Such inspections involve two separate but equally important activities: (1) evaluation of their data acquisition techniques, and (2) evaluation of the leak detection program records and reports.

One of the goals of this course is to enable you, as a field inspector, to determine if plant personnel are fully complying with the U.S. EPA Method 21 field monitoring techniques and if they are adequately identifying leaking equipment in VOC service. Inspectors must be thoroughly familiar with VOC detector operating principles, calibration procedures, operating problems, and leak screening techniques in order to confirm that the data acquisition portion of the leak detection programs are in compliance.

Another goal of this course is to assist inspectors in evaluating the often complicated and voluminous records which are an essential part of the leak detection programs. This is an especially important portion of the course since most violations concern deficiencies in this area. It should also be noted that fugitive VOC regulations are complicated and are not uniform from one category to another. It is imperative that the inspector be thoroughly knowledgeable of the source specific regulations before conducting an inspection.

After completing this course, you should be able to:

1. Determine which source categories are covered by Federal and State fugitive VOC regulations.

2. Find the applicable Federal and State regulations.

3. Understand the overall approach of using both equipment standards and leak detection and repair standards to achieve reductions in fugitive VOC emissions.

4. Determine if a source is complying with all the requirements of component identification, component marking, equipment design, monitoring, repair, recordkeeping, and reporting.

5. Understand the alternate standards.

6. List the VOC analyzer performance specifications required by U.S. EPA Method 21.

7. Describe the basic operating principles of flame ionization analyzers, photoionization analyzers, and catalytic combustion analyzers.

8. Select the proper VOC detector for a given VOC compound using published response factor tables.

9. Describe why VOC analyzers used for leak detection do not provide a direct indication of emission concentration and emission rate.

10. Evaluate source personnel's calibration procedures and records.

11. Evaluate field monitoring procedures used by source personnel to detect leaks from pumps, valves, compressors, safety relief, values and other equipment in VOC service.

# LECTURE 2

## INTRODUCTION TO FUGITIVE EMISSION REGULATIONS

**Notes**

The purpose of this lecture is to provide an overview of what the equipment leak standards cover in terms of types of emissions, sources regulated, and equipment regulated. After the completion of this lecture, you should be able to identify and locate the Federal regulations for equipment leaks in terms of the equipment and source categories covered; to describe the various standards applicable to each type of equipment covered; and to describe the differences between the standards. Slide 2-1

### OVERVIEW

Equipment leak standards are designed to reduce volatile organic compound (VOC) or volatile hazardous air pollutants (VHAP) emissions that occur when certain process equipment leak. For example, pumps have seals designed to keep the process fluid in the pump. These seals may fail, thereby leaking to the environment the process fluid. These standards are designed to reduce or eliminate emissions that occur as a result of such leaks. Slide 2-2

Equipment leak standards for VOC emissions are found in both Federal and State regulations. Equipment leak standards for VHAP emissions are found in Federal regulations only. Slide 2-3

### Federal Regulations

The Federal regulations are either new source performance standards (NSPSs) or national emission standards for hazardous air pollutants (NESHAPs). NSPSs are implemented under Section 111 of the Clean Air Act. They apply to newly constructed stationary sources. Newly constructed sources are those that are constructed after the date an NSPS is proposed in the Federal Register. In addition, existing stationary sources (those that exist prior to the proposal date of an NSPS) can become subject to an NSPS if they are modified or reconstructed after the proposal date of the NSPS. NESHAPs are implemented under Section 112 of the Clean Air Act. They apply to both new and existing stationary sources.

An overriding purpose and long range goal of an NSPS is to minimize emissions at all new and modified sources, wherever they are located, in order to prevent new pollution problems from developing and to enhance air quality as the Nation's industrial base is replaced. In addition to achieving emissions reductions, standards of performance have other benefits Standards of performance establish a degree of national uniformity to air pollution standards, and, therefore, preclude situations in which some States may attract new industries as a result of having relaxed standards relative to other States. NESHAPs are developed to control pollutants that are hazardous because they are carcinogens or cause other serious diseases.

<u>State Regulations</u>

State regulation of equipment leaks for VOC emissions are contained in State implementation plans (SIPs) and apply to existing stationary sources. SIPs are plans that provide for the implementation, maintenance, and enforcement of national primary and national secondary ambient air quality standards. Promulgation of an NSPS requires States to establish standards of performance for existing sources in the same industry if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112).

## WHY REGULATE VOCS AND VHAPS?

Volatile organic compounds, along with nitrogen oxides ($NO_x$) and sunlight, contribute to produce ozone. Ozone is one of the criteria pollutants for which national ambient air quality standards (NAAQS) exist under Section 109 of the Clean Air Act. Nonattainment of the ozone NAAQS is a serious problem in the United States. Reduction of ozone formation can be accomplished by reducing emissions of VOC and $NO_x$ or their exposure to sunlight. Controlling VOC is easier than $NO_x$ and, of course, easier than controlling sunlight. Slide 2-4

Note, however, that NSPSs are not directly designed to achieve the ambient air quality goals. As noted earlier, an overriding purpose and long range goal of an NSPS is to minimize emissions at all new and modified sources, wherever they are located, in order to prevent new pollution problems from developing and to enhance air quality as the Nation's industrial base is replaced. Equipment leak standards will limit

VOC emissions from all new, modified, or reconstructed process units and will result in emission reductions well into the future. Even though these reductions may not bear directly on attainment or nonattainment of NAAQS for ozone, they will make room for future industrial growth while preventing future air quality problems. The NSPS complements the PSD (prevention of significant deterioration) and nonattainment rules as a means of achieving and maintaining the NAAQS, while on a broader basis they prevent new sources from making air pollution problems worse regardless of the existing quality of ambient air.

Control of VHAP is implemented because such air pollutants are a direct threat to human health. Benzene and vinyl chloride, the two specific VHAP pollutants currently being regulated by equipment leak standards, are both known human carcinogens.

In Slide 2-5, estimates of VOC emissions from selected source categories covered by these standards are presented. The emission estimates shown for each of the source categories reflect estimates of uncontrolled emissions from projected newly constructed, modified, and reconstructed facilities over a five-year period (typically from 1980 to 1985). For example, EPA estimated that approximately 830 newly constructed, modified, or reconstructed facilities would be affected by the SOCMI equipment leak standards by 1985. If left uncontrolled, fugitive VOC emissions from these 830 facilities would be approximately 91,500 tons per year. These numbers represent large quantities of organic material being emitted into the atmosphere where ozone is formed. Slide 2-5

Slide 2-6 shows the emission that would be emitted to the atmosphere after control. For example, the 830 SOCMI facilities would emit approximately 41,000 tons of VOC from fugitive emission sources after control. Thus, compliance with the equipment leak standards would reduce fugitive emissions from these SOCMI sources by approximately 55 percent. For the other sources shown, the emission reduction percentages are approximately 63 percent for petroleum refineries and 68 percent for benzene sources. Slide 2-6

## REGULATED SOURCE CATEGORIES

Slide 2-7

As of August 1, 1990, three source categories are regulated by NSPSs for equipment leaks of VOC. These three source categories are:

1. The Synthetic Organic Chemical Manufacturing Industry (SOCMI);

2. Petroleum refineries; and

3. On-shore natural gas processing plants.

It is anticipated that equipment leak standards for VOC from certain types of polymer manufacturing plants will have been promulgated in October, 1990. Polymer manufacturing plants that would be affected are those that produce polypropylene, polyethylene, polystyrene (crystal, impact and expandable), and copolymers of these three major polymer types.

**Synthetic Organic Chemical Manufacturing Industry (SOCMI)**

The SOCMI is a broad source category, covering plants that produce many types of organic chemicals. The EPA identified a list of organic chemicals produced in a segment of this industry. The products of this industry segment are derived from about ten basic petrochemical feedstocks and are used as feedstocks in a number of synthetic products industries. Organic chemicals produced in this segment of SOCMI include acetone, methyl methacrylate, toluene, and glycine. The organic chemicals in the segment of the SOCMI covered by equipment leak standards are listed in §60.489 of the SOCMI equipment leak standard.

More formally, the SOCMI equipment leak standards apply to affected facilities in the synthetic organic chemicals manufacturing industry, which is defined as the industry that produces, as intermediates or final products, one or more of the chemicals listed in §60.489.

**Petroleum Refineries**

Petroleum refineries are defined in the equipment leak standard applicable to them as:

> **" ... any facility engaged in producing gasoline, kerosene, distillate fuel oils, residual oils, lubricants, or other products through the distillation of petroleum, or through the redistillation, cracking, or reforming of unfinished petroleum derivatives."**

## On-Shore Natural Gas Processing Plants

Natural gas processing plants are defined as:

" ... any processing site engaged in the extraction of natural gas liquids from field gas, fractionation of mixed natural gas liquids to natural gas products, or both."

"On-shore" means all facilities except those that are located in the territorial seas or on the outer continental shelf.

## Benzene

Unlike the NSPS VOC equipment leak standards that apply to specifically defined source categories, the benzene equipment leak standards apply to all sources except coke by-product plants. [Note: The specific applicability of this standard and the others are discussed later in the lecture.]

## Vinyl Chloride

The vinyl chloride equipment leak standard identifies specific sources subject to the standard. These sources are ethylene dichloride, vinyl chloride, and polyvinyl chloride plants.

## REGULATED EQUIPMENT

Slide 2-8

There is a general set of equipment covered by all of the equipment leak standards. These are listed in Slide 2-8. Product accumulator vessels are only covered by the equipment leak standards for benzene. The vinyl chloride fugitive emission standards also cover additional sources (loading and unloading lines, agitators, slip gauges, opening of equipment, and in process wastewater). Except for agitators, the emissions from these sources, however, are generally 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. The following paragraphs describe the components covered by the equipment leak standards.

## Pumps

Pumps are used extensively in the SOCMI and petroleum refinery industry, as well as in natural gas processing plants, for the movement of organic fluids. The most widely used pump is the centrifugal pump.

Other types of pumps may also be used, such as the positive-displacement, reciprocating and rotary action, and special canned and diaphragm pumps.

Chemicals transferred by pumps can leak at the point of contact between the moving shaft and stationary casing. Consequently, all pumps except the sealless type (canned-motor and diaphragm) require a seal at the point where the shaft penetrates the housing in order to isolate the pump's interior from the atmosphere. Packed and mechanical seals are most commonly used.

Packed seals can be used on both reciprocating and rotary action types of 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 2-1. To prevent buildup of frictional heat, lubrication is required. A sufficient amount of 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. Degradation of this packing and/or the shaft seal face after a period of usage can be expected to eventually result in leakage of organic compounds to the atmosphere.

Mechanical seals are limited in application to pumps with rotating shafts and can be further categorized as single and dual mechanical seals. There are many variations to the basic design of mechanical seals, but all have a lapped seal face between a stationary element and a rotating seal sing. In a single mechanical seal application (see Figure 2-2 for an illustration), the rotating-seal ring and stationary element faces are lapped to a very high degree of flatness to maintain contact throughout their entire mutual surface area. 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 packing, the faces must be lubricated; however, because of the seal's construction, much less lubrication is needed. There are many variations to the basic design, but all have the lapped seal face between a stationary element and a rotating seal ring. Again, if the seal becomes imperfect due to wear, the organic compounds being pumped can leak between the seal faces and can be emitted to the atmosphere.

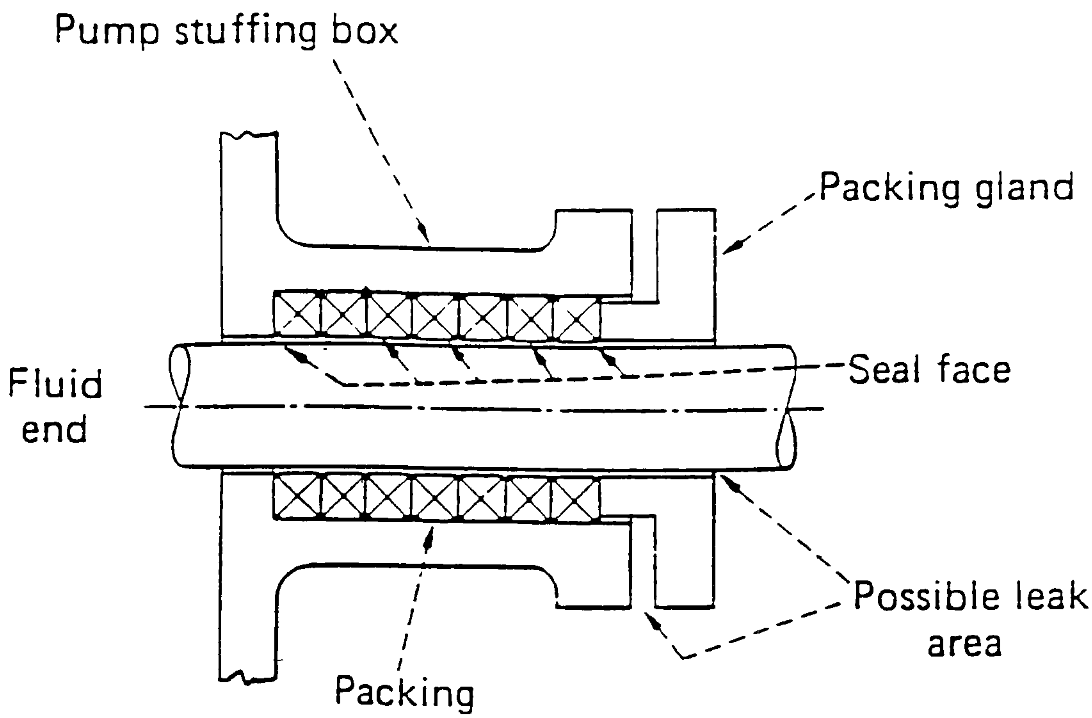


Figure 2-1. Diagram of Simple Packed Seal

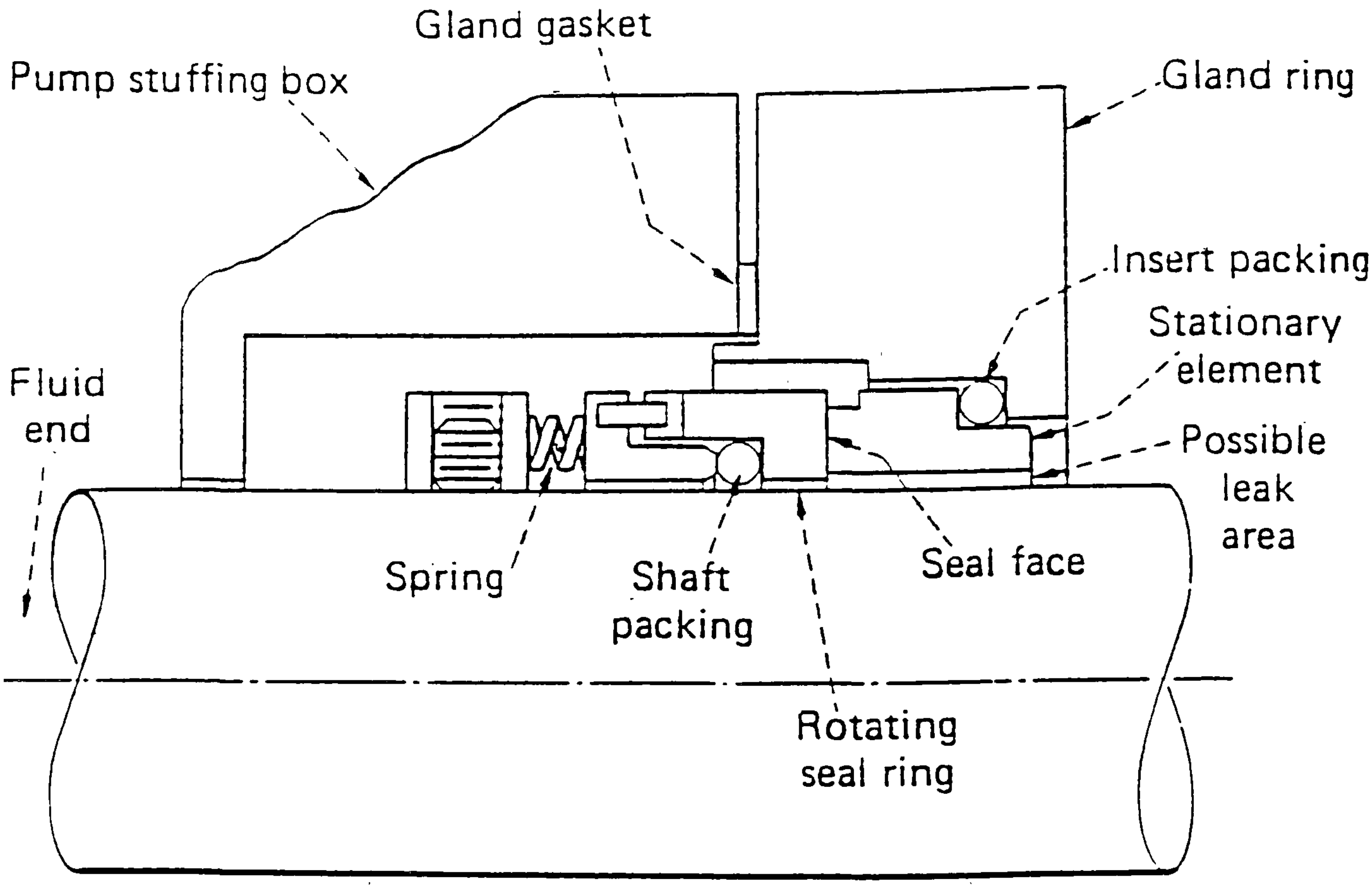


Figure 2-2. Diagram of Basic Single Mechanical Seal

In a dual mechanical seal application (see Figure 2-3 for an illustration), two seals can be arranged back-to-back or in tandem. In the back-to-back arrangement, the two seals provide a closed cavity between them. 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 in this arrangement, the heat transfer and seal life characteristics 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 as well as with the environment.

In a tandem dual mechanical seal arrangement, the seals face the same direction. 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. However, the barrier fluid 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 has leaked into the seal cavity will also be transferred to the reservoir. At the reservoir, the process liquid that has leaked into the seal cavity will also 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 which represents a relatively new development, is the face-to-face arrangement. In this configuration two rotating faces are mated with a common stationary. Barrier fluid may be provided at higher or lower pressures than the stuffing box. As in the tandem arrangement, if the barrier fluid is at a lower pressure than the stuffing box, the barrier fluid reservoir would require venting to a control device.

Another type of pump that has been used is the sealless pump, which includes canned-motor and diaphragm pumps. In the canned-motor pumps (see Figure 2-4), 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 seals are eliminated. Because the process liquid is the bearing lubricant, abrasive solids cannot be tolerated. Canned-motor pumps are being widely used for handling

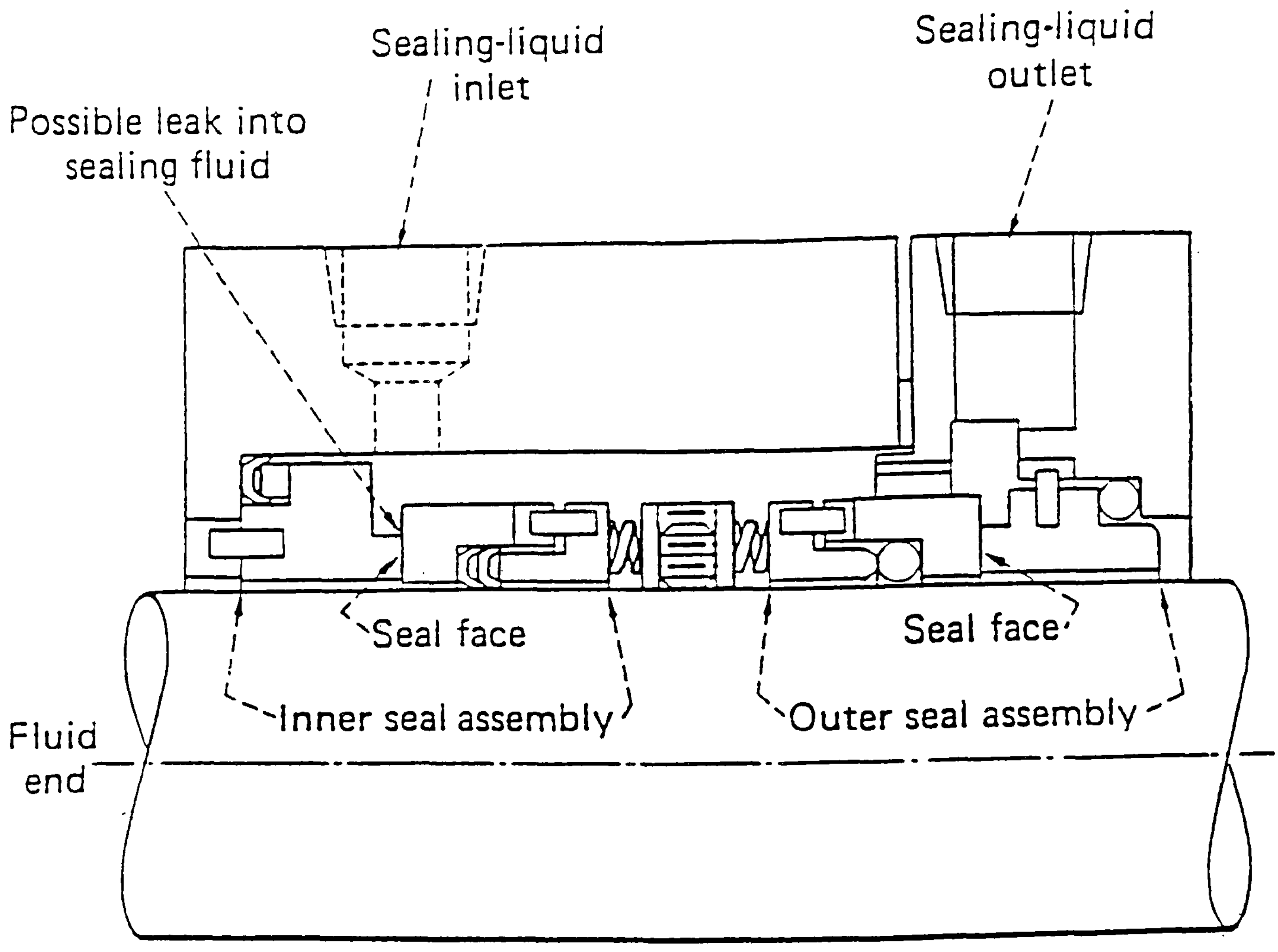


Figure 2-3. Diagram of Double Mechanical Seal

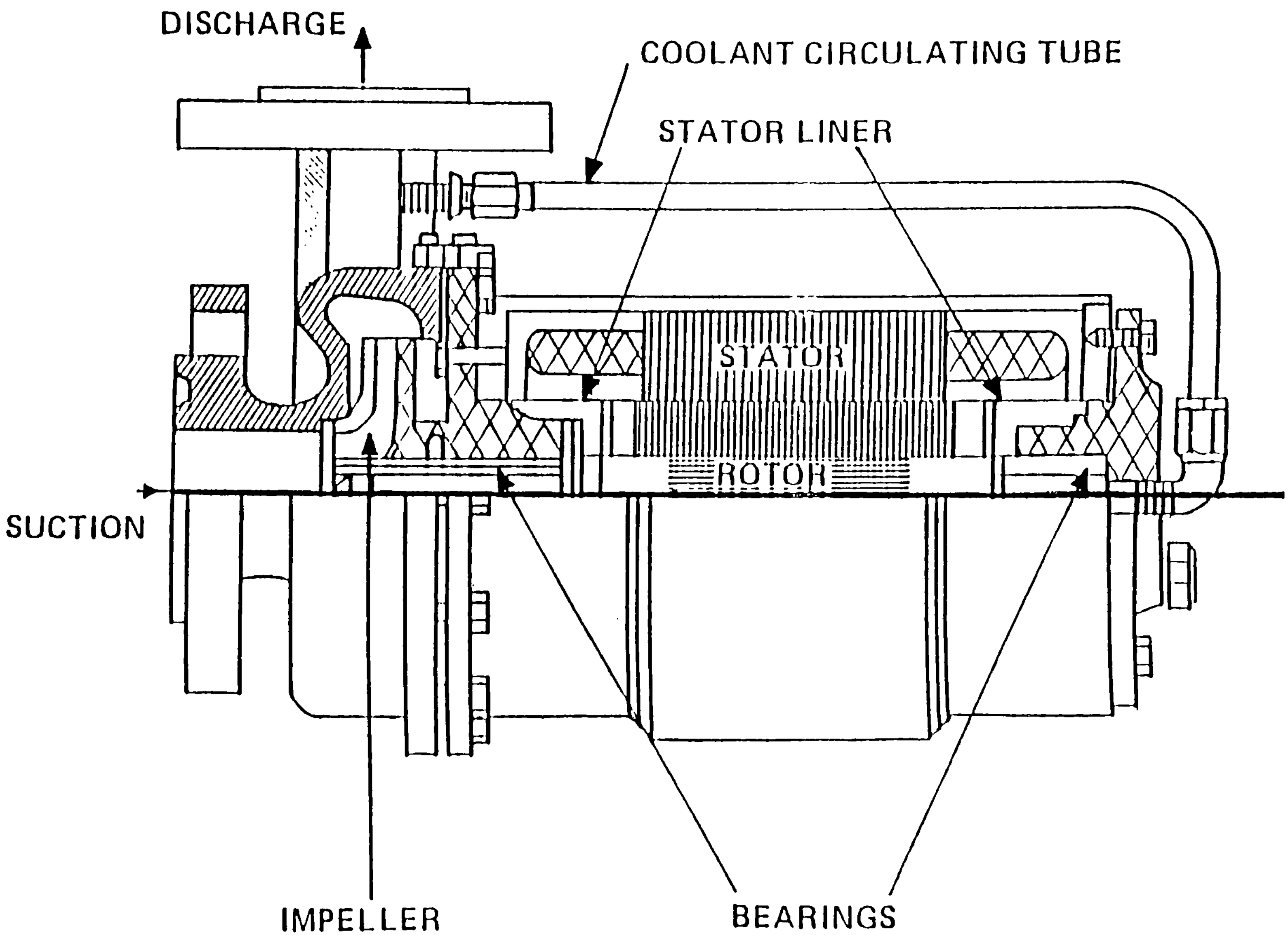


Figure 2-4. Diagram of Seal-less Canned Motor Pump

Notes

organic solvents, organic heat transfer liquids, light oils, as well as many toxic or hazardous liquids, or where leakage is an economic problem.

Diaphragm pumps (see Figure 2-5) perform similarly to piston and plunger pumps. However, the driving member is a flexible diaphragm fabricated of metal, rubber, or plastic. The primary advantage of this arrangement is the elimination of all packing and shaft seals exposed to the process liquid. This is an important asset when hazardous or toxic liquids are handled.

## Compressors

There are three basic types of compressors used in the industries affected by these standards: centrifugal, reciprocating, and rotary. The centrifugal compressor utilizes 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 in a cavity and progressively decreasing the volume of the cavity. Reciprocating compressors usually employ a piston and cylinder arrangement, while rotary compressors utilize rotating elements such as lobed impellers or sliding vanes.

As with pumps, sealing devices are required to prevent leakage from compressors. Rotary shaft seals for compressors may be chosen from several different types: labyrinth, restrictive carbon rings, mechanical contact, and liquid film. Figure 2-6 is an illustration of a liquid-film compressor shaft seal. All of these seal types are leak restriction devices; none of them completely eliminate leakage. Many compressors may be equipped with ports in the seal area to evacuate collected gases.

The labyrinth type of compressor seal is composed of a series of close tolerance, interlocking "teeth" which restrict the flow of gas along the shaft. Many variations in "tooth" design and materials of construction are available. Although labyrinth type seals 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.

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

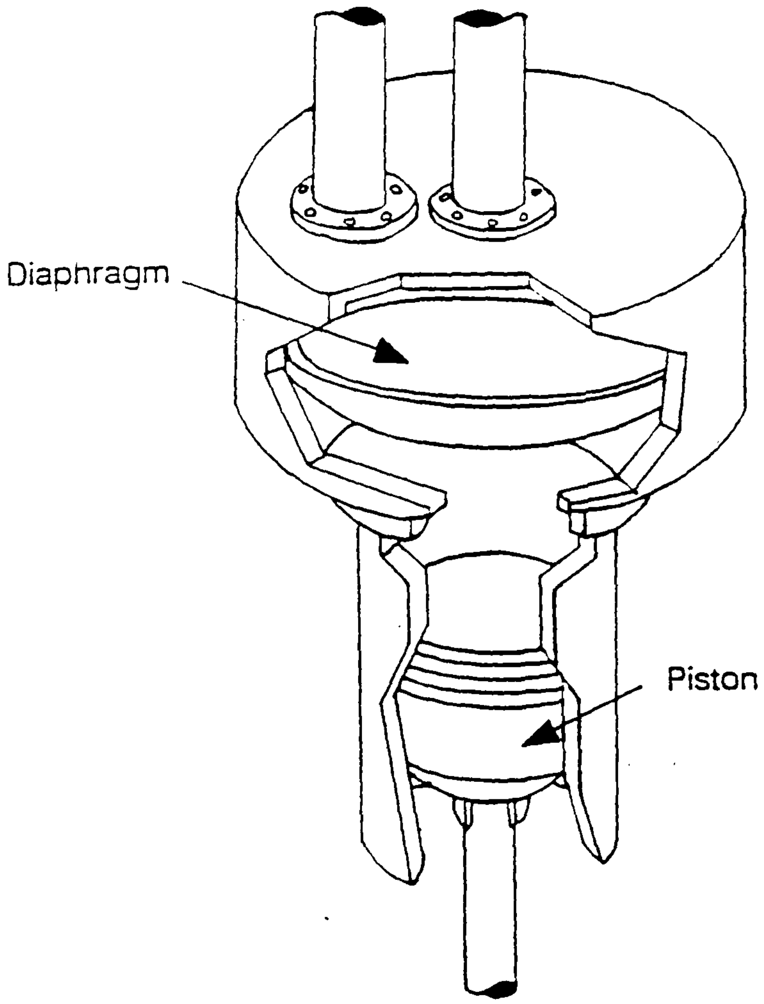


Figure 2-5. Diagram of Diaphragm Pump

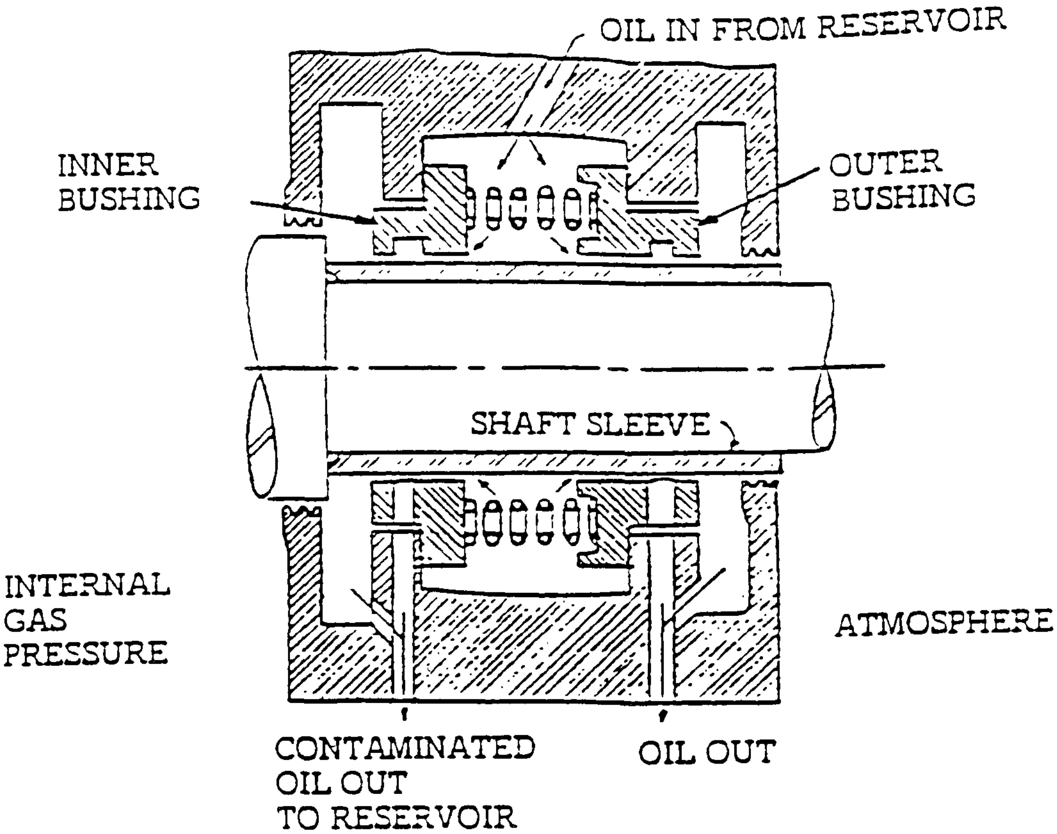


Figure 2-6. Diagram of Liquid-Film Compressor Shaft Seal

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. Oil or another suitable lubricant is supplied to the seal faces. Mechanical seals can achieve the lowest leak rates of the types identified above, but they are not suitable for all processing

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. Because of safety considerations, the area between the compressor seals and the compressor motor (distance piece) is normally enclosed and vented outside of the compressor building. If hydrogen sulfide is present in the gas, then the vented vapors are normally flared.

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

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 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 VOC and VHAP can be released to atmosphere.

## Pressure Relief Devices

Engineering codes require that pressure-relieving devices or systems be used in applications where the process pressure may exceed the maximum allowable working pressure of the vessel. The most common type of pressure-relieving device used is the pressure relief valve. Typically, relief valves are spring-loaded (see Figure 2-7) and designed to open when the process 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 disk on a seat, and the possibility of a leak through this seal makes the pressure relief valve a potential source of VOC and VHAP fugitive emissions. The potential causes of leakage from relief valves are:

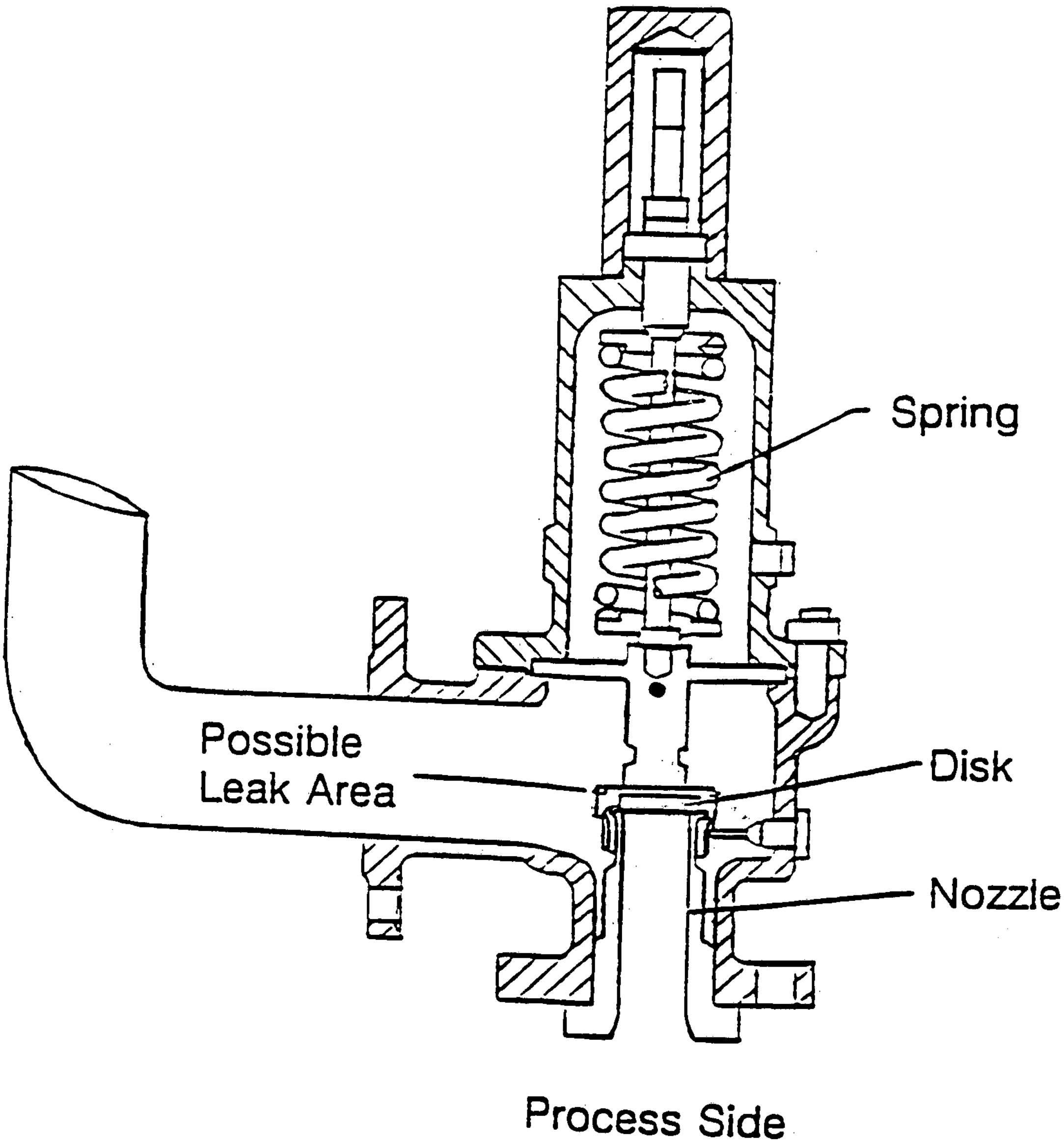


Figure 2-7. Diagram of a Spring-Loaded Relief Valve

"simmering or popping", a condition due to the system pressure being 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.

Rupture disks may also be used in process units (see Figure 2-8). These disks are made of a material that ruptures when a set pressure is exceeded, thus allowing the system to depressurize. The advantage of a rupture disk is that the disk seals tightly ad does not allow any VOC or VHAP to escape from the system under normal operation. However, when the disk does rupture, the system depressurizes until atmospheric conditions are obtained, unless the disk is used in series with a pressure relief valve.

## Sampling Connections

The operation of process units is checked periodically by routine analysis of feedstocks and products. To obtain representative samples for these analyses, sampling lines must first be purged. If this flushing liquid is not returned to the process, it could be drained onto the ground or into a process drain, where it would evaporate and release VOC or VHAP to the atmosphere. Two closed-loop sampling systems are illustrated in Figure 2-9.

## Open-Ended Valves or Lines

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

## Process Valves

One of the most common pieces of equipment in plants affected by these standards is the valve. The types of valves commonly used are control, globe, gate, plug, ball, relief, and check valves (see Figures 2-10 and 2-11). All except the relief valve (which is discussed above) and check valve are activated through a valve stem, which may have either a rotational or linear motion, depending on the specific design. This stem requires a seal to isolate the process fluid inside the valve from

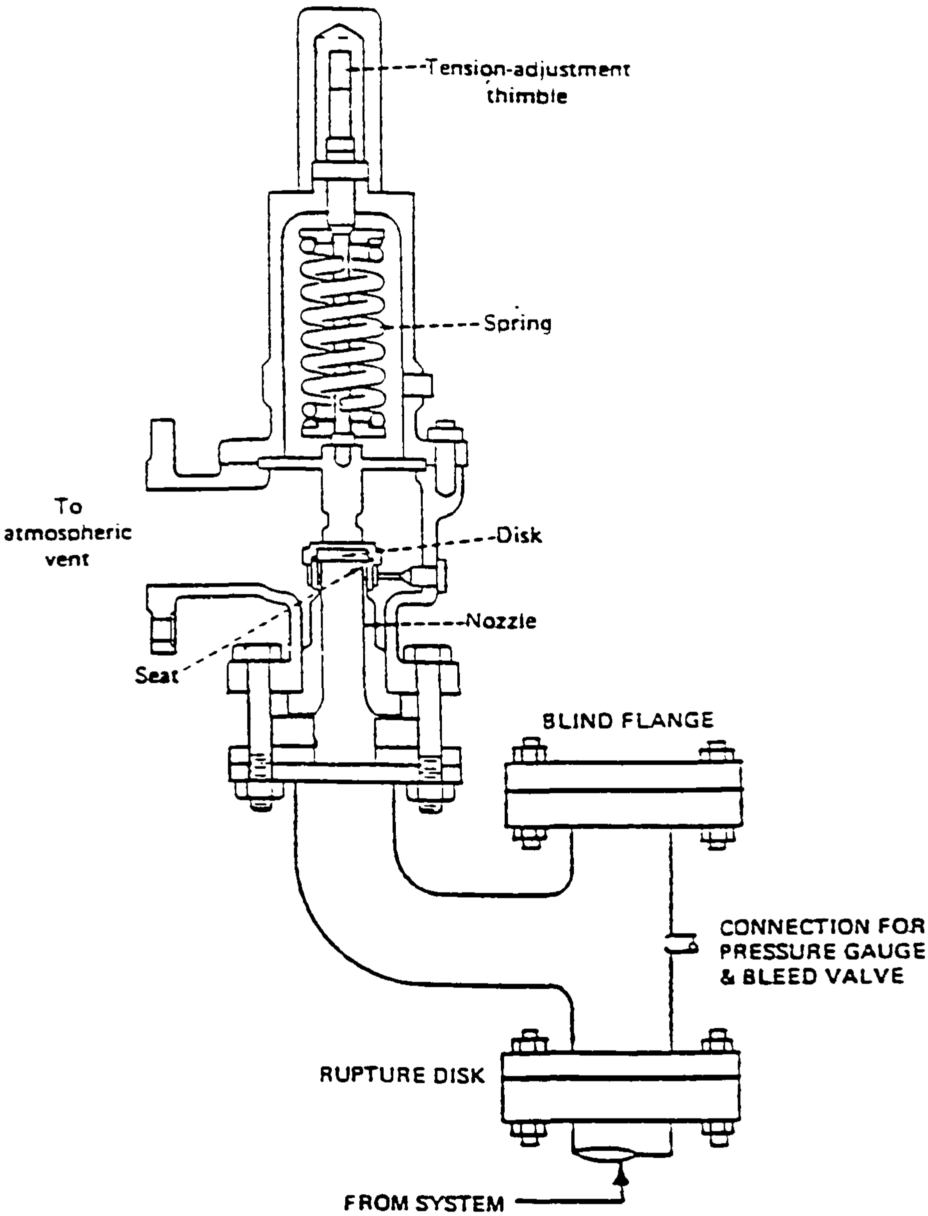


Figure 2-8. Diagram of Rupture Disk Installation Upstream of a Relief Valve

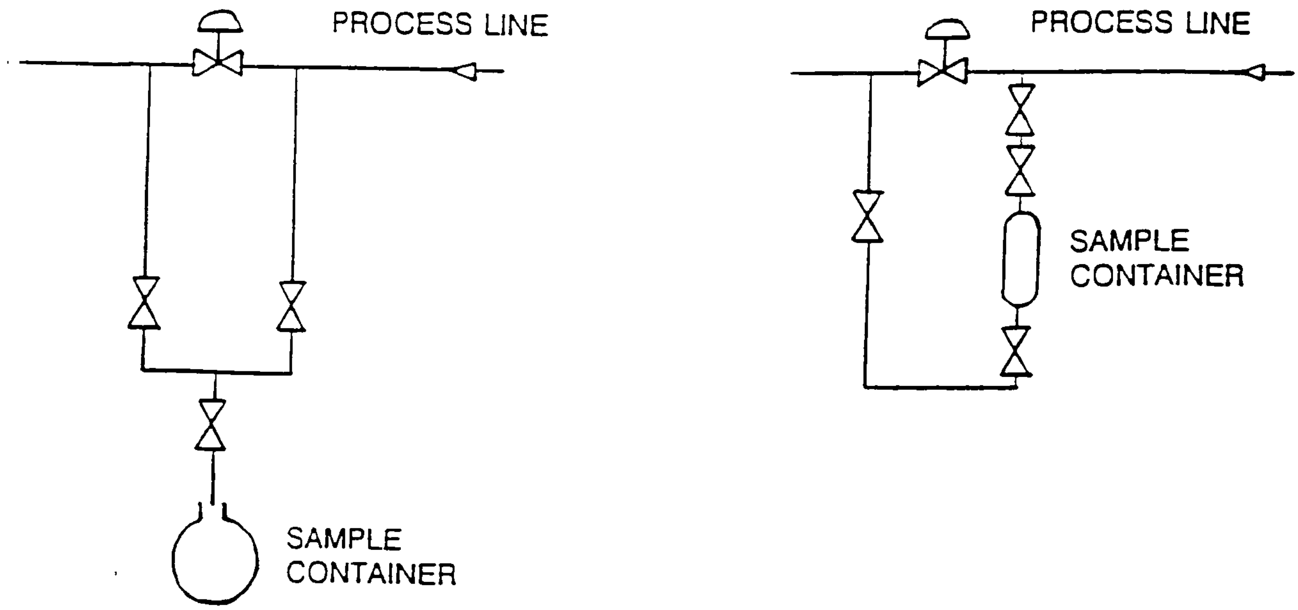


Figure 2-9. Diagram of Two Closed-Looped Sampling Systems

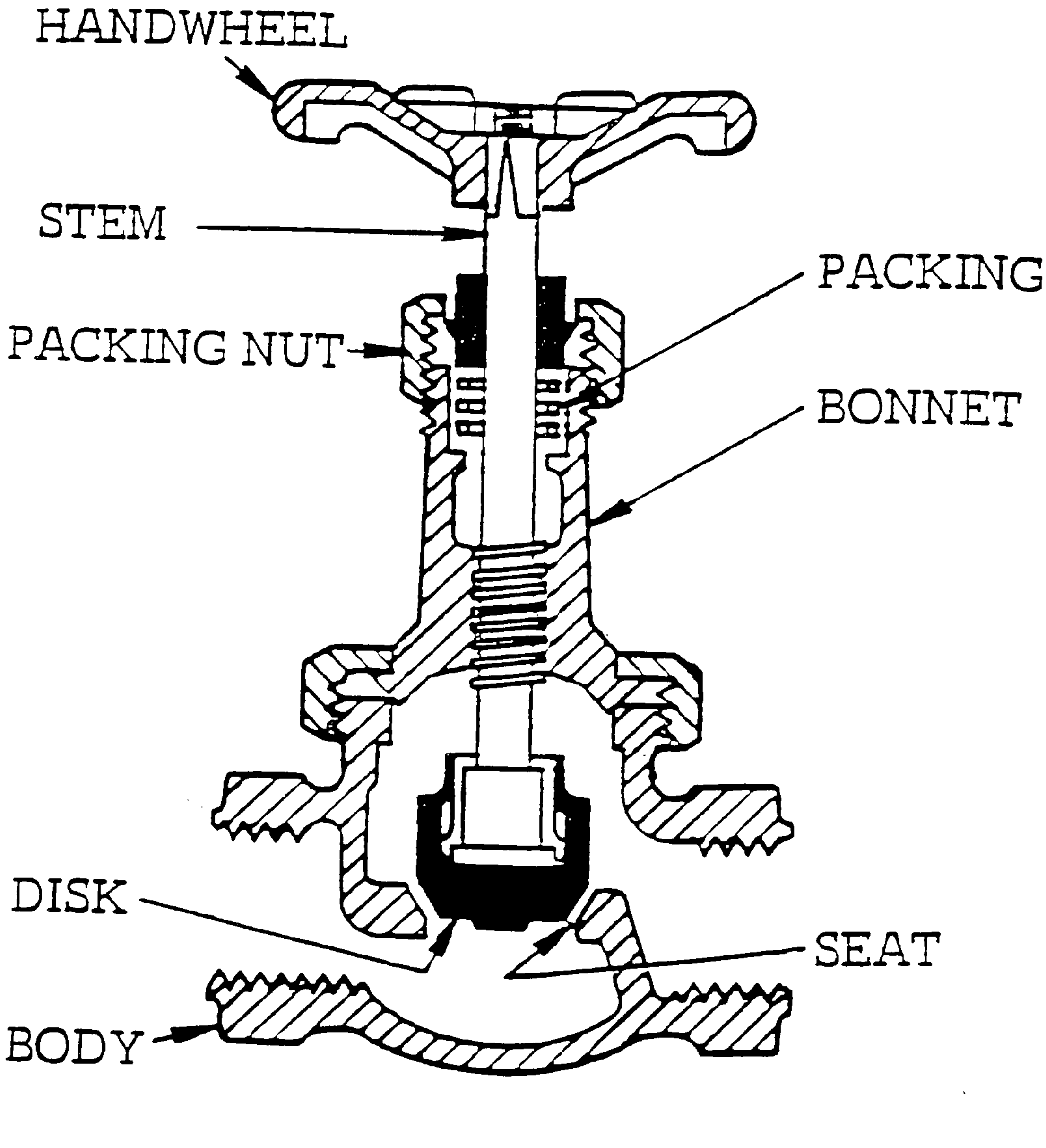


Figure 2-10. Diagram of a Globe Valve with a Packed Seal

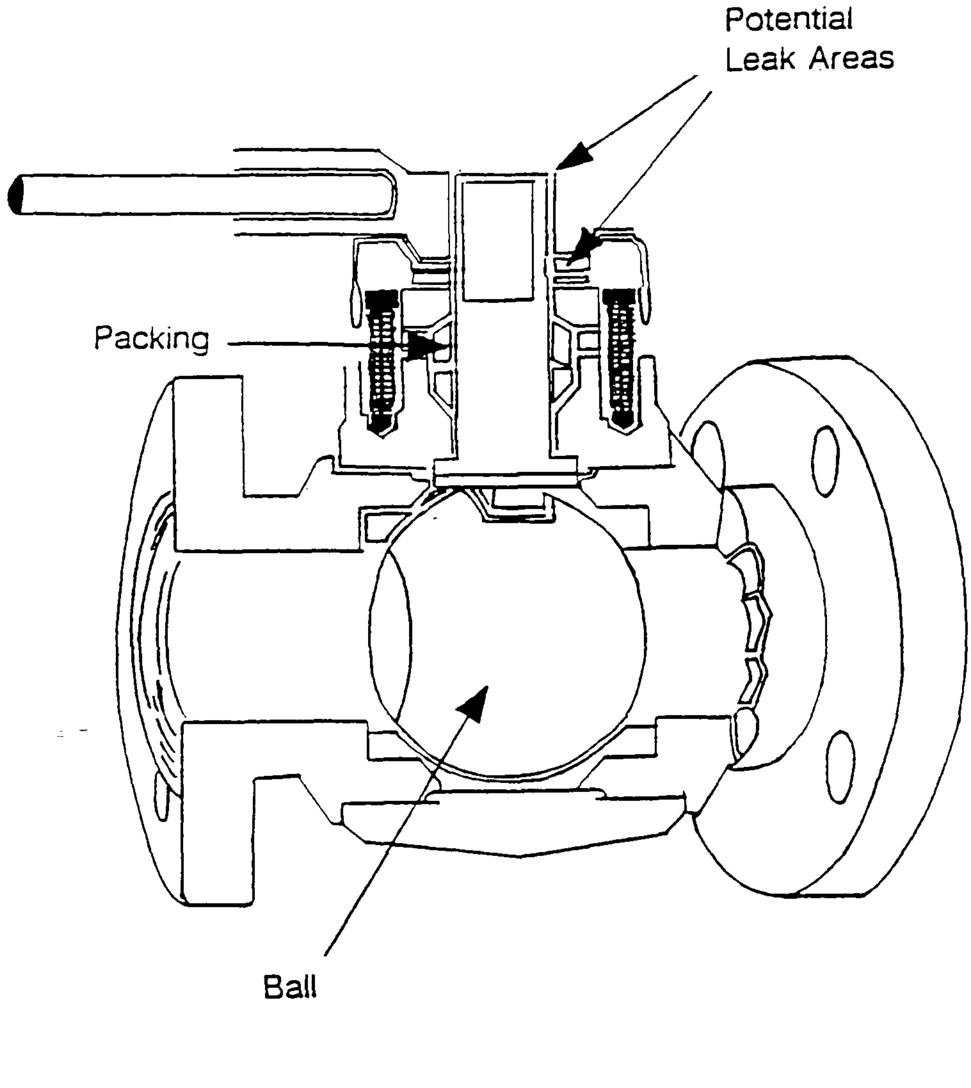


Figure 2-11. Diagram of a Ball Valve

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 to be a potential source of fugitive emissions.

Sealing of the stem to prevent leakage can be achieved by packing inside a packing gland or O-ring seals. Valves that require the stem to move in and out with or without rotation must utilize 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 wide range of operating temperatures. At high pressures, these glands must be quite tight to attain a good seal.

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

Bellows seals are more effective for prevention process fluid leaks than 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 body bonnet joint (see Figure 2-12). The bellows is the weak point of type system and service life can be quite variable. Consequently, this type of seal is normally backed up with a conventional packing gland and is often-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. Figures 2-13 and 2-14 illustrate two types of diaphragm seals. The diaphragm may also 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 it is impossible for them to be separated 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

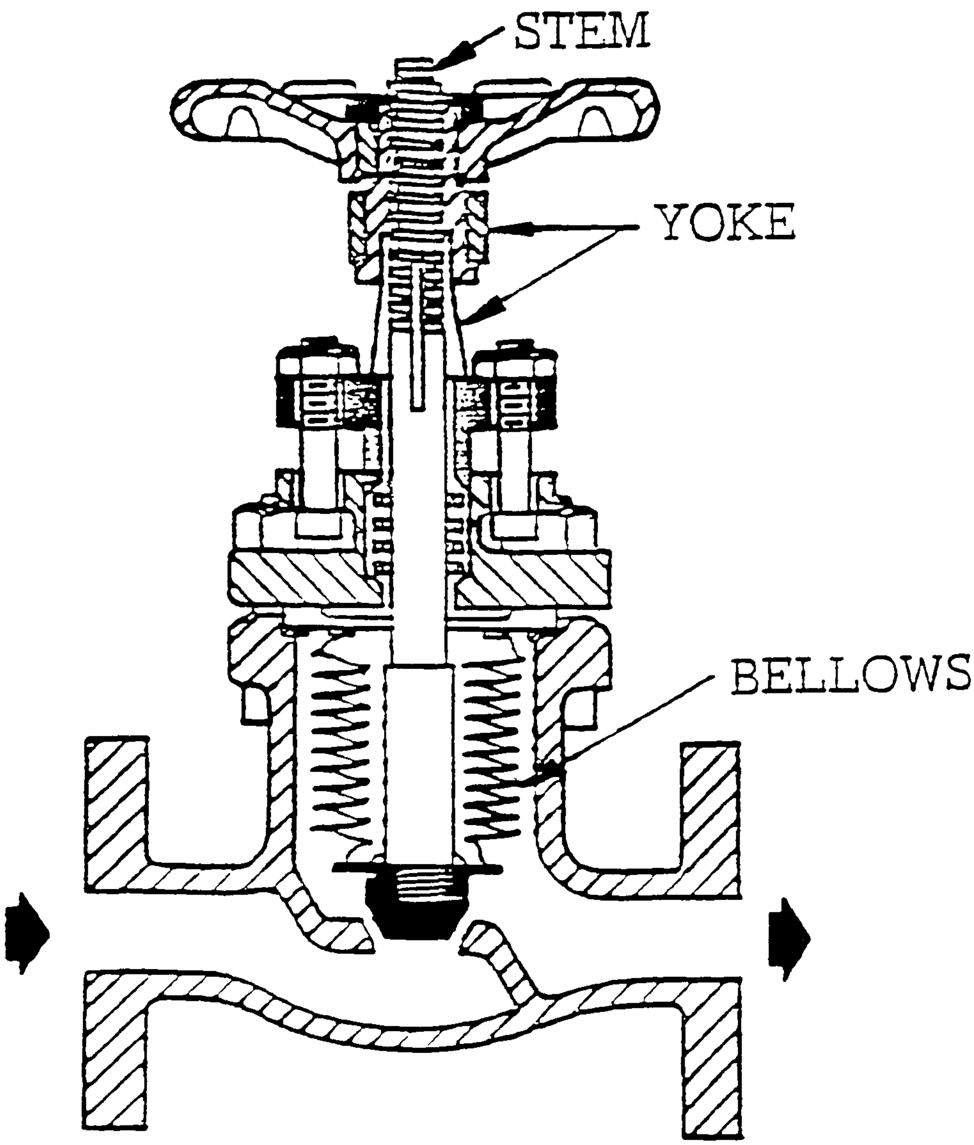


Figure 2-12. Diagram of a Sealed Bellows Valve

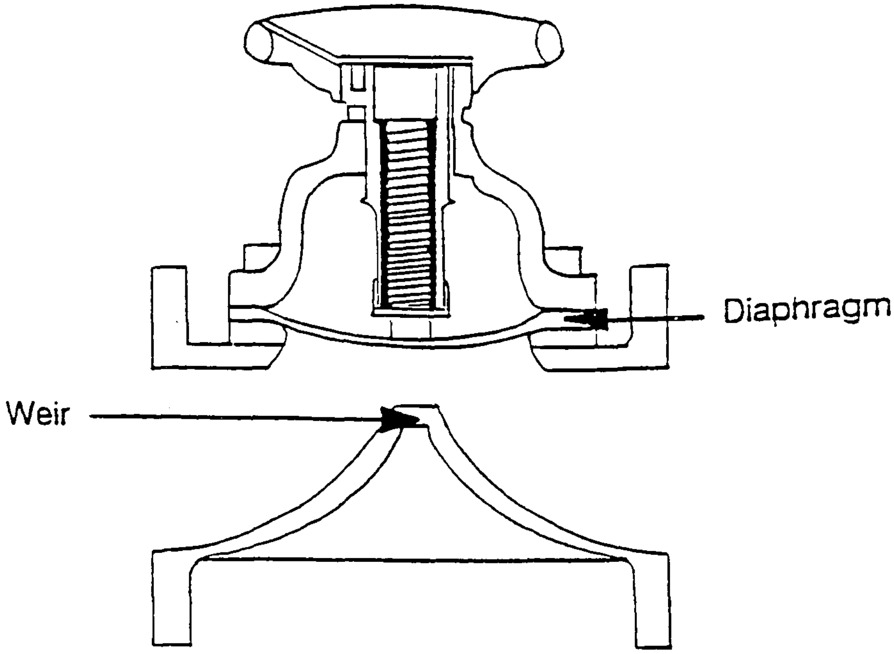


Figure 2-13. Diagram of a Weir Diaphragm Seal

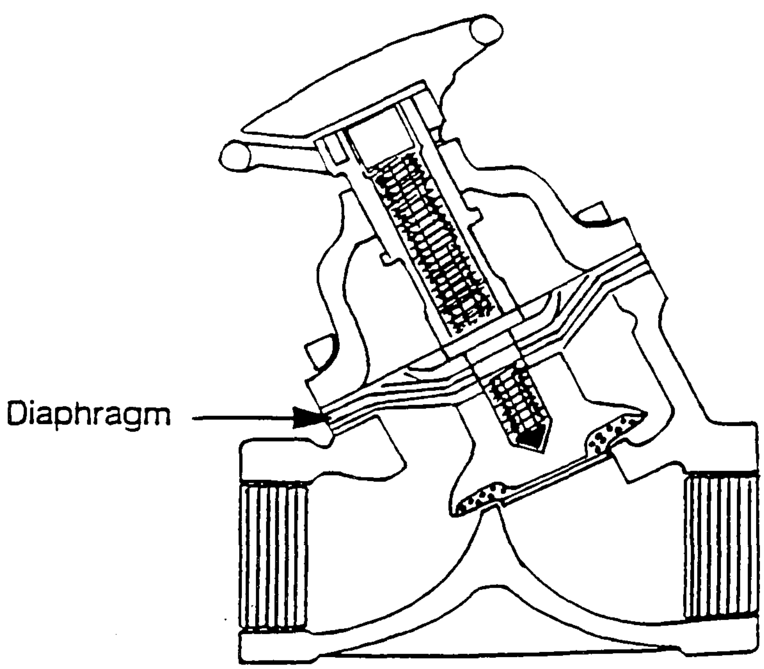


Figure 2-14. Diagram of a Bonnet Diaphragm Seal

severe acid solutions. If failure of the seal occurs, a valve employing a diaphragm seal can become a source of fugitive emissions.

## Flanges and Other Connectors

Flanges are bolted, gasket-sealed junctions used wherever pipe 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, that also allow bends in pipes (ells), joining two pipes (couplings), or joining three or four pipes (tees or crosses). The connectors are typically threaded.

Flanges may become fugitive emission sources when leakage occurs due to improperly chosen gaskets or poorly assembled flanges. The primary cause of flange leakage is due to thermal stress that piping or flanges in some services undergo; this results in the 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.

## Product Accumulator Vessels

Product accumulator vessels include overhead and bottoms receiver vessels utilized with fractionation columns, and product separator vessels utilized in series with reactor vessels to separate reaction products. Accumulator vessels can be vented directly to atmosphere or indirectly to atmosphere through a blowdown drum or vacuum system. When an accumulator vessel contains benzene and vents to atmosphere, benzene emissions can occur. This equipment is covered only by the benzene equipment leak standard.

## 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 from agitators. Four seal arrangements are commonly used with agitators; they include: compression packing (packed seal), mechanical seals, hydraulic seals, and lip seals. Packed seals for agitators are very similar in design and application to the packed seals for pumps.

Although mechanical seals are more costly than the other three seal arrangements, they offer a greatly reduced leakage rate to offset their higher cost. The maintenance frequency of mechanical seals is, also, one-half to one-fourth that of packed seals. In fact, at pressures greater than

1140 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 to the design and application of mechanical seals for pumps.

The hydraulic seal is the simplest and least used agitator shaft-seal. In this type of seal, an annular cup attached to the process vessel 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 non-contact seal. However, this seal is limited to low temperatures and pressures and can only handle very small pressure fluctuations. 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 psi because it operates without lubrication. Operating temperatures are limited by the characteristics of the elastomer. Fugitive emissions can be released through this seal when this seal wears excessively or the operating pressure surpasses the pressure limits of the seal.

<u>Closed Vent Systems and Control Devices</u>

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

Several types of control devices could 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 are typically applied. Control efficiencies of the three methods are dependent on specific operating characteristics of types of emissions. Typically, enclosed combustion devices (boilers, process heaters, 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 are commonly found at plants subject to these standards. Several types of flares may be found: steam-assisted. air-assisted, nonassisted, ground, dual-flare systems. Certain flares have been demonstrated to achieve destruction efficiencies equal to those of enclosed combustion devices provide certain design specifications are met (heat content and exit velocity).

## TYPES OF STANDARDS

Slide 2-9

The regulations for equipment leaks incorporate three different types of standards. These are: (1) performance standards; (2) equipment standards: and (3) work practice standards. For most equipment, more than one of these types of standards are applicable.

### Performance Standards

As defined in the Clean Air Act, a "standard of performance" refers to an allowable emission limit (e.g., a limit on the quantity of a pollutant emitted over a specified time period or a percent reduction). For most sources of equipment leaks, EPA determined that it is not feasible to prescribe performance standards, because except in those cases in which the performance standard can be set at "no detectable emissions" the only way to measure emissions from equipment leak sources such as pumps, pipeline valves, and compressors would be to use a bagging technique for each component in a process unit. The EPA determined that the large number of components and their dispersion over large areas would make such a requirement economically impracticable.

The standard of performance included in these standards is "no detectable emissions." A source is demonstrated to be operating with "no detectable emissions" as indicated by an instrument reading of less than 500 ppm above background. The "no detectable emissions" standard is, in general, applicable to pumps, compressors, pressure relief devices in gas/vapor service, and valves.

The equipment leak standards also contain standards of performance for closed vent systems and several types of control devices. Closed vent system are to meet the "no detectable emissions" standard of performance. Vapor recovery systems (e.g., carbon adsorbers, condensers, absorbers) are to have control efficiencies of at least 95 percent. This standard of performance (95 percent reduction) is also applicable to enclosed combustion devices.

When it is not possible to specify a standard of performance, equipment, design, work practice, or operational standards, or combustion thereof can be promulgated. The equipment leak standards contain all of these alternatives.

## Equipment, Design, and Operational Standards

As noted above, the equipment leak standards contain each of these three types of standards.

### Equipment Standards

Equipment standards refer to those instances where the regulation specifies the use of a particular piece of equipment. If that piece of equipment is used, then the component is in compliance. For example, open-ended valves or lines are to be equipped with a cap, blind flange, plug, or a second valve. An open-ended lines that is capped, for example, is in compliance with the regulation. Other fugitive emission sources for which equipment specifications exist are pumps, compressors, sampling connections, and product accumulator vessels.

### Design Standards

Design standards refer to those instances where the regulations specify how the equipment is to be designed. For example, enclosed combustion devices that meet design specifications related to minimum residence times and temperatures can be used to comply with these standards. Flares also can be used provided they meet certain design specifications.

### Operational Standards

Operational standards refer to those instances where the regulations specify how a piece of equipment is to be operated. If the equipment is operated in the specified manner, then it is in compliance with the regulations. For example, each open-ended valve or line that is equipped with a second valve is to be operated in a manner such that the valve on the process fluid end is closed before the second valve is closed.

## Work Practice Standards

Work practice standards refer primarily to the leak detection and repair (LDAR) programs implemented by these regulations. These LDAR programs rely on the monitoring of various components at regular intervals in order to determine whether or not they are leaking. If they are leaking, then the repair part of LDAR program is instituted. Components covered by LDAR programs are pumps and valves.

The regulations also require certain components to be monitored to determine if there is "evidence of a leak." Components covered by this requirement are pumps and valves in heavy liquid service, pressure relief devices in liquid service, and flanges and other connectors.

## COMPARISON OF REGULATIONS

The various equipment leak standards contain many similarities. This is due primarily to the fact that the best control technology applicable to a specific component type is the same regardless of whether it is in a SOCMI plant, a petroleum refinery, an on-shore natural gas processing plant, or a vinyl chloride plant. Thus, there is little need to enact different equipment leak standards across different source categories. Nevertheless, there are differences between source categories that affect the selection of components to be covered, the applicability of the standards to certain plants, etc. Similarities are reviewed first and then differences. Neither discussion is intended to be comprehensive, and additional examples of differences are identified throughout the lecture.

Slide 2-10 and Slide 2-11

### Covered Equipment

For the most part, the standards cover the same equipment: pumps, compressors, valves, open-ended valves and lines, pressure relief devices, sampling connections and flanges and other connectors. In addition to these components, the benzene equipment leak standard covers product accumulator vessels and the vinyl chloride equipment leak standards covers a number of additional components such as agitators and in process wastewater. Some of the standards exempt certain equipment based on a number of factors such as type (e.g., reciprocating compressor), location, and plant size. The petroleum refinery and on-shore natural gas processing plant standards, for example, exempt from the standards certain equipment located in the Alaskan North Slope.

### Leak Definitions

The standards contain the same leak definitions. For pumps, a leak is detected if:

1. An instrument reading of 10,000 ppm or greater is measured, or

2. There are indications of liquids dripping from the pump seal.

For compressors, a leak is detected if the sensor indicates failure of the seal system, the barrier system, or both. [The standards require each barrier fluid system to be equipped with a sensor that will detect failure of the seal system, barrier fluid system, or both.]

For valves in gas/vapor service or light liquid service or in VHAP service, a leak is detected if an instrument reading of 10,000 ppm or greater is measured.

For pumps and valves in heavy liquid service, pressure relief devices in liquid service, and flanges and other connectors, a leak is detected if an instrument reading of 10,000 ppm or greater is measured.

**Definitions of "In Light Liquid Service" and "In Heavy Liquid Service"**

While all of the NSPS use the same definition for "in light liquid service" and "in heavy liquid service," the on-shore natural gas processing plant standards provide alternative definitions to those found in the SOCMI standards. The petroleum refinery standard also provides an alternative definitive for "in light liquid service."

**Sampling Method**

All of the standards require the use of the same sampling method for detecting a leak. This sampling method is contained in Method 21.

## Monitoring Frequency

Although fairly consistent among the Federal regulations, State regulations frequently cite different monitoring intervals than the Federal regulations for the same component.

## Component Labeling

All components subject to Subpart V (Part 61) are required to be marked in such a manner that they can be distinguished readily from other pieces of equipment. Components subject to one of the NSPS equipment leak standards need only to be so marked when a leak is detected.

## Repair/Retest Procedures

Once a leak is detected, it is to be repaired to eliminate the leak. "Repaired" means that equipment is adjusted, or otherwise altered, in order to eliminate a leak as indicated by one of the following: an instrument reading of 10,000 ppm or greater, indication of liquids dripping, or indication by a sensor that a seal or barrier fluid system has failed. Repairing a leak, therefore, means that the piece of equipment is retested to determine whether a leak is detected. If no leak is detected, then it is repaired. If a leak is detected, then it is not repaired.

The procedures for repairing and retesting detected leaks are the same in each standard. Covered are when first attempts at repair are required, when leaks are to be repaired, and conditions under which repair can be delayed.

## Recordkeeping and Reporting

In general, the reporting and recordkeeping requirements are the same between the standards.

At this point in the lecture, major areas in the standards will be covered. These areas are shown in Slide 2-12. Slide 2-12

## DEFINITIONS

Slide 2-13

The first major area deals with defining various terms used in the standards. Most of these terms are defined in §60.481 and §61.241, and are the same between these sections. The other standards may have different definitions or supplement the ones in these two sections. The definitions reviewed here are selected ones; others are contained in the

Slide 2-14

standards. These were selected to assist in understanding how the standards are applied.

## Affected Facility

An affected facility is an emission source or group of emission sources to which a standard applies.

The various definitions of affected facility for the three NSPS equipment leak standards are shown below:

| Standard | Affected Facility |
|---|---|
| SOCMI | the group of all equipment within a process unit |
| Petroleum refinery | each compressor<br><br>the group of all equipment within a process unit |
| On-shore natural gas processing plants | a compressor in VOC service or in wet gas service<br><br>the group of all equipment except compressors within a process unit |

For the NESHAP equipment leak standards, each individual piece of equipment (e.g., each pump, each compressor) is the affected facility.

## Process Unit

Each standard defines process unit in two parts. The first part makes the definition specific to the subpart. The second part defines the characteristic of a process unit, and is the same for each standard. The equipment leak standards for benzene and vinyl chloride incorporate the definition found in the VHAP standard.

| Standard | Process Unit Definition |
|---|---|
| SOCMI | Components assembled to produce; as intermediate or final products, one or more of the chemicals listed in §60.489 of this part.<br><br>A process unit can operate independently if supplied with sufficient feed or raw materials and sufficient storage facilities for the product. |
| Petroleum refinery | Components assembled to produce intermediate or final products from petroleum, unfinished petroleum derivatives, or other intermediates.<br><br>A process unit can operate independently if supplied with sufficient feed or raw materials and sufficient storage facilities for the product. |
| On-shore natural gas processing plants | Equipment assembled for the extraction of natural gas liquids from field gas, the fractionation of liquids into natural gas products, or other operations associated with the processing of natural gas products.<br><br>A process unit can operate independently if supplied with sufficient feed or raw materials and sufficient storage facilities for the product. |
| VHAP | Equipment assembled to produce VHAP or its derivatives as intermediates or final products, or equipment assembled to use a VHAP in the production of a product.<br><br>A process unit can operate independently if supplied with sufficient feed or raw materials and sufficient storage facilities for the product. |

With regard to the definition of process unit for the SOCMI standards, EPA wrote in the promulgation BID:

The definition was drafted by EPA to provide a common sense, practical way to determine which equipment are included in an affected facility. There are no specific physical boundaries or size criteria. The definition instead depends upon several operational factors, including definition instead depends upon several operational factors, including chemical produced and the configuration of the processing equipment may be different for different producers of the same chemical, and, therefore, it may be fairly site-specific. However, in practice, the definition will implement the selection of a process unit basis as the "source" covered by the standards.

**Equipment**

Each of these standards also define equipment, as follows:

| Standard | Equipment Definition |
|---|---|
| SOCMI | Each pump, compressor, pressure relief device, sampling connection system, open-ended valve or line, valve,and flange or other connector in VOC service and any devices or systems required by this subpart. |
| Petroleum refinery | Each valve, pump, pressure relief device, sampling connection system, open-ended valve or line, and flange or other connector in VOC service. For the purposes of recordkeeping and reporting only, compressors are considered equipment. |
| On-shore natural gas processing plants | Each pump, pressure relief devices, open-ended valve or line, valve, compressor, and flange that is in VOC service or in wet gas service, and any device or system required by this subpart. |
| VHAP | Each pump, compressor, pressure relief device, sampling connection system, open-ended valve or line, valve, flange or other connector, product accumulator vessel in VHAP service, and any control devices or systems required by this subpart. |

The differences in the definitions of "equipment" result from different ways to handle the identification of compressors as a separate affected facility in the petroleum refinery and on-shore natural gas processing plant standards and from the exemption of sampling connection systems in on-shore natural gas processing plants from the requirements of the SOCMI equipment leak standards.

<u>In VOC Service</u>

The NSPS equipment leak standards apply to components that are "in VOC service." The SOCMI equipment leak standards define "in VOC service" as:

> " ... means that the piece of equipment contains or contacts a process fluid that is at least 10 percent VOC by weight."

This definition is retained in both the petroleum refinery and the on-shore natural gas processing equipment leak standards. The 10 percent VOC cutoff was selected by EPA to avoid covering those sources that have only small amounts of ozone forming substances in the line.

The NSPS equipment leak standards differ depending on whether the equipment in VOC service is in "gas/vapor service", in "light liquid service" or in "heavy liquid service."

<u>In Gas/Vapor Service</u>

"In gas/vapor service" means that the piece of equipment contains process fluid that is in the gaseous state at operating conditions. Each of three NSPS standards use this definition.

<u>In Light Liquid Service</u>

Equipment is "in light liquid service" if the following conditions apply:

1. The vapor pressure of one or more of components is greater than 0.3 kPa at 20°C, or

2. The total concentration of the pure components having a vapor pressure greater than 0.3 kPa at 20°C is equal to or greater than 20 percent by weight and the fluid is a liquid at operating conditions.

In addition to the above definition, the petroleum refinery and on-shore natural gas processing plant standards allow an owner or operator to define "in light liquid service" as follows:

Equipment is in light liquid service if the percent evaporated is greater than 10 percent at 150°C as determined by ASTM Method D-86.

In Heavy Liquid Service

"In heavy liquid service" means that the piece of equipment is not in gas/vapor service or in light liquid service. The on-shore natural gas processing plant standard also allows the following definition for "in heavy liquid service":

Equipment is in heavy liquid service of the weight percent evaporated is 10 percent or less at 150°C as determined by ASTM Method D-86.

Although not explicitly stated in the petroleum refinery standard, this alternative definition can also be used for equipment located at petroleum refineries.

Volatile Hazardous Air Pollutant (VHAP)

The NESHAP equipment leak standards apply to volatile hazardous air pollutants (VHAP), which are defined in Subpart V (40 CFR Part 61) as:

" ... a substance regulated under this part for which a standard for equipment leaks of the substance has been proposed and promulgated. Benzene is a VHAP. Vinyl chloride is a VHAP."

In VHAP Service

"In VHAP service" means that a piece of equipment either contains or contacts a fluid (liquid or gas) that is at least 10 percent by weight a VHAP. This is the same basic definition for "in benzene service" found in the benzene equipment leak standard (Subpart J, 40 CFR Part 61).

For vinyl chloride, the definition of "in vinyl chloride service" means that a piece of equipment either contains or contacts a liquid that is at least 10 percent vinyl chloride by weight or a gas that is at least 10 percent vinyl chloride by volume. This definition is used in the vinyl chloride standards (Subpart F, 40 CFR Part 61) rather than using the "in VHAP service" found in Subpart V for determining the applicability of Subpart F.

Subpart V defines "<u>in gas/vapor service</u>" the same as the NSPS equipment leak standards.

Subpart V defines "in liquid service" rather than "in light liquid service" and "in heavy liquid service." "In liquid service" means that a piece of equipment is not in gas/vapor service.

While these definitions are incorporated by reference by Subpart J (benzene), Subpart F (vinyl chloride) does not differentiate between "in gas/vapor service" and "in liquid service." Components "in vinyl chloride service" are covered the same regardless of the fluid state.

One of the groups of equipment components by the equipment leak standards are "flanges and other connectors."

<u>**Connector**</u>

In Subpart VV (40 CFR Part 60), connector is defined as..." flanged, screwed, welded, or other joined fittings used to connect two pipe lines or a pipe line and a piece of process equipment.

In Subpart V (40 CFR Part 61), this definition is expanded by the following phrase:

> "For the purpose of reporting and recordkeeping, connector means flanged fittings that are not covered by insulation or other materials that prevent location of the fittings."

The phrase was added September 30, 1986 (51 FR 34915). A discussion of this is found in Lecture 8.

<u>**Product Accumulator Vessel**</u>

"Product accumulator vessel" means any distillate receiver, bottoms receiver, surge control vessel, or product separator in VHAP service that is vented to atmosphere either directly or through a vacuum-producing system. A product accumulator vessel is in VHAP service if the liquid or the vapor in the vessel is at least 10 percent by weight VHAP.

Only Subpart V defines product accumulator vessel and only Subpart J applies to product accumulator vessels. There have been a number of questions raised concerning the application of this definition. Lecture 8 presents some additional clarifications.

## LOCATING THE STANDARDS

Slide 2-15

We now turn to where one can find the individual equipment leak regulations.

### NSPSs

Slide 2-16

The three NSPSs are found in Part 60 of Title 40 of the Code of Federal Regulations. This is written as 40 CFR Part 60. Title 40 contains Federal regulations pertaining to the protection of the environment. Part 60 contains the standards of performance for new stationary sources. Within Part 60 there are subparts, which contain the specific regulations for new stationary sources.

The SOCMI equipment leak standards are found in Subpart VV of 40 CFR Part 60. Sections (§) of this standard are found in §60.480 through §60.489.

The petroleum refinery equipment leak standards are found in Subpart GGG of 40 CFR Part 60, and are found in §60.590 through §60.593.

The on-shore natural gas processing plants equipment leak standards are found in Subpart KKK of 40 CFR Part 60, and are found in §60.630 through §60.636.

The dates shown in Slide 2-16 are those dates when the regulations were initially proposed.

### NESHAPs

Slide 2-17

The three NESHAP standards are found in Part 61 of Title 40 of the Code of Federal Regulations (i.e., in 40 CFR Part 61). Part 61 contains the national emission standards for hazardous air pollutants.

Subpart V of 40 CFR Part 61 contains the national emission standard for equipment leaks for volatile hazardous air pollutants (VHAPs). This subpart contains the "generic" provisions and standards that apply to benzene and vinyl chloride sources, as incorporated by reference in the two subparts in 40 CFR 61 that apply specifically to these two pollutants. This subpart was added to the regulations on June 6, 1984.

Subpart J of 40 CFR Part 61 specifies the national emission standard for equipment leaks of benzene, and basically incorporates

Subpart V as its standards. Subpart J was added at the same as Subpart V (June 6, 1984). Subpart J is found in §61.110 through §61.112 (§61.113 - §61.119 are reserved).

Subpart F of 40 CFR Part 61 contains various standards for vinyl chloride, not just equipment leak standards (§61.60 through §61.71). Equipment leak standards are found in §61.65(b). The vinyl chloride standards were added in 1976. At that time, some fugitive emission sources were covered. Section 61.65 was revised at a later date to incorporate the standards found in Subpart V (40 CFR Part 61). The most recent correction was made on July 10, 1990.

## APPLICABILITY OF THE STANDARDS

Slide 2-18

This part of the lecture reviews the applicability of the equipment leak regulations. As noted earlier, new source performance standards apply to newly constructed sources and only to existing sources when they are modified or reconstructed. Thus, NSPSs have applicability dates to identify when the standards become effective and thereby distinguish between new and existing sources. The applicability date is the date of proposal. NESHAPs, on the other hand, apply to both existing and new sources and thus do not need an applicability date to distinguish between new and existing sources. Both NSPSs and NESHAPs become effective upon promulgation. Slide 2-18

Each regulation also exempts certain sources, equipment, or process units from the entire regulation or portions thereof. These are identified for each regulation.

### <u>Subpart VV - SOCMI</u>

Slide 2-19

Subpart VV of 44 CFR Part 60 applies to equipment leaks in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The industry is defined as the industry that produces, as intermediates or final products, one or more of the chemicals listed in §60.489.

The standards apply to any affected facility that commences construction or modification after January 5, 1981.

The SOCMI rule defines the affected facility as the "group of all equipment...within a process unit."

These equipment are covered if they are "in VOC service," which means that the piece of equipment contains or contacts a process fluid that is at least 10 percent VOC by weight.

The SOCMI rule identifies several exemptions:

1. Any affected facility that has the design capacity to produce less than 1,000 megagrams per year is exempt from §60.482.

   There are some process units (e.g., research and developmental facilities) that have production rates so small that their VOC emissions from equipment leaks are likely to very small and, as a consequence, the cost to control these emission would be unreasonably high. This lower production rate cutoff was developed on the basis of cost and emission reduction considerations. Explanation of their analysis is found in Section 5.7 of the background information document for the promulgated standards (EPA-450/3-80-033b).

2. If an affected facility produces heavy liquid chemicals only from heavy liquid feed or raw materials, then it is exempt from §60.482.

   Based on data obtained in petroleum refinery studies, equipment processing VOC with vapor pressures above 0.3 kPa leaked at significantly higher rates and frequencies than equipment processing VOC with vapor pressure below 0.3 kPa. Therefore, EPA elected to exempt equipment processing lower vapor pressure VOC substances from the routine leak detection and repair requirements of the standards (BID Vol. II, p. 5-21). Even though the standards do not require monitoring equipment in heavy liquid service for leaks, the standards require VOC leaks that are visually or otherwise detected from these equipment to be repaired within 15 days if a leak is confirmed using Reference Method 21.

3. Any affected facility that produces beverage alcohol is exempt from §60.482.

   During the public comment period on the proposed rule, EPA received comments from the beverage alcohol producers saying that they should be exempt from coverage by the standards because beer and whisky producers were exempted from the priority list. The EPA concluded that process units within beer and whisky plants that are producing fermented beverages solely for purposes of human consumption should be exempt from the standards. However, any process unit (e.g., a distillation train to produce industrial grade alcohols from fermentation products) in beer and whisky plants that are used to manufacture nonbeverage fermented products are subject to the standards. (BID Vol. II, p. 1-12).

4. Any affected facility that has no equipment in VOC service is exempt from §60.482.

   The EPA believes it appropriate to grant an exemption to any SOCMI unit that does not process VOC. A few SOCMI process units may produce their products without the use of VOC; however, these units are expected to be the exception rather than rule. SOCMI units that do not process VOC would not have any potential to emit VOC.

5. Equipment in vacuum service is excluded from the requirements of §§60.482-2 to 60.482-10 if it is identified as required in §60.486(e)(5).

   In EPA's judgement, it is inappropriate to cover sources in vacuum service because sources operating even at a slight vacuum would have little if any potential to emit VOC.

   "In vacuum service" means that equipment is operating with an internal pressure which is at least 5 kPa below ambient pressure.

**Subpart GGG - Petroleum Refineries** Slide 2-20

Subpart GGG of 40 CFR Part 60 applies to equipment leaks in petroleum refineries. The standards apply to any affected facility that commences construction or modification after January 4, 1983.

This NSPS specifies that affected facilities covered by the equipment leak standards for the SOCMI (Subpart VV) or on-shore natural gas processing plants (Subpart KKK) are excluded from these standards. Some refineries, for example, produce organic chemicals on the SOCMI list. Because some refineries have sources of fugitive VOC emissions (such as pumps and valves) involved in producing one or more SOCMI chemicals, EPA believes that the SOCMI standards are appropriately applied to process units in these refineries that produce these chemicals. Therefore, to eliminate any potential redundancy or confusion, process units covered under the SOCMI standards are exempted from the refinery standards.

The affected facilities for this NSPS are:

1. each compressor; and

2. the group of all the equipment (defined in §60.591) within a process unit.

In selecting the affected facilities for petroleum refineries, EPA considered, in part, selecting each equipment component (such as each pump and each valve). If this definition were selected, situations would arise in which replaced equipment components in existing process units would be subject to the standards, while adjacent component would not be subject to the standards. With such a mixture of new and existing components, the effort to keep track of equipment components covered by the standards and components not covered would be costly. Implementing a leak detection and repair program for a very small proportion of all the equipment components at a plant site would be too costly. Thus, this definition was rejected except for compressors.

Relatively few compressors are located in petroleum refineries; in fact, many process units do not contain compressors. When a compressor is used in a process unit, it is designed for use only within that process unit. In general, there are no spare compressors in petroleum refineries, and compressors that are in place are readily identifiable. Thus, it would not be costly to keep track of compressors covered by the standards and those it covered. Based on these considerations, EPA selected the equipment component as the affected facility. (For all other equipment, the process unit is affected facility.)

The petroleum refinery NSPS allows owners or operators to define "in light liquid" service as: "if the percent evaporated is greater than 10 percent at 150°C as determined by ASTM Method D-86..."

This NSPS also contain several exemptions.

1. As for the SOCMI, equipment in vacuum service are exempted.

2. Compressors in hydrogen service are exempted. The EPA analyzed the cost of control of equipment that, based on EPA's data, would be found in hydrogen service. This analysis showed that emission reductions from compressors in

hydrogen service could not be achieved at a reasonable cost. Thus, EPA decided to exclude such compressors from the standards.

3. These standards also exempt from §60.482-2 and §60.482-7 pumps in light liquid service and valves in gas/vapor service and light liquid service within a process unit that is located in the Alaskan North Slope. This exempts refineries located in the North Slope of Alaskan from the routine leak detection and repair requirements, but does not include an exemption from the equipment requirements of the standards.

   Commenters on the proposed standards identified several unique aspects of refining in the North Slope of Alaska. These were:

   - the products are used locally;
   - process units are totally enclosed because of the harsh environment; thus present safety controls are adequate and additional requirements are unwarranted;
   - requiring rupture disks ahead of pressure relief devices would compromise safety, especially under this application;
   - repair labor is 2-½ to 4 times more costly; and
   - control of VOC is of limited value in an attainment area, especially in the arctic where cold ambient temperature, the degree of isolation, and a low concentration of photochemical precursors limit ozone formation.

   The EPA considered these comments and acknowledged that there are several unique aspects to refining in the North Slope of Alaska. Accordingly, EPA concluded that the costs to comply with the routine leak detection and repair requirements may be unreasonable. These operations incur higher labor, administrative, and support costs associated with leak detection and repair programs, because (1) they are located at great distances from major population centers, (2) they must necessarily deal with the long term extremely low temperatures of the arctic, and consequently (3) they must provide extraordinary services for plant personnel. These unique aspects make the cost of routine leak detection and repair unreasonable.

<u>Subpart KKK - Onshore Natural Gas Processing Plants</u>

Slide 2-21

Subpart KKK of 40 CFR Part 60 applies to equipment leaks in the natural gas industry. Only equipment that is located at on-shore natural gas processing plants are covered. Pieces of equipment that are remotely located (i.e., not located at an on-shore natural gas processing plant) are not covered by this NSPS. The standards apply to any affected facility that commences construction, reconstruction, or modification after January 20, 1984.

This NSPS specifies that affected facilities covered by the equipment leak standards for the SOCMI (Subpart VV) or for petroleum refineries (Subpart GGG) are excluded from these standards.

As for petroleum refineries, this NSPS identifies two affected facilities:

1. each compressor in VOC service or in wet gas service, and

2. the group of all equipment except compressors defined in §60.631) within a process unit.

"In wet gas service" means that a piece of equipment contains or contacts the field gas before the extraction step.

At proposal, EPA defined "in VOC service" using a 1.0 weight percent VOC limit (rather than 10 weight percent). The intent of using the 1.0 weight percent VOC limit was to ensure that inlet (wet) gas streams were subject to NSPS controls, since emissions can be reduced at reasonable costs from inlet gases. However, based on comments received on the proposed standards, EPA agreed that a 1.0 weight percent limit was inappropriate for dry gas streams. Therefore, EPA selected a VOC concentration limit of 10 weight percent was selected in the final rule for the "in VOC service" definition and decided to include equipment in wet gas service (except for wet gas reciprocating compressors) by covering them as a class.

The on-shore natural gas process plant NSPS allows owners to use alternative definitions for "in heavy liquid service" and "in light liquid service." An owner or operator may define in heavy liquid service" as:

> Equipment is in heavy liquid service if the weight percent evaporated is 10 percent or less at 150°C as determined by ASTM Method D-86.

An owner or operator may define "in light liquid service" as:

Equipment is in light liquid service if the weight percent evaporated is greater than 10 percent at 150°C as determined by ASTM Method D-86.

This NSPS generally requires owners and operators to follow the provisions found in Subpart VV (Equipment Leaks for the SOCMI). Exceptions are provided. These include:

1. Sampling connection system are exempt from §60.482-5, Standards: Sampling connection systems.

2. Pumps in light liquid service, valves in gas/vapor service and in light liquid service, and pressure relief devices in gas/vapor service that are located at a nonfractionating plant with a design capacity to process less than 10 million standard cubic feet per day of field gas are exempt from the routine monitoring requirements of §60.483-2(a)(1), §60.482-7(a), and §60.633(b)(1).

   Small, nonfractionating plants often operate unmanned or without personnel having the ability necessary to carry out responsibly a leak detection and repair program. In these cases, central office personnel or an outside consultant would be required to conduct leak detection and repair. The EPA examined the additional costs that would be incurred in such cases and the amount of resulting emission reduction. The EPA judged the costs to change from reasonable to unreasonable at plants having capacities between 5 and 10 million standard cubic feet per day. Therefore, EPA decided to exempt any nonfractionating plant with a design capacity of less than 10 million scfd of field gas from the routine monitoring requirements for valves, pumps, and pressure relief devices.

   However, all fractionating plants, regardless of capacity, or required to implement the routine monitoring requirements.

3. Pumps in light liquid service, valves in gas/vapor service and in light liquid service, and pressure relief devices in gas/vapor service within a process unit that is located in the Alaskan North Slope are exempt from the routine monitoring requirements of §60.482-2(a)(1), §60.482-7(a), as §60.633(b)(1).

The EPA reviewed comments concerning natural gas plant operations in the North Slope of Alaska and determined that the costs to comply with certain aspects of the proposed standards can be unreasonable. Leak detection and repair programs incur higher labor, administrative, and support costs at plants that are located at great distances from major population centers and particularly those that experience extremely low temperatures as in the arctic. Thus, EPA decided to exempt plants located in the North Slope of Alaska from the routine leak detection and repair requirements. The EPA excluded these plants only from the routine leak detection and repair requirements because the costs of the other requirements are reasonable.

4. Reciprocating compressors in wet gas service are exempt from the compressor control requirements of §60.482-3, compressors.

   At proposal, EPA exempted reciprocating compressors in wet gas service only if they were located at a gas plant that did not have an existing control device. The cost effectiveness of controlling such compressors was high due to the cost of installing and operating a control device. However, the cost effectiveness of controlling wet gas reciprocating compressors at plants with an existing control device ($1,700 per megagram of VOC reduced) was considered reasonable, given that the average cost effectiveness (combining cost-effectiveness numbers for centrifugal and reciprocating compressors) was estimated to be much lower ($460 per megagram). However, since proposal, several industry representatives commented that many gas plants, especially small ones, will use reciprocating compressors almost exclusively. For such plants, the compressor control cost effectiveness would be essentially the same as the cost effectiveness for controlling only wet gas reciprocating compressors at plants with an existing control device (i.e., $1,700 per megagram). This cost effectiveness, when considered representative of the overall compressor control costs for small plants, was judged by EPA to be unreasonably high. For this reason, EPA revised the standards to exempt all wet gas reciprocating compressors. Reciprocating compressors used in natural gas liquids (NGL) service and all centrifugal compressors in wet gas or NGL service are still required to be equipped with closed vent systems, however, because they can be controlled at a reasonable cost effectiveness.

**Subpart J - National Emission Standard for Equipment Leaks (Fugitive Emission Sources) of Benzene** Slide 2-22

The national emission standards for equipment leaks (fugitive emission sources) of benzene apply to pumps, compressors, pressure relief devices, sampling connection systems, open-ended values or lines, valves, flanges, and other connectors that are intended to operate in benzene service.

These standards apply to both new and existing sources. Thus, unlike the NSPS, there is no initial applicability date separating new from existing sources.

"In benzene service" means that a piece of equipment either contains or contacts a fluid (liquid or gas) that is at least 10 percent benzene by weight as determined according to the provisions of §61.245(d). The provisions of §61.245(d) also specify how to determine that a piece of equipment is not in benzene service.

The benzene equipment leak NESHAP contains several exemptions.

1. Any equipment in benzene service that is located at a plant site designed to produce or use less than 1,000 megagrams of benzene per year is exempt from the requirements of §61.112, Standards.

   Comments received on the proposed standards requested certain small-volume or intermittent benzene uses be exempt from the standard. Because EPA believes it is reasonable to exempt plants from the standard when the cost of the standard is unreasonably high in comparison to the achieved emission reduction, EPA determined a cutoff for exempting plants based on a cost and emission reduction analysis. Based on this analysis, EPA determined that the cost complying with the standard is unreasonable for plants in which the benzene emission reduction is about 4 megagrams per year. In order to exclude plants on this basis, EPA selected a minimum cutoff of 1,000 Mg/yr per plant site based on a benzene design usage rate or throughput. It is expected that this cutoff will exempt most research and development facilities and other small-scale operations. For plants with a benzene design usage rate greater than 1,000 Mg/yr, the cost of the standard is reasonable.

2. Any process unit that has no equipment is benzene service is exempt from the requirements of §61.112.

3. Sources located in coke-by-product plants are exempt from the standard.

4. Equipment that is in vacuum service is excluded from the requirements of §61.242-2 to §61:242-11 if it is identified as required in §61.246(e)(5).

__Subpart F - National Emission Standard for Vinyl Chloride__ Slide 2-23A

Subpart F of 40 CFR Part 61, the vinyl chloride standards, affect emissions from plants that produce ethylene dichloride, vinyl chloride, and one or more polymers containing any fraction of polymerized vinyl chloride. On January 9, 1985, EPA proposed to add vinyl chloride to the list of substances covered by Subpart V, National Emission Standard for Equipment Leaks (Fugitive Emission Sources) of 40 CFR Part 61. This was promulgated on September 30, 1986.

Subjecting facilities that had been already controlled by Subpart F to the requirements of Subpart V substantively affected only valves and flanges in vinyl chloride service because all other equipment in vinyl chloride were already required by Subpart F to comply with equipment and work practice standards consistent with those in Subpart V. Thus, the primary effect was to require a specific monitoring schedule, leak definition, and repair provisions for valves and flanges in vinyl chloride service.

Like the other standards, Subpart F contains several exemptions affecting equipment subject to the fugitive emission standards.

1. Subpart F does not apply to equipment used in research and development if the reactor used to polymerize the vinyl chloride processed in the equipment has a capacity of no more than 0.19 $m^3$ (50 gallons).

2. Equipment used in research and development are exempted from some of Subpart F if the reactor used to polymerize the vinyl chloride processed in the equipment has a capacity of greater than 0.19 $m^3$ (50 gallons) and less than 4.07 $m^3$ (1,075 Slide 2-23B

gallons). This includes exemption from §61.65, which contains the standards for fugitive emission sources.

Sections of Subpart F that remain applicable are:

61.61, which contains the definitions,
61.64(a)(1), (b), (c), (d), which include some of the standards for polyvinyl chloride plant reactors; strippers; mixing; weighing, and holding containers; and monomer recovery systems.
61.67, which contains emission test requirements.
61.68, which contains emission monitoring requirements.
61.69, which contains initial report requirements.
61.70, which contains reporting requirements.
61.71, which contains recordkeeping requirements.

3. Equipment in vacuum service is exempt.

4. Any process unit in which the percentage of leaking valves is demonstrated to be less than 2.0 percent is exempt from the following sections of Subpart V (40 CFR Part 61):

- 61.242-1(d), which requires each piece of equipment to be marked in such a manner that it can be readily distinguished from other pieces of equipment.

  61.242-7(a), (b), and (c), of the standards for valves, covering monitoring period and method to be used, leak definition, and skip period.

- 61.246, which contains recordkeeping requirements.

- 61.247, which contains reporting requirements.

Such process units are still subject to the reporting and recordkeeping requirements found specifically in Subpart F.

**COMPONENT IDENTIFICATION** Slide 2-24

In order to comply with the various equipment leak standards, an owner or operator needs to be able to locate and identify components subject to the standards. A number of such needs are identified in the next slide.

## Identification Number

Slide 2-25

Each component needs an identification (id) number. The id number is used to comply with various recordkeeping and reporting requirements. For example, the id number of each component that is found to be leaking is recorded in a log. In addition, a list of the id numbers of all equipment subject to the standards are to be recorded in a log. Lists of identification numbers are also required for (1) equipment in vacuum service, (2) valves designated as unsafe-to-monitor, (3) valves designated as difficult-to-monitor, and (4) pressure relief devices required to comply with §60.482-4.

## Affected Facility

For the NSPS equipment leak standards, components are only subject to the standards if they are located in an affected facility. Therefore, it is important to identify the location of each component with regard to the process unit it is in and whether that process unit is an affected facility. For the NESHAP equipment leak standards, individual components are exempt from the standards if located in process units that have less than 2 percent of the valves leaking. Thus, it can be important to locate the equipment in VHAP service to determine whether they can be exempted.

## Component Type

The standards have different requirements (e.g., monitoring intervals) depending on the type of component. Thus, the component type needs to be identified.

## Component Location

Many plants are large, containing many components. Locating a specific component that is to be repaired can be difficult. Thus, identifying the component location (where is it exactly in the plant) can facilitate compliance with the standards.

Fluid State

The standards also have different requirements depending on the fluid state of the component. Thus, it is important to identify whether the component is in gas/vapor service, in light liquid service, or in heavy liquid service (if subject to an NSPS standard) or in VHAP service (if subject to a NESHAP standard).

Mark Each Component

Under Subpart V [§61.241-1(d)], each piece of equipment to which this subpart applies to be marked in such a manner that it can be distinguished readily from other pieces of equipment.

Percent VHAP

Under Subpart V, each piece of equipment within a process unit that can conceivably contain equipment in VHAP service is presumed to be VHAP service unless an owner or operator demonstrates that the price of equipment is not in VHAP service. A piece of equipment is considered to be not in VHAP service if the percent VHAP content can be reasonably expected never to exceed 10 percent by weight. Thus, for these components, it is important to identify the percent (%) VHAP.

## THE STANDARDS IN DETAIL

This part of the lecture looks at the specific equipment leak standards. The work practice standards (leak detections and repair programs) are covered first. Then the equipment and performance standards are discussed. This section concludes with a discussion on equivalent means of emission limitations.

Leak Detection and Repair Slide 2-26

There are two phases to leak detection and repair (LDAR) programs. The first phase involves monitoring potential fugitive emission sources within a process unit to detect equipment leaks of VOC. After detection of the leak, the second phase involves the repair or replacement of the fugitive emission source. Slide 2-27

The level of emission reduction achieved by a LDAR program is affected by several factors. The three main factors are the monitoring interval, leak definition, and repair interval. Training and diligence of personnel conducting the program, repair methods attempted, and other Slide 2-28 site-specific factors may also influence the level of emission reduction achievable; however these factors are less quantifiable than the three main factors.

### Monitoring Interval

The monitoring interval is the frequency at which individual component monitoring is conducted. Pumps and valves are to monitored once a month. For valves, the monitoring interval may be increased to once every quarter for each valve that is found not to be leaking for two successive months. For pumps, the LDAR program also specifies a weekly visual inspection for indications of liquids dripping from the pump seal.

### Leak Definition

The leak definition is the VOC (or VHAP) concentration observed during monitoring that defines leaking sources that require repair. Two primary factors affected the selection of the leak definition. These factors were: (1) the percent total mass emissions that can potentially be controlled by the LDAR program and (2) the ability to repair the leaking components. The leak definition selected for leak detection monitoring is 10,000 ppm.

### Repair Interval

The repair interval is defined as the length of time allowed between the detection of a leak and repair of the leak. For each component, when a leak is detected it is required to be repaired as soon as practicable, but not later than 15 calendar days after it is detected except if the conditions described under "Delay of repair" are met.

For each component, the first attempt at repair is to be made no later than 5 calendar days after each leak is detected For valves, first attempts at repair include, but are not limited to, the following best practices where practicable: Slide 2-29

- tightening of bonnet bolts;
- replacement of bonnet bolts;
- tightening of packing gland nuts; and
- injection of lubricant into lubricated packing.

The standards do not identify similar first attempt repair practices for the other components.

**Delay of Repair** Slide 2-30

The EPA recognized that repair of leaking equipment may need to be delayed for technical reasons. Thus both Subpart VV and Subpart V identify circumstances under which repairs may be delayed. These circumstances are identified below.

1. Delays of repair of equipment for which leaks have been detected are allowed if the repair is technically infeasible without a process unit shutdown. An example of such a situation would be a leaking valve that could not be isolated from the process stream and requires complete replacement or replacement of internal parts. When a valve cannot be physically isolated from the process stream, the process unit must be shutdown to effect certain repairs on the valve. Thus, because EPA believes shutdown to effect repair of valves is unreasonable, EPA allows delay of repair when repair is infeasible without a process unit shutdown.

2. Delay of repair equipment is allowed for equipment which is isolated from the process and does not remain in VOC (or VHAP) service. This typically applies to spare equipment that is out of service. Delay of repair is not allowed for spare equipment that is pressurized and prepared to be placed on-line; such equipment is considered to be in (VOC or VHAP) service.

3. Delay of repair for valves is allowed if the emissions of purged material resulting from the immediate repair are greater than the fugitive emissions likely to result from the delay and, when repair procedures are affected, the purged material is collected and destroyed or recovered in a control device complying with §60.482-10 or §60.242-11, as applicable. Slide 2-31

4. Delay of repair beyond a process unit shutdown is allowed for valves, if three conditions are met:

   - valve assembly replacement is necessary during the process unit shutdown;

   - valve assembly supplies have been depleted; and

   - valve assembly supplies had been sufficiently stocked before the supplies were depleted.

Delay of repair beyond the next process unit shutdown is not allowed unless the next process unit shutdown occurs sooner than 6 months after the first process unit shutdown.

5. Delay of repair for pumps is allowed if repairs requires the use of a dual mechanical seal system that includes a barrier fluid system and repair is completed as soon as practicable, but not later than 6 months after the leak was detected. Slide 2-32

Subpart F (vinyl chloride) basically adopts the same LDAR requirements as identified in Subpart V for like components. The differences are as follows:

1. A reliable and accurate vinyl chloride monitoring system shall be operated for detection of major leaks and identification of the general area of the plant where a leak is located.

2. The monthly monitoring requirements for valves are not applicable to any process unit in which the percentage of leaking valves is demonstrated to be less than 2.0 percent. The calculation of this percentage is based, in part, on the monitoring of a minimum of 200 valves or 90 percent of the total valves in a process unit, whichever is less.

As noted earlier in this lecture, LDAR programs affect valves and pumps. In addition, other components have LDAR programs. Each of these components are discussed in more detail below. Slide 2-33

## Valve LDAR Programs

There are basically four categories of valves in Subpart VV to which monitoring requirements apply. These are:

1. valves in gas/vapor or light liquid service or VHAP service;
2. valves demonstrated to be difficult-to-monitor;
3. valves demonstrated to be unsafe-to-monitor; and
4. valves in heavy liquid service.

The first three categories of valves are discussed first. Valves in heavy liquid service is discussed later. Slide 2-34

## Valves in Gas/Vapor or Light Liquid or VHAP Service

For valves in gas/vapor or light liquid service, monthly monitoring is required. Slides 2-35 through 2-37 illustrate two types of common valves that would typically be subject to a LDAR program. Slides 2-35 to 2-37

In selecting the monitoring interval, EPA noted that, in general: " ... more frequent monitoring would result in greater emissions reduction because more frequent monitoring would allow leaks to be detected earlier and thus allow more immediate repair."

The EPA considered monitoring intervals of less than one month for these valves, but rejected shorter intervals. The EPA noted that the large number of valves in certain SOCMI process units limits the practical minimum for the monitoring intervals. For typical large process units, it might take a two-man team more than one week to monitor all the valves. Since some time is required to schedule repair after a leak is detected, monitoring intervals less than one month could result in a situation where a detected leak could not be repaired before the next monitoring was required.

The EPA also considered a number of larger monitoring intervals. These were annual; semiannual; quarterly; and quarterly with monthly follow-up on leaking valves. These intervals, along with monthly monitoring, were compared in terms of cost effectiveness and the emission reduction achievable. Based on the analysis of the affect of monitoring interval on costs and emission reduction, EPA determined that a monthly monitoring program is to be used for these SOCMI standards. While less frequent programs were found by EPA to be more cost-effective, EPA determined that monthly monitoring also had reasonable cost effectiveness, reasonable incremental cost effectiveness, and yielded the largest emissions reduction of the programs examined.

At the National Air Pollution Control Techniques Advisory Committee meeting (a public hearing held during the development of standards), industry representatives argued that monitoring all valves monthly would be an inefficient expense of time and manpower for valves that leak infrequently or less often than others. If this is correct, more monitoring effort should be expended on valves found leaking and less on those found leaking infrequently. Therefore, for any valve that is not found to be leaking for two successive months, the standards allow an owner or operator to exclude such valves from monitoring until the first month of the next quarterly period. Thereafter, such valves can be monitored once every quarter until a leak is detected. If a valve leak is detected, monthly monitoring of that valve is required until it has been shown leak free for two success months. At such time, quarterly monitoring can be reinstituted.

Alternative Standards. In an effort to provide flexibility to the standards, EPA included two alternative standards for valves in gas/vapor service, in light liquid service, and in VHAP service. Owners or operators of affected facilities are allowed to identify and to elect and comply with either of the alternative standards rather than the monthly monitoring LDAR program. This allows owners and operators to tailor the equipment leak requirements for these valves to their own operations. Slide 2-38

Owners and operators are first required to carry out a monthly monitoring program for at least one year. Then, a plant owner or operator can elect to comply with one of the alternative standards based on the information gathered during the one year's implementation of monthly monitoring.

The first alternative standard for these valves limits to 2 percent the maximum percent of valves leaking within a process unit, determined by a minimum of one performance test annually. This alternative was provided to eliminate unreasonable costs. It provides an incentive to maintain a good performance level and promotes low-leak unit design. The standard can be met by implementing any type of leak detection and repair program and engineering controls chosen at the discretion of the owner or operator. Slide 2-39

A performance test to demonstrate compliance is required to be conducted initially upon designation, annually, and at other times requested by the Administrator. Performance tests are to be conducted by monitoring all valves in gas/vapor service and all valves in light liquid service located in the affected facility within 1 week. If an instrument reading of 10,000 ppm or greater is measured, a leak is detected. The leak percentage is calculated by dividing the number of valves for which leaks are detected by the number of valves in gas/vapor service and light liquid service within the affected facility. Inaccessible valves that would not be monitored on a routine basis are included in the performance test and subsequent annual tests. The annual monitoring interval is not considered burdensome for such valves. If the results of a performance test show a percentage of valves leaking higher than 2 percent, the process unit is not in compliance with the alternative standard.

Owners and operators electing to comply with this alternative standard are required to notify the Administrator 90 days before implementing this alternative standard. If an owner or operator determines that he no longer wishes to comply with this alternative standard, he can submit a notification in writing to the Administrator stating that he will comply with the work practice standard in §60.482-7 as appropriate.

The second alternative standard for these valves is a skip-period leak detection and repair program. Under the skip-period leak detection provisions, an owner or operator can skip from routine monitoring (monthly) to less frequent monitoring after completing a number of successful sequential monitoring intervals. Considering a performance level of less than 2 percent leaking and better than 90 percent certainty that all periods have this performance level, the following sets of conservative periods and fractions of periods skipped were determined: Slide 2-40

- two consecutive quarterly periods achieved to skip to semi-annual monitoring, and
- five consecutive quarterly periods achieved to skip to annual monitoring.

This alternative requires that, if the percentage of valves leaking is greater than 2.0, the monthly leak detection and repair program specified in §60.482-7 or §61.242-7, as appropriate, must be reinstituted. This does not preclude an owner or operator from electing to use this alternative standard again. Compliance with this alternative work practice standard would be determined by inspection and review of records.

As with the first alternative standard, owners and operators electing to comply with this alternative standard are required to notify the Administrator 90 days before implementing alternative standard. In addition, the owner or operator must identify with which of the two skip periods he or she is electing to comply.

**Difficult-to-Monitor Valves** Slide 2-41

Some valves are difficult to monitor because access to the valve is restricted. The standards allow an annual leak detection and repair program for valves that are difficult to monitor. Valves that are difficult to monitor are defined as valves that would require elevating the monitoring personnel more than two meters above any permanent available support surface. The intent of this definition is that ladders should be used to elevate monitoring personnel under safe conditions. However, valves that cannot be safely monitored by, at least, the use of ladders are classified as difficult to monitor, and, therefore, they may be monitored annually rather than monthly.

Difficult-to-monitor valves can be limited (but not necessarily entirely eliminated) in new process units, but can not be eliminated in existing process units. In new units, up to 3 percent of the valves can be designated as difficult-to-monitor; all other valves are subject to the monthly monitoring. This "less than 3 percent" allowance is not contained in the NESHAP standards.

Unsafe-to-Monitor Valves

Slide 2-42

In addition, some valves are "unsafe to monitor". Valves that are unsafe to monitor cannot be eliminated in new or existing units. The standards allow an owner or operator to submit a plan that defines a leak detection and repair program conforming with the routine monitoring requirements of the standards as much as possible given that monitoring should not occur under unsafe conditions. Valves that are unsafe to monitor are defined as those valves which could, based on the judgment of the owner or operator, expose monitoring personnel to imminent hazards from temperature, pressure, or explosive process conditions.

## Pump LDAR Programs

Slide 2-43

For pumps in light liquid service, monthly monitoring is required (unless an owner or operator elects to comply with the equipment standards). Slides 2-44 and 2-45 illustrate two types of pumps that would typically be subject to a LDAR program.

Slides 2-44 and 2-45

The EPA examined monthly and quarterly monitoring leak detection and repair programs and the use of dual mechanical seals with controlled degassing vents. Both LDAR programs are less costly than the equipment installation. The lowest average and incremental costs per megagram of VOC reduced were found to be associated with the monthly LDAR program. The monthly LDAR program achieves greater emission reduction than the quarterly LDAR program, but less than the installation of the control equipment. The cost of the control equipment, however, was found to be high. Because the incremental costs for this equipment was considered to be unreasonably high in light of the resulting incremental emission reductions, EPA selected monthly monitoring as the basis for the standards.

In addition, each pump in light liquid service is to be checked by visual inspection each calendar week for indications of liquids dripping from the pump seal.

The LDAR requirements for pumps in VHAP service are the same as those for pumps in light liquid service under the NSPS standards. The

In addition, each pump in light liquid service is to be checked by visual inspection each calendar week for indications of liquids dripping from the pump seal.

The LDAR requirements for pumps in VHAP service are the same as those for pumps in light liquid service under the NSPS standards. The NESHAP LDAR requirements, however, added a provision whereby any pump that is located within the boundary of an unmanned plant site is exempt from the weekly visual inspection requirements and the daily requirement to check sensors, provided that each pump is visually inspected as often as practicable and at least monthly.

**Other Equipment LDAR Programs**

Pumps and valves in heavy liquid service, pressure relief devices in light liquid or heavy liquid service, and flanges and other connectors are to be monitored within 5 days if evidence of a potential leak is found by visual, audible, olfactory, or any other detection method. A leak is considered detected if the monitoring shows a reading of 10,000 ppm or greater. These requirements also apply to NESHAP pressure relief devices in liquid service and flanges and other connectors. Slide 2-46

For pressure relief devices in gas/vapor service, the on-shore natural gas processing plant standards allow an owner or operator to monitor these components on a quarterly basis to determine whether there is a leak, and defines a leak as a reading of 10,000 ppm or greater. This differs from Subpart VV, which required these components to be operated with "no detectable emissions." (The difference is due to the results of the cost and emission reduction analyses for emission reduction alternatives at on-shore natural gas processing plants). Both subparts require monitoring of the pressure relief devices within 5 days after each pressure release.

After a pressure release, pressure relief devices located in a non-fractionating plant that is monitored only by nonplant personnel may be monitored the next time personnel are on site (instead of the 5 days noted above). However, these components must be monitored within 30 days after a pressure release.

**Exemptions from LDAR Programs**

Pumps in light liquid service, valves in gas/vapor service, valves in light liquid service, and pressure relief devices in gas/vapor service are exempt from the routine LDAR requirements of §60.482-2(a)(1),

§60.482-7(a) and §60.633(b)(1) if they are located (1) at a nonfractionating plant with a design capacity to process less than 10 million scfd of field gas or (2) in process units located in the Alaskan North Slope.

**Equipment, Design, and Operational Standards and Performance Standards** Slide 2-47

This part of the lecture focuses on the equipment, design, and operational standards and performance standards associated with each component. The components that have these standards are listed in Slide 2-48. Slide 2-48

Equipment standards, for our purposes, refer to either: (1) the design of the fugitive equipment, or control device; or (2) the physical control specifications. Design standards include requirements for dual mechanical seals; closed purge and vent systems; caps, blind flanges, second valves, and control equipment specification associated with flares and enclosed combustion devices. Included are operational standards that specify how certain equipment is to be operated.

Performance standards, for our purposes, refer to: (1) no detectable emissions, and (2) for control devices, percent reduction efficiency. Annual monitoring is used for components subject to the "no detectable emissions" requirement. These components include pumps, compressors, valves (those specifically designated for no detectable emissions), and closed-vent systems for both NSPS and NESHAP. As discussed earlier, "no detectable emissions" means emissions are less than 500 ppm above background levels. These components are to be tested for compliance with "no detectable emissions" initially upon designation, annually, and at other times requested by the Administrator. The longer interval reflects the expectation that leaks do not occur in leakless equipment.

Other monitoring intervals are specified in the rules. Pressure relief devices in gas/vapor service (NSPS and NESHAP) are to be monitored as soon as practicable, but no later than 5 calendar days after a pressure release, to determine whether the device has been returned to a condition of "no detectable emissions."

**Pumps** Slide 2-49

In addition to the LDAR program, the regulations identify both equipment, design, and operation standards and performance standards. The wording of the regulations is such that a pump does not need to comply with the LDAR program if it meets one of three conditions.

Dual Mechanical Seal System. A pump in light liquid service is exempt from the LDAR program if it is equipped with a dual mechanical seal system that includes a barrier fluid system. (This does not exempt such pumps from the weekly visual inspection for indications of liquids dripping from the pump seals). This equipment standard was the original standard proposed for these pumps.

The regulation identifies three conditions, one of which must be met in order for pumps with a dual mechanical seal system that includes a barrier fluid system to be exempt from the LDAR program. These are:

1. Operated with the barrier fluid at a pressure that is at all times greater than the pump stuffing pressure. Slide 2-50

   (VOC leakage to the atmosphere will not occur if the barrier fluid is maintained at a pressure greater than the stuffing box pressure, because all leaks would be inward, into the process fluid).

2. Equipped with a barrier fluid degassing reservoir that is connected by a closed vent system to a control device.

3. Equipped with a system that purges the barrier fluid into a process stream with zero VOC (or VHAP) emissions to the atmosphere.

   (If the stuffing box pressure is greater than the barrier fluid pressure, the barrier fluid between the two seals collects leakage from the inner seal. The VOC collected by the barrier fluid can be controlled by connecting the barrier fluid reservoir to a control device with a closed vent system or by returning it to the process).

When equipment standards are established, Section 111(h) of the Clean Air Act requires that requirements be also established to ensure the proper operating and maintenance of the equipment. The standards for pumps therefore require the following:

- The barrier fluid system is to be either in heavy liquid service or not in VOC service. Slide 2-51

(The use of light liquid VOC as a barrier fluid could result in emissions of VOC of the same magnitude as those that would occur if product VOC were allowed to leak past the seals.)

- Each barrier fluid system is to be equipped with a sensor that will detect failure of the seal system, the barrier fluid system, or both. The regulations allow the owner/operator to determine the criterion to be used to indicate failure. Slide 2-52

  (Such a system would reveal any catastrophic failure of the inner or outer seal or barrier fluid system).

- Each sensor is to be checked daily or is to be equipped with an audible alarm.

- When a leak is detected (either by visual inspection or by the sensor indicating a failure), it is to be repaired as soon as practicable, but no later that 15 days after it is detected, except as provided by the "Delay of Repair" provisions. A first attempt at repair is to take place no later than 5 days after each leak is detected.

Slide 2-53 illustrates a typical double mechanical seal on a pump. Slide 2-53

No Detectable Emissions. Pumps do not need to comply with the LDAR program or dual mechanical seal system requirement if it is designated for no detectable emissions, which is indicated by an instrument reading of less than 500 ppm above background. However, any pump that is designated for "no detectable emissions" can not have an externally actuated shaft that penetrates the pump housing. Slides 2-55 through 2-57 illustrate several types of pumps that do not have an externally actuated shaft penetrating the pump housing. These pumps are candidates for designation for "no detectable emissions." Slide 2-54 Slides 2-55 to 2-57

Pumps designated for "no detectable emissions are to be (1) demonstrated to be operating with no detectable emissions as indicated by an instrument reading of less than 500 ppm above background and (2) tested for compliance with the less-than-500 ppm above background reading initially upon its designation, annually, and at other times as requested by the Administrator.

<u>Closed Vent System and Control Device</u>. If a pump is equipped with a closed vent system capable of capturing and transporting any leakage from the seal or seals to a control device that complies with the requirements identified in the rule for such control device, it is exempt from the requirements identified in the above paragraphs. Slide 2-58

<u>Exemptions</u>. Subparts GGG and KKK exempt pumps in light liquid service located in process units that are located in the Alaskan North Slope from the routine leak detection and repair requirements, but not the equipment standards.

Subpart KKK also exempts these pumps if they are located in nonfractionating plants with a design capacity of less than 10 million standard cubic feet per day from the routine leak detection and repair requirements but not the equipment standards.

<u>Compressors</u> Slide 2-59

The basic requirements for compressors are found in §60.482-3 of Subpart VV (40 CFR Part 60) and §61.242-3 of Subpart V (40 CFR Part 61). Compressors may comply with either an equipment standard or a performance standard. The equipment standard requires either:

1. A seal system that includes a barrier fluid system and that prevents leakage of VOC to the atmosphere; or

2. A closed vent system and control device.

<u>Seal System with Barrier Fluid System</u>. As for pumps in light liquid service, there are three conditions associated with this equipment standard, any one of which must be met. These are: Slide 2-60

1. Operated with the barrier fluid at a pressure that is at all times greater than the compressor stuffing box pressure; or

2. Equipped with a barrier fluid system that is connected by a closed vent system to a control device that meets the requirements specified in the rule for such control device; or

3. Equipped with a system that purges the barrier fluid into a process stream with zero VOC (or VHAP) emissions to the atmosphere

Also, as for pumps in light liquid service, there are several operation- and maintenance-type conditions that are to be met. These are:

- The barrier fluid system is to be either in heavy liquid service or not in VOC (or VHAP) service. Slide 2-61

- Each barrier fluid system is to be equipped with a sensor that will detect failure of the seal system, the barrier fluid system, or both.

- Each sensor is to be checked daily or is to be equipped with an audible alarm. (Subpart V exempts compressors located is unmanned plant sites from this particular requirement.)

- When a leak is detected (based on the sensor indicating failure), it is to be repaired as soon as practicable, but no later than 15 days after it is detected, except as provided by the "Delay of Repair" provisions. A first attempt at repair is to take place no later than 5 days after each leak is detected.

Note that the standards for compressors do not require weekly visual inspection for indications of a potential leak as was required for pumps in light liquid service.

<u>Closed Vent System and Control Device</u>. A compressor does not need to comply with the above equipment standard if it is equipped with a closed vent system capable of capturing and transporting any leakage from the seal to a control device that complies with the requirements specified in the rules for that control device. Slide 2-63 illustrates a liquid-film compressor shaft seal. This type of seal does not eliminate VOC leakage, and thus a closed-vent system to a control device is likely to be needed. Slide 2-62 Slide 2-63

<u>No Detectable Emissions</u>. Some compressors may be designated for "no detectable emissions." Such compressors do not need to comply with either equipment standard described above. Compressors that are designated for "no detectable emissions" are to comply with this performance standard by: Slide 2-64

1. demonstrating that it is operating with no detectable emissions, as indicated by an instrument reading of less than 500 ppm above background; and

2. testing for compliance with the less-than-500 ppm above background reading initially upon designation, annually thereafter, and at other times as requested by the Administrator.

**Exemptions**. Both Subparts VV and GGG exempt reciprocating compressors from the equipment standards for compressors, if the only means for bringing the compressor into compliance with §60.482-3(a) through (e) and (h) are through either the recasting of the distance piece or the replacement of the compressor. Subpart GGG also has an exemption for compressors in hydrogen service.

Subpart KKK exempts reciprocating compressors in wet gas service from all of §60.482-3, but requires reciprocating compressors in natural gas liquid service to comply with §60.482-3.

Subparts V, F, and J do not exclude any type of compressor from compliance; both rotating and reciprocating compressors are covered. The monitoring requirements for compressors in VHAP service are the same as those for compressors in VOC service under the NSPS standards, except that for compressors located within the boundary of an unmanned plant site each sensor required does not need to be checked daily or equipped with an audible alarm.

**Pressure Relief Devices in Gas/Vapor Service** Slides 2-65 through 2-67

The standards for pressure relief devices in gas/vapor service requires them either to operate with no detectable emissions or to be equipped with a closed vent system and control device. As for pumps and compressors, "no detectable emissions" refers to an instrument reading of less than 500 ppm above background. Pressure relief devices complying with the no detectable emissions standard are to be returned to that condition within 5 calendar days after each pressure release, except as provided in the "Delay of Repair" provisions. The standards also require that the pressure relief device be monitored not later than 5 calendar days after a pressure release to confirm the condition of no detectable emissions has been achieved. Slide 2-68

The pressure relief devices do not need to comply with the "no detectable emissions" standard if they are equipped with a closed-vent system capable of capturing and transporting leakage from the pressure relief device to a control device that meets the requirements for that control device. Slide 2-69

All of the subparts cover all pressure relief devices in gas/vapor service with one exception. Subpart KKK exempts these devices from the routine monitoring requirements if they are in process units located in the Alaskan North Slope.

<u>Sampling Connection Systems</u> Slide 2-70

Sampling connection systems are to be equipped with a closed purge system or a closed vent system. Each closed-purge system or closed-vent system is to do one of the following:

- return the purged process fluid directly into the process line with zero VOC or (VHAP) emissions to the atmosphere; or
- collect and recycle the purged process fluid with zero VOC (or VHAP) emissions; or
- be designed and operated to capture and transport all the purged process fluid to a control device that complies with the requirements for that control device.

Slide 2-71 illustrates two closed-loop sampling systems. Slide 2-71

Subparts VV, GGG, V, and J exempt in-situ sampling systems, while Subpart KKK exempts all sampling connection systems.

<u>Open-Ended Valves or Lines</u> Slide 2-72

Like sampling connection systems, open-ended valves or lines only have equipment standards including operational requirements; there are no performance or work practice standards. Open-ended valves or lines are to be equipped with a cap, blind flange, plug, or second valve. 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 valve or line.

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 line or valve.

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. Slide 2-73

If a double block-and-bleed system is being used, the bleed valve or line is allowed to 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 is to be sealed (again, except during operations requiring process fluid flow through the open-ended line or valve).

**Process Valves** Slide 2-74

Leak detection and repair programs are the primary standards for controlling equipment leak emissions from process valves. The standards allow these valves to comply with the performance standard of "no detectable emissions." A valve may be designated for "no detectable emissions" only if it does not have an external actuating mechanism in contact with the process fluid. As for the other equipment so designated, "no detectable emissions" refers to an instrument reading of less than 500 ppm above background. Valves designated for "no detectable emissions" are to be operated with emissions less than 500 ppm above background and to be tested for compliance with the less-than-500 ppm above background reading initially upon designation, annually thereafter, and at other times as requested by the Administrator. Slides 2-76 and 2-77 illustrate two types of diaphragm seals. These types of seals would allow these valves to be designated for "no detectable emissions" as there is no external actuating mechanism in contact with the process fluid. Similarly, sealed bellows valves (see Slide 2-78) do not have a stem or gland and, therefore, are not prone to leak. These valves can also be designated for "no detectable emissions."

Slide 2-75

Slides 2-76 and 2-77

Slide 2-78

**Flanges and Other Connectors**

Flanges and other connectors are subject to the "no evidence of a potential leak" work practice standard, which was discussed earlier. There are no equipment or performance standards for these components.

**Product Accumulator Vessels** Slide 2-79

These vessels (NESHAP only) are subject to equipment standards only; there are no performance or work practice standards. The equipment standards require product accumulator vessels to be equipped with a closed-vent system capable of capturing and transporting any leakage from the vessel to a control device that meets the requirements for that control device.

**Agitators** Slide 2-80

Vinyl chloride emissions from seals on all agitators in vinyl chloride service are to be minimized by installing agitators with double mechanical seals or equivalent. If double mechanical seals are used, then one of the following is required:

- maintaining the pressure between the two seals so that any leak that occurs is into the agitated vessel; or
- ducting any vinyl chloride between the two seals through a control system from which the vinyl chloride in the exhaust gases does not exceed 10 ppm; or
- equivalent.

**Closed Vent Systems and Control Devices**

As with the various individual equipment components, the closed vent systems and control devices that can be used to comply with the standards also have equipment and performance standards.

Closed Vent Systems. Closed vent systems are to be designed for and operated with no detectable emissions. They are to be monitored at startup, annually thereafter, and at other times as may be requested by the Administrator. In addition, closed vent systems are to be operated at all times when emissions may be vented to them. Slide 2-81

Control Devices. Control devices identified are vapor recovery systems, enclosed combustion devices, and flares. Control devices are to be monitored to ensure proper maintenance and operation. The parameters to be monitored are selected by the plant owner or operator. The regulations also require that control devices are operated at all times when emissions may be vented to them. Slide 2-82 Slide 2-83

Vapor recovery systems (such as condensers and adsorbers) are to be designed and operated to recover the organic vapors vented to them with an efficiency of 95 percent or greater.

Enclosed combustion devices are required to reduce emissions by at least 95 percent or to be operated with a minimum residence time at a minimum temperature. For enclosed combustion devices used to comply with the NSPS, minimum residence time is 0.75 seconds and the minimum temperature is 816°C. For enclosed combustion devices used to comply with the NESHAP, these values are 0.5 seconds and 760°C, respectively The differences in the residence times and temperatures reflects, in part, continuing research and conclusions as to the minimum residence time and temperature required to ensure that 95 percent (or higher) reduction efficiencies are achieved.

Subpart VV states that flares used to comply with this subpart are to comply with the requirements §60.18. Section 60.18 requires the use of a steam-assisted, air-assisted, or nonassisted flare. These flares are to be operated with no visible emissions, except for periods not to exceed a total of 5 minutes during any 2 consecutive hours. They are to be operated with a flame present at all times. The presence of a flare pilot flame is to be monitored using a thermocouple or any other equivalent device to detect the presence of a flame. In addition, owners or operators are to monitor the flares to ensure that they are operated and maintained in conformance with their designs. Finally, Section 60.18 identifies minimum net heating values and maximum exit velocities for the flares. Slide 2-84

Subpart V incorporates these same provisions. There may be some discrepancies in the methods identified in Subpart V for calculating net heating values or exit velocities with those in §60.18. Where such discrepancies are found, the methods identified in §60.18 should be used.

Slide 2-85 illustrates a simplified closed-vent system with a dual flare system. Slide 2-85

## Equivalent Means of Emission Limitations

Slide 2-86

Under the standards, any owner or operator of an affected facility can request that the Administrator determine the equivalence of any alternative means of emission limitation to the equipment, design, operational, and work practice requirements of the standards. Excluded from this provision are the standards for pressure relief devices in gas/vapor service and the standards for delay of repair. The equivalent means of emission limitations are the same for both NSPSs (§60.484) and NESHAPs (§61.244).

Each owner or operator subject to the provisions of these subparts may apply to the Administrator for determination of equivalence for any means of emission limitation that achieves a reduction in VOC emissions of at least equivalent to the reduction in emissions of VOC achieved by the controls required in these subparts. In addition, manufacturers of equipment used to control equipment leaks of VOC can apply to the Administrator for determination of Slide 2-87 equivalence for any equivalent means of limitation that achieves a reduction in VOC emissions achieved by the equipment, design, and operational requirements of these subparts.

After a request for determination of equivalence is received, the Administrator publishes a notice in the Federal Register and provides an opportunity for a public hearing if the Administrator judges that the request may be approved. After the notice has been published and an opportunity for a public hearing provide, the Administrator determines the equivalence of the means of emission limitation. (Guidelines used to make this determination are outlined below.) The determination is then published in the Federal Register. Any approved equivalent means of emission limitations constitute a required work practice, equipment, design, or operational standard within the meaning of Section 111(h)(1) of the Clean Air Act.

The standards identify guidelines for determining equivalence. For determining equivalence to the equipment, design, and operational requirements, the following guidelines are specified:

- Each owner or operator or equipment manufacturer is responsible for collecting and verifying test data to demonstrate equivalence of means of emission limitation. Sufficient information needs to be collected to demonstrate that the alternative control technique is equivalent to the control technique specified in the standards.

- The Administrator then compares the test data submitted by the owner, operator, or equipment manufacturer to the test data for the equipment, design, and operational requirements.

- The Administrator is allowed to condition the approval of equivalence on requirements that may be necessary to ensure operation and maintenance to achieve the same emission reduction as the equipment, design, and operational requirements.

For determining equivalency with the required work practices, the following guidelines are specified:

- As above, each owner or operator is responsible for collecting and verifying test data to demonstrate equivalence of means of emission limitation.

- For each affected facility for which a determination of equivalence is requested, the emission reduction achieved by the required work practice is to be demonstrated.

- Each owner or operator is to commit to work practice(s) that provide for emission reductions equal to or greater than the emission reductions achieved by the required work practice.

- The Administrator then compares the demonstrated emission reduction for the equivalent means of emission limitation to the demonstrated emission reduction for the required work practice and will consider the commitment of the owner or operator to work practices (as noted in the above paragraph).

- The Administrator may condition the approval of equivalence or requirements that may be necessary to ensure operation and maintenance to achieve the same emission reduction as the required work practice.

If he or she desires, an owner or operator may offer a unique approach to demonstrate the equivalence of any equivalent means of emission limitation.

## TEST METHODS AND PROCEDURES

Slide 2-88

This section of the lecture outlines the requirements associated with the test methods and procedures used to comply with the standards. Each owner or operator subject to these standards are required to comply with the test methods and procedure requirements provided in these sections of the regulations. Slide 2-89 lists the areas covered by test methods and procedures, which are discussed briefly below.

Slide 2-89

### Monitoring Method

All monitoring for leaks is to be performed in accordance with Reference Method 21. The test methods and procedures section discusses some of the specifics in using Method 21. A detailed discussion of Method 21 is presented in Lecture 6.

In VOC (or VHAP) Service Presumption

One of the basic presumptions of the equipment leak standards is that a piece of equipment is in VOC (or VHAP) service and, thus, is subject to the standards. This presumption can be overcome by an owner or operator demonstrating that the piece of equipment is not in VOC (or VHAP) service.

In order for a piece of equipment to be considered not in VOC (or VHAP) service, it must be determined that the percent VOC (or VHAP) can be reasonably expected never to exceed 10 percent by weight. For VOCs, the weight percent determination is to conform to the general methods described in ASTM E-260, E-168, or E-169. For VHAPs the weight percent determination is to conform to the general method described in ASTM D-2267.

Subpart KKK extends this presumption to equipment in wet gas service (i.e., each piece of equipment is presumed to be in VOC service or in wet gas service). For a piece of equipment to be in wet gas service, it must be determined that it contains or contacts the field gas before the extraction step in the process. An owner or operator must demonstrate otherwise to exclude equipment from the in-wet-gas-service presumption.

In determining the weight percent VOC of the process fluid, an owner or operator may exclude non-reactive organic compounds from the total quantity of organics provided:

- the substances excluded are those considered to have negligible reactivity by the Administrator, and

- the owner or operator demonstrates that the percent organic content, excluding non-reactive organic compounds, can be reasonably expected never to exceed 10 percent by weight.

An owner or operator may elect to use engineering judgment rather than procedures outlined above to demonstrate that the weight percent does not exceed 10 percent. The rule requires that the engineering judgment demonstrates that the VOC (or VHAP) content clearly (emphasis added) does not exceed 10 percent by weight. If there is disagreement between EPA and an owner or operator about whether the engineering judgement clearly demonstrates this, then the procedures outlined above (use of the appropriate ASTM method) are to be used to resolve the disagreement.

If an owner or operator determines that a piece of equipment is in VOC (or VHAP) service, the determination can be revised only after following the procedure associated with the ASTM methods; engineering judgement cannot be used to revise the determination.

In Light Liquid Service Conditions

For the NSPSs, a distinction is made between equipment according to the type of service. In this section of the rule, the conditions for determining whether a piece of equipment is in light liquid service are identified. In Subpart V, the conditions are:

- the vapor pressure of one or more of the components is greater than 0.3 kPa at 20°C;
- the total concentration of the pure compounds have a vapor pressure greater than 0.3 kPa at 20°C is equal to or greater than 20 percent by weight; or
- the fluid is liquid at room temperature.

In making the above determination, vapor pressures may be obtained from standard references or may be determined by ASTM D-2879.

As noted earlier, Subparts KKK and GGG allow owners or operators to use an alternative definition for in light liquid service. In these two standards, a piece of equipment can be designated as being in light liquid service if:

- the weight percent evaporated is greater than 10 percent at 150°C (as determined by ASTM Method D86).

Representative Samples

This part of the rules simply states that the samples taken in conjunction with: (1) determining that a piece of equipment is not in VOC (or VHAP) service, (2) determining whether a piece of equipment is light liquid service, and (3) the heat content of the gas shall be representative of the process fluid that is contained in or contacts the equipment or the gas being combusted in a flare.

<u>Flares</u>

Both Subpart VV (40 CFR Part 60) and Subpart V (40 CFR Part 61) identify certain requirements associated with the use of flares in complying with these standards. These requirements include the use of Reference Method 22 to determine compliance with the visible emission provisions for flares and the monitoring of the presence of a flare pilot flame using a thermocouple or any other equivalent device to detect the presence of a flame. The requirements also include calculation and sampling procedures for determining the heat content and exit velocity. All of these requirements are also found in Section 60.18 of 40 CFR Part 60. Some discrepancies may be found in the individual subparts when compared to Section 60.18. If so, the procedures in Section 60.18 should be followed.

**RECORDKEEPING AND REPORTING REQUIREMENTS**

Slides 2-90 through 2-93

Recordkeeping and reporting requirements are included in regulations to provide documentation for the assessment of compliance with each type of standard (work practice, performance, equipment, etc.). Review of these records and reports provide information for enforcement personnel to assess implementation of the standards. Compliance with the standards is determined, in general, by the inspection and review of the records.

Slide 2-91 lists some of the records to be kept by the plant owner or operator during activities associated with complying with the standards. Slide 2-93 lists some of the reports an owner or operator is required to submit. Review of the submitted reports reduces, but does not necessarily eliminate, the need for in-plant inspections. A detailed discussion on the specific recordkeeping and reporting requirements is found in Lecture 7.

# LECTURE 3

## SUMMARY OF THE HAZARDOUS ORGANIC NESHAP (HON)

### INTRODUCTION

Notes

Existing regulations, adopted under sections 111 and 112 of the Clean Air Act and in State Implementation Plans (SIPs), have been effective in heightening industry's awareness of the significance of equipment leaks and in stimulating their control efforts. When these rules were established, EPA estimated that emissions would be reduced by between 60 and 70 percent, and that after control, leak frequencies at applicable plants would be approximately 5 percent. Slide 3-1

Since that time, data gathered on equipment leaks at some selected chemical plants indicate that lower leak frequencies can be achieved. Unfortunately, procedures specifying how low leak frequencies could be obtained at all chemical plants were not included in the data. Consequently, EPA saw the need for a new regulatory approach, but at the same time recognized that establishing a regulation for such a broad and varied source category as chemical production units would be difficult. Slide 3-2

### RULEMAKING PROCESS

Slide 3-3

Accordingly, on April 25, 1989 (under 54 FR 17944), EPA announced its intent to form an advisory committee to negotiate issues leading to this new regulatory approach. On September 12, 1989, it announced the formation of the Committee, under the Federal Advisory Committee Act (54 FR 37725). During the course of the following year, the Committee met periodically and successfully agreed in principle to the provisions and language of an equipment leak regulation. EPA plans to propose this rule in early 1992 with promulgation scheduled for fall 1992 as part of the hazardous organic national emission standards for hazardous air pollutants (NESHAP). Additionally, the proposed Hazardous Organic NESHAP, or HON, will cover other emission points as well as equipment leaks; specifically, storage and transfer points, process vents, and wastewater emissions.

Standards would apply to equipment in volatile hazardous air pollutant (VHAP) service 300 or more hours per year associated with any of the 453 processes listed in the regulation that make or use as a reactant one of the organic VHAPs listed in § XX.X8-1 of the regulation (these VHAPs are also listed in Reference Volume 1-3.1).

Standards also apply to equipment handling specific chemicals for a limited number of non-SOCMI processes (including benzene and vinyl chloride) listed in the negotiated rule.

It is notable that petroleum refinery processes are not covered by the HON. EPA plans to conduct a separate rulemaking for these processes.

The equipment to be affected include valves, pumps, connectors, compressors, pressure-relief devices, open-ended lines, sampling connection systems, instrumentation systems, agitators, product accumulation vessels, and closed-vent systems and control devices that are used "in VHAP service."

"In VHAP service" means that the equipment contains or contacts a fluid that is 5 percent or greater VHAPs.

**RULE MILESTONES**

Standards would also split the chemicals and processes to be covered into 5 distinct groups to which the regulation would apply over specific periods of time. The chemicals and processes to be affected are listed in Reference Volume 1-2.1, mentioned previously, and Reference Volume 1-3.2 which lists the chemical processes to be covered (note that benzene and vinyl chloride are in Group I).

The rule applies to the first group 6 months after promulgation (scheduled for Fall 1992). Thereafter, the rule would become applicable to another group every 3 months until all of the processes are covered. The plant owner/operator may also elect to apply the applicability date of an earlier to a later group if he so desires.

**STANDARDS FOR PUMPS AND VALVES**

**Pumps and Valves**

The standards for pumps and valves are to be implemented in 3 phases; and standards for both pumps in light liquid service, and valves in gas/vapor and light liquid service must have associated quality improvement programs (QIPs). These QIPs will be discussed in detail later. Phase I of the standards includes the provisions listed on Slide A-6.

Phase II for existing pumps and valves begins 1 year after the applicability date of the regulation and includes a lower leak definition than Phase I. Its provisions are listed on Slide 3-7.

Equipment base performance levels are associated with Phase III monitoring, and encompass the provisions listed on Slide 3-8.

**Phase III for Pumps and Valves**

- For existing units, the standards apply 2 1/2 years after the applicability date of the regulation.

- For new process units, the standards apply 1 year after start-up.

- The LDAR leak definitions for pumps and valves are as follows:

    - 5,000 ppm - (pumps) polymerizing monomers
    - 2,000 ppm - (pumps) food/medical service
    - 1,000 ppm - (pumps) all other processes (repair required only if detection instrument reads in excess of 2,000 ppm)

- The LDAR leak definition for Phase III valves is the same as Phase II:

    - 500 ppm - all valves

**Phase III Pumps**

The equipment base performance level is calculated on a 6 month rolling average and is defined as the larger number of the following 2 values:

(1) 10 percent of the pumps in a process unit (or plant site), or

(2) 3 pumps in a process unit (or plant site).

If the number of pumps found to be leaking in a process unit or plant site is equal to or greater than the larger of (1) or (2) above, the owner/operator must implement a quality improvement program (QIP) for pumps that complies with the requirements of § XX.X3-2 of the HON.

The formula for calculation of percent leaking pumps is somewhat different than under the old regulation and is defined on Slide 3-9.

## QIP PROGRAMS

Generally, a QIP program consists of information gathering, determining superior performing technologies, and replacing poorer performance with the superior technologies until the required base performance levels are achieved. [In this vein, the QIP is a concept that enables plants exceeding base performance levels to eventually achieve the desired levels without incurring penalties or being in noncompliance].

The comprehensive QIP program for pumps is outlined in Reference Volume 1-3.3 as follows:

- The owner/operator shall comply with the QIP program until the number of leaking pumps is less than the greater of either 10 percent of the pumps or 3 pumps, as calculated as a 6-month-rolling average, in the process unit (or plant site). Once this performance level is achieved, the owner/operator shall again be under the compliance requirements of Phase III.

- If in a subsequent monitoring period, the process unit or plant site has greater than 10 percent of the pumps leaking or 3 pumps leaking, as calculated previously, the owner/operator shall resume the QIP program.

- The QIP program shall include data collection on the following processes/equipment:

  - pump type, manufacturer, seal type and manufacturer, pump design, materials of construction; if applicable, barrier fluid or packing material, and year installed;

  - service characteristics of the emission stream such as discharge pressure,temperature, flow rate, corrosivity, and annual operating hours;

  - maximum instrument readings;

  - repair methods used and the instrument readings after the repair.

- The owner/operator shall inspect all pumps that exhibit frequent failure and recommend, as appropriate, design changes or changes in specifications to reduce leak potential.

- The data gathered shall be analyzed to determine the services, operating or maintenance practices, and pump or pump seal designs or technologies that have poorer than average performance and those that are better. The analysis shall be used to identify specific trouble areas.

- The analysis shall also be used to determine if there are superior performing pump or pump seal technologies that are applicable to the service(s), operating conditions, or pump or pump seal designs associated with poorer than average emission performance.

- The first analysis of the data shall be completed no later than 18 months after the start of the program, shall use a minimum of 6 months of data, may be conducted through an interior intracompany program, and shall be done yearly for as long as the pump is in the QIP.

- There shall be a trial evaluation program for plants that have no demonstrated superior technologies. The program shall focus on operating and maintenance practices that have been identified by others as having low emission performance.

- The number of pump seal technologies or pumps in the trial program shall be the lesser of 1 percent or 2 pumps for programs involving single process units and the lesser of 1 percent or 5 pumps for groups of process units. The minimum number of technologies in the program shall be 1.

- The program shall specify and include documentation of the designs and/or technologies to be tried, the evaluation stages, the frequency of monitoring or inspection, the range of operating conditions, and conclusions.

- The performance trials shall be conducted for a 6-month period beginning no later than 18 months after the beginning of the QIP. Conclusions will be drawn no later than 24 months after the beginning of the QIP.

- Each owner/operator shall prepare and implement a pump quality assurance program that details purchasing specifications and maintenance procedures for all pumps and pump seals in the process unit. This program shall be implemented no later than the start of the third year of the QIP program for plant sites with more than 400 valves or 100 or more employees, and no later than the start of the fourth year for other plants.

Beginning at the start of the third year of the QIP for plants with 400 or more valves or 100 or more employees and at the start of the fourth year for others, the owner/operator shall replace the pumps and pump seals that are not of superior technology. Pumps or pump seals shall be replaced at the rate of 20 percent per year and shall continue to be replaced until all are of superior technology.

## VALVES

Valves would initially require quarterly monitoring in Phases I and II, but the length of time between monitoring cycles could be increased in Phase III if the percent leaking valves demonstrates incrementally better performance over the base level. The base performance level for valves in Phase III is defined as 2 percent "leakers". These performance characteristics can be seen in Slide 3-11.

(1) At process units with 2 percent or greater leaking valves, the owner/operator shall either monitor each valve once per month; or implement a QIP program and monitor quarterly.

(2) At process units with less than 2 percent leaking valves, the owner/operator shall monitor each valve once each quarter.

(3) At process units with less than 1 percent leaking valves, the owner/operator may elect to monitor each valve once every 2 quarters.

(4) At process units with less than 0.5 percent leaking valves, the owner/operator may elect to monitor each valve once every 4 quarters.

Calculation of leaking units is made with the same type of equation as for pumps and can be found in § XX.X2-7 of the HON as well as in Slide 3-12. As can be seen from this calculation, the owner/operator can take partial credit for valves permanently removed from the process units; and a limited number (maximum of 1 percent) of "nonrepairable" valves (those that cannot be repaired without a process unit shutdown) may also be excluded. Additionally, plants with fewer than 250 valves in VHAP service are subject only to LDAR and not the base performance level of 2 percent leaking valves of Phase III.

If an owner/operator elects to use a QIP to demonstrate further progress, he must meet the requirements of the basic QIP for valves as has been presented in Reference Volume 1-3.4.

After the process unit has fewer than 2 percent leaking valves, the owner/operator may elect one of three options:

(1) to continue the QIP, which exempts him from the requirements for performance trials under the technology review section, and further progress requirements as outlined in the Reference Volume 1-3.4;

(2) to comply with the technology review section of the QIP and the procedures outlined in Phase III requirements for valves, which takes advantage of the lower monitoring frequencies associated with lower leak rates;

(3) to discontinue the QIP (the QIP will no longer be an option if the process unit again exceeds 2 percent leaking valves [monthly monitoring will be required]).

**CONNECTORS**

The HON mandates that all connectors in gas/vapor and light liquid service must be monitored within the first 12 months after the rule applicability date for each process OR within 12 months of start-up or rule promulgation, whichever is later, for new process units. It also specifies a base performance level of 0.5 percent and a leak definition of 500 ppm or greater.

| CONNECTOR MONITORING SCHEDULE | |
|---|---|
| **Performance Level** | **Monitoring Schedule** |
| 0.5% or greater leaks during the last monitoring period | once a calendar year |
| less than 0.5% leaks during the last monitoring period | once every 2 calendar years<br>OR<br>at least 40% during year 1 and the remainder in year 2 |
| less than 0.5% leaks during the last 2-year monitoring period | once every 4 calendar years<br>OR<br>at least 20% every year until all are monitored |
| **CONTINGENCY PLAN** | |
| 0.5% < leaks < 1% during the last 4-year monitoring period | once every 2 years<br>OR<br>at least 40% during year 1 and the remainder in year 2 |
| 1% or greater leaks during the last 4-year period | once per calendar year |

As can be seen in this slide, a consistent achievement of base performance results in monitoring being required less frequently, while failure to achieve the base performance (0.5 percent leaking connectors) causes a source to remain in an annual monitoring cycle. In any case, monitoring is conducted according to the schedule outlined on the slide.

Slide 3-15a
Slide 3-15b

The percent leaking connectors is calculated using one of two formulas:

(1) equation #1 is to be used for the first monitoring period only, and — Slide 3-16

(2) equation #2 for all subsequent monitoring periods. — Slide 3-17

**OTHER EQUIPMENT** Slide 3-18

The standards for compressors, open-ended lines, pressure relief devices, sampling connection systems, and closed vent systems and control devices remain essentially unchanged from existing regulations (40 CFR 61, Subpart V.)

Agitators must meet LDAR requirements and have a leak definition of 10,000 ppm but have no base performance levels.

Pumps, valves, connectors, and agitators in heavy liquid service; instrumentation systems; and pressure relief devices in liquid service are subject to instrument monitoring only if evidence of a potential leak is found through sight, sound, or smell. (In which case monitoring is required within 5 days of detection).

Instrumentation systems are defined as consisting of smaller pipes and tubing that carry samples of process fluids to be analyzed to determine process operating conditions.

**ALTERNATIVE STANDARDS**

Specific alternative standards have been written for batch or cyclical processes, and total building enclosure systems. Batch/cyclical processes are required to either; (a) meet similar standards to those for continuous processes with the monitoring frequency prorated to time in use or, (b) periodically pressure test the entire system, again based on process time in use. Additionally, under (b), each batch process that operates in VHAP service during a calendar year must be pressure tested at least once during that same calendar year.

If the owner/operator chooses to meet monitoring standards similar to those for continuous processes, he must base his frequency of monitoring on the schedule presented in Slide 3-19a (with adjustments allowed to accommodate process conditions). Exceptions to the rule include: connectors that must be monitored the same as for continuous processes, valves that may be monitored once each year, and agitators that may be monitored once each quarter if the time that each valve and/or agitator is in VHAP service is less than 2190 hours in a calendar year. Monitoring for other equipment must be modeled after the Table on the following slide. Slide 3-19A

**BATCH PROCESSES** (Prorate for time of use as shown below)

| **BATCH PROCESS EQUIPMENT MONITORING FREQUENCIES** | | | |
|---|---|---|---|
| **Batch Process Time in Use** | **Equivalent Continuous Process Monitoring Frequency** | | |
| | **Monthly** | **Quarterly** | **Semiannually** |
| 0 to < 25% | quarterly | annually | annually |
| 25 to < 50% | quarterly | semiannually | annually |
| 50 to < 75% | bimonthly | three times a year | semiannually |
| 75 to < 100% | monthly | quarterly | semiannually |

**OR**

Periodically Pressure Test the System.

- When testing with a gas, Leak Definition = Pressure Change of 1 psig/hr,
- When testing with a liquid, Leak Definition = Dripping Liquid.

Building Enclosure Systems.

- No monitoring is required if negative pressure is maintained in the building,
- All emissions must be routed through a control device.

Under option (b), pressure testing, using a gas; a leak is defined as a rate of pressure change in excess of 1 psig in 1 hour; or if there is visible, audible, or olfactory evidence of fluid loss. For pressure tests using a liquid, a leak is defined as dripping liquid or other evidence of fluid loss from process units. When leaks are detected, repairs must be made and a retest conducted before VHAP is fed to the equipment. If the process unit fails this retest or the second of 2 consecutive pressure tests, the equipment must be repaired as soon as practicable but not later than 30 calendar days after the equipment is placed in VHAP service.

Total building enclosure systems may forego monitoring of pumps, valves, liquid service equipment, agitators, and connectors if the building is kept under a negative pressure and all emissions are routed through a closed vent system to an approved control device.

## TEST METHODS AND PROCEDURES

Slide 3-20

Several changes are to be made to testing methods and procedures as outlined in the HON, not the least of which will be the use of EPA Method 18 for the purpose of determining the percent VHAP in a process fluid that is contained in, or contacts equipment. The Reference Volume 1-4, entitled EPA Reference Method 18 details this procedure. No change has been made in the leak detection procedures, EPA Method 21 will continue to be used here.

### Calibration

Slide 3-21

There are several basic changes to instrumentation, beginning with calibration of the instruments and indeed, with the type of instrumentation allowable since the HON mandates that the calibration gas must be methane. (Photoionization and infrared instruments do not respond to methane and therefore cannot be used). Daily instrument calibration must also be carried out according to the presentation of Slide 3-21 - notice that calibrations are equipment and Phase specific.

| INSTRUMENT CALIBRATION EQUIPMENT | | | |
|---|---|---|---|
| **Equipment** | **Calibration** | | |
| | **Phase I** | **Phase II** | **Phase III** |
| **Agitators** | 10,000 ppm | 10,000 ppm | 10,000 ppm |
| **Pumps** | 10,000 ppm | 5,000 ppm | |
| food,medical | | | 2,000 ppm |
| polymerizing monomer | | | 5,000 ppm |
| other | | | 1,000 ppm |
| **All Other Equipment** | 10,000 ppm | 500 ppm | 500 ppm |

The proposed rule specifies that the detection instrument may be calibrated at a higher methane concentration (up to 2000 ppm) than the leak definition concentration for a specific piece of equipment for monitoring that piece of equipment, as presented in the Slide. However, the instrument may not be calibrated at a methane concentration lower than that leak definition concentration for monitoring that piece of equiptment.

The HON also addresses the problem of instrument response factors and specifies that the one used must be determined for the individual VHAP at 500 ppm and unless it is less than 3; it cannot be used without adjustment. Stated differently, if any of the response factors at 500 ppm for the VHAPs that account for 90 percent or more by weight of the process stream are 3 or greater, then a weighted average response factor for the VHAP in the process stream must be calculated using the following procedure: Slide 3-22a Slide 3-22b

$$RF_{AVG} = \frac{\sum_{i=1}^{n} (\%C_i)\,(RF_{C_i})}{\sum_{i=1}^{n} (\%C_i)}$$

Pressure Testing Batch Operations Slide 3-23

Lastly, procedures used to pressure test batch product-process equipment using a gas (for example air or nitrogen) encompass testing the equipment for 15 continuous minutes (unless a determination can be made sooner) and using a detection device which has a precision of ±2.5 mm Hg in the test range. Procedures to be used for testing liquid process equipment are somewhat different in that the test must continue for 60 minutes (unless a determination can be made sooner), and each equipment seal must be inspected for indications of fluid loss.

## RECORDKEEPING/REPORTING

Recordkeeping/Reporting Slide 3-24

The HON requires that the recordkeeping system be readily accessible and that the records should include:

- ID of equipment that would be covered by the standards,

- ID of equipment that is found to be leaking during a monitoring period and when it is repaired,

- testing associated with batch processes,

- design specifications of closed vent systems and control devices,

- test results from performance tests or testing process streams for organic content,

- and information required for equipment in QIP.

Recordkeeping and reporting requirements are outlined in Reference Volume 1-3.5. Note that the HON specifies that records must be kept for the total number of pieces of equipment monitored.

**Reporting**

Under the HON owner/operators are required to submit an initial report (for existing processes within 90 calendar days of the applicability date of the rule) that describes the source and a summary of the equipment subject to the standards. Every 6 months, a report must be submitted that summarizes the results of monitoring and performance tests conducted during the period, changes in the process unit, changes in the monitoring frequency or monitoring alternatives, and/or initiation of a QIP (to be filed within 30 days). Reports can be submitted on electronic media where acceptable by the Administrator and the owner/operator. A summary of the required items are also listed in Reference Volume 1-3.5. Slide 3-25

# LECTURE 4

## PORTABLE VOC ANALYZER CHARACTERISTICS

Notes

A number of portable VOC detection devices are capable of measuring leaks from process equipment. Any analyzer can be used, providing that it meets the specifications and performance criteria in EPA Reference Method 21, which contains both performance specifications and performance criteria for analyzers. In order to meet the required performance specifications, the instrument:

Slide 4-1
Method 21

- must respond to organic compounds being processed
- must be intrinsically safe for operation in explosive atmospheres;
- must measure concentration specified in the regulation;
- must have nominal flow rate of 0.1-3 liter/min; and
- must have a scale readable to ± 5 percent of the defined leak concentration.

The performance criteria which are specified in the Method are:

Slide 4-2

- a response time of 30 seconds or less;
- the calibration precision must be less than or equal to 10 percent of the calibration gas value;
- the instrument must be subjected to response time and calibration precision tests prior to being placed in service;
- calibration precision must be repeated every 6 months of if modification or replacement of the instrument detector is required; and
- the response time must be retested after modifications to sample pumping system or flow configuration.

There are four general classes of portable VOC analyzers: flame ionization detectors, photoionization detectors, catalytic combustion analyzers, and infrared analyzers. However, there are a

Slide 4-3

wide variety of instrument designs within each class. This section will only consider the first three types since at the present time, infrared analyzers are not used frequently for fugitive VOC leak detection.

Inspectors should fully understand operating principles and design characteristics of the instruments. This is so they can understand the importance of check-out procedures, calibration procedures, and field monitoring procedures. Lectures 5, 6

## FLAME IONIZATION DETECTORS

In a flame ionization detector (FID), the sample is introduced into a detection chamber where it is exposed to a hydrogen flame. The flame is surrounded by negative collecting electrodes. When most organic vapors burn, they form positively-charged carbon ions as intermediate products of combustion. The ion current between the flame and the collector is measured electronically. Pure hydrogen burning in air produces very little ionization, so background effects are minimal. The calibrated output current is read on a panel meter or chart recorder.

Slide 4-4
Slide 4-5
Slide 4-6

In FIDs used in portable instruments the oxygen used for organic vapor combustion is drawn from the sample gas itself. Therefore, there are two separate gas streams approaching the burner chamber: the sample gas and the hydrogen stream. This "two stream" design is different than laboratory scale FIDs in which a separate combustion air stream is supplied to the burner. The response of the portable ("two stream") instruments is different than the response of the larger, heavier laboratory ("three stream") units.

Carbon monoxide and carbon dioxide do not produce interferences. However, if water condenses in the sample tube, it may block the tube and give erratic readings. As with most gas samplers, a filter is used to remove any particulate matter which may be present.

Certain organic compounds that contain nitrogen, oxygen, or halogen atoms give a reduced response. In addition, some organics may not give any response at all. Also, FIDs manufactured by different companies may respond differently to the same chemical compound. Reference Method 21 requires that a response factor be determined for each compound that is to be measured. These response factors are discussed later. Presently, FIDs are one of the most accepted and widely used detectors for measuring organic leaks from process equipment.

Changes in the sample gas flow rate have almost a linear effect on the instrument measurement, since FIDs detect the total quantity of positive ions being generated in the burner. However, at very high or very low sample gas flowrates, the air-to-fuel ratios of the hydrogen flame can be misbalanced stoichiometrically that combustion can not be sustained. FIDs are also sensitive to air infiltration prior to the burner. Slide 4-7

Since the organic vapor is at least partially oxidized in the hydrogen flame, it is impossible to collect the effluent from the instrument for further analysis. For this reason, FIDs are classified as "destructive" instruments.

**PHOTOIONIZATION DETECTORS**

Photoionization detectors (PID) utilize high energy ultraviolet light (instead of a flame) for ionization of organic vapors. The lamps are mounted on one side of the exposure chamber and have a high quality quartz lamp window for transmission of the UV light. Slide 4-8 Slide 4-9 Slide 4-10

In the photoionization process, ultraviolet light ionizes a molecule as follows: R & hv $\rightarrow$ $R^+$ + $e^-$, where $R^+$ is the ionized species and hv represents a photon with energy greater than or equal to the ionization potential of the molecule. Generally all species with an ionization potential less than the ionization energy of the lamp are detected. Because the ionization potentials of all major components of air ($O_2$, $N_2$, CO, $CO_2$, and $H_2O$) is greater than the ionization energy of the lamps in general use, they are not detected.

The sensor consists of an ultraviolet (UV) light source that emits photons. A chamber adjacent to the sensor contains a pair of electrodes. When a positive potential is applied to one electrode, the field that is created drives any ions formed by the absorption of UV light to the collector electrode, where the current (proportional to the concentration) is measured.

Only a very small fraction of the organic vapor is ionized in photoionization analyzers, due partially to the short light path length and due partially to the short residence time in the exposure chamber. Accordingly, the response of these instruments are essentially insensitive to sample gas flowrate. The PID instruments are similar to the FID instruments in that they are sensitive to air infiltration prior to the burner. Slide 4-11

Furthermore, the sample gas exhausted from the same instruments can be collected and saved for further analyses such as gas chromatograph tests. For this reason, PID instruments are classified as "nondestructive."

The UV lamp optical windows for photoionization analyzers must be cleaned whenever contaminants have condensed on the surface or whenever liquids have been captured along with the sample gas stream. the windows are cleaned "in-place" without removal from the instruments. A small quantity of manufacturing supplied cleaning compound is used for cleaning. The need for cleaning is indicated by a sudden change in the instrument response or an observed change in the calibration data.

## CATALYTIC COMBUSTION ANALYZERS

Combustion analyzers utilize either the thermal conductivity of a gas, or heat produced by combusting the gas. By far, the most common method used in portable VOC detection devices is measuring the heat of combustion. These devices are referred to as catalytic combustion analyzers.

Slide 4-12
Slide 4-13

The catalytic combustion analyzer oxidizes the organic vapor in a sintered metal reaction chamber equipped with two wires. One is catalyst coated to promote oxidation and the other wire of similar length is not coated. The heat of combustion around the coated wire changes its electrical resistance relative to the uncoated wire. The difference in resistance between the coated wire and the reference wire (whose resistance is unaltered by the oxidation of combustible gas) is sensed by a Wheatstone Bridge circuit and a current signal is generated. This signal is then measured and related to VOC concentration.

Slide 4-14

The basic operating characteristics of the catalytic combustion analyzer are identical to those of the flame ionization instruments. The instrument is sensitive to sample gas flow rate since changes in the quantity of organic vapor affect the heat of combustion released near the sensing wire. The catalytic combustion instruments are classified as "destructive" since most of the organic vapor is at least partially oxidized while passing through the unit, and they are sensitive to air infiltration prior to the detector cell.

## RESPONSE OF INSTRUMENTS

One important criterion in the selection of organic vapor detectors is the response of the instrument to the specific chemical or chemicals present in the as stream. The abilities of the major classes of organic vapor analyzers to detect different organic chemicals differ substantially.

Inspectors should develop a clear understanding on the uses and limitations of response factor data. The response factor, defined below, provides a convenient index of this property. Reference 1

$$\text{Response Factor} = \left[\frac{\text{Actual Concentration}}{\text{Instrument Indicated Concentration}}\right]$$

Slide 4-15

A response factor of 1.0 means that the instrument readout is identical to the actual concentration of the chemical in the gas sample. As the response factor increases, the instrument readout is proportionally less than the actual concentration. It should be understood that a high response factor means that a given instrument does not detect a compound very well. The following examples may help explain the definition.

Example 1. Slide 4-16

| | | |
|---|---|---|
| Actual Concentration | = | 10,000 ppm |
| Instrument Gauge Reading | = | 5,000 ppm |
| Response Factor | = | 2 |

Example 2. Slide 4-17

| | | |
|---|---|---|
| Actual Concentration | = | 1,000 ppm |
| Instrument Gauge Reading | = | 3,000 ppm |
| Response Factor | = | 0.33 |

Example 3. Slide 4-18

| | | |
|---|---|---|
| Actual Concentration | = | 100,000 ppm |
| Instrument Gauge Reading | = | 10,000 ppm |
| Response Factor | = | 10 |

If the regulatory limit is 10,000 ppmv (observed), the use of an instrument with a response factor of 10 for the specific chemical(s) would allow an actual concentration of 100,000 ppmv. Conversely, the Slide 4-19 use of an instrument with a response factor of 0.1 would indicate that the regulatory limit of 10,000 ppmv had been exceeded when the actual concentration is only 1000 ppmv. Typical response factors vary over a range of 0.1 to 40. The lower the response factor, the more sensitive a given instrument is for a specific type or organic compound.

In accordance with Method 21, only instruments having response factors less than 10 for the organic compounds being monitored may be used for leak detection. The response factor must be determined either by consulting published tabular data provided by instrument manufacturers or the U.S. EPA, or alternatively by laboratory testing of the specific instrument being used with the chemicals of interest. Obviously, the latter approach is more accurate. However, it is very expensive for instruments used for a large number of compounds. Response factor tables are provided in the Portable VOC Analyzer User's Manual.

Slide 4-20
Reference 2

Response factors for many compounds are very sensitive to the actual concentration of the organic vapor. This is illustrated by a series of examples drawn from EPA sponsored studies performed during the development of Method 21.

Slide 4-21

Example 1: Response Factor Data for OVA-108 FID, Xylenes

Slide 4-22

| Compound | Actual Concentration (ppm) | Instrument Response Factor |
|---|---|---|
| para-Xylene | 50 | 3.49 |
| | 500 | 3.70 |
| | 7700 | 2.27 |
| meta-Xylene | 200 | 1.04 |
| | 1500 | 0.60 |
| | 3000 | 0.42 |
| ortho-Xylene | 200 | 0.89 |
| | 1500 | 0.86 |
| | 3000 | 0.39 |

Example 2: Response Data for OVA-108 FID, Paraffinic Compounds

Slides 4-23 and 4-24

| Compound | Actual Concentration (ppm) | Instrument Response Factor |
|---|---|---|
| Ethane | 1000 | 1.04 |
| | 3000 | 1.16 |
| | 4500 | 0.57 |
| Propane | 1000 | 0.84 |
| | 2000 | 3.12 |
| | 4000 | 0.59 |
| Pentane | 200 | 1.33 |
| | 1500 | 0.94 |
| | 5000 | 0.48 |
| n-Hexane | 150 | 0.48 |
| | 550 | 0.57 |
| | 1500 | 0.57 |
| | 3200 | 0.63 |
| | 8000 | 0.69 |
| Heptane | 200 | 1.00 |
| | 1500 | 0.67 |
| | 4000 | 0.32 |
| Decane | 200 | 10.77 |
| | 300 | 0.83 |
| | 400 | 1.61 |

Example 3: Response Factor Data for OVA-108 FID, Aromatic Compounds

Slide 4-25

| Compound | Actual Concentration (ppm) | Instrument Response Factor |
|---|---|---|
| Benzene | 50 | 0.88 |
| | 2000 | 0.32 |
| | 2800 | 0.28 |
| | 5000 | 0.51 |
| Toluene | 200 | 0.67 |
| | 1500 | 0.49 |
| | 3000 | 0.39 |
| Ethylbenzene | 50 | 0.52 |
| | 1500 | 0.83 |
| | 8000 | 1.23 |

Example 4: Response Factor Data for OVA-108 FID, Chlorotoluenes

Slide 4-26

| Compound | Actual Concentration (ppm) | Instrument Response Factor |
|---|---|---|
| Meta-chlorotoluene | 200 | 0.61 |
| | 1500 | 0.53 |
| | 3100 | 0.50 |
| Ortho-chlorotoluene | 200 | 0.85 |
| | 1500 | 0.63 |
| | 3100 | 0.63 |
| Para-chlorotoluene | 200 | 0.75 |
| | 1500 | 0.55 |
| | 3200 | 0.51 |

It should be also noted that most response factors have been determined at concentrations less than 10,000 ppm and that extrapolations have been performed to calculate the response factors at the action level of 10,000 ppm. It should also be noted that the concentration variability of response factor generally does not affect conformance with the Method 21 response factor upper limit of 10.

Laboratory studies conducted under carefully controlled conditions have demonstrated some instrument-to-instrument variations in response to known concentration reference standards. The extent of these differences are illustrated in the following examples. Slide 4-27

The following three examples are admittedly extreme examples of instrument-to-instrument variation. This could be due to subtle design differences, sample capture differences, or even undetected instrument malfunctions during the studies. Nevertheless, this type of data underscores the importance of not using published response factor to calculate actual concentration. It also suggests the value of performing independent laboratory analyses to determine instrument specific response factors.

Example 1: Instrument-to-Instrument Variations for OVA-108 FID: Cyclohexanol Slide 4-28

| Compound | Actual Concentration (ppm) | Response Factors at 10,000 ppm | |
|---|---|---|---|
| | | Instrument 1 | Instrument 2 |
| Cyclohexanol | 200 | 1.98 | 2.21 |
| | 700 | 1.67 | 1.71 |
| | 1200 | 1.21 | 1.41 |

Example 2: Instrument-to-Instrument Variations for Catalytic Combustion Analyzer: Xylenes Slide 4-29

| Compound | Actual Concentration (ppm) | Response Factors at 10,000 ppm | |
|---|---|---|---|
| | | Instrument 1 | Instrument 2 |
| para-Xylene | 50 | 2.50 | 1.51 |
| | 500 | 9.43 | 3.98 |
| | 7700 | 7.83 | 4.00 |
| meta-Xylene | 200 | 3.53 | 1.70 |
| | 1500 | 9.44 | 2.01 |
| | 3000 | 12.84 | 1.64 |
| | 4500 | 15.01 | 1.53 |
| | 7000 | 37.86 | 1.73 |

Example 3: Instrument-to-Instrument Variations for Catalytic Combustion Analyzer: Ethylbenzene

Slide 4-30

| Compound | Actual Concentration (ppm) | Response Factors at 10,000 ppm | | |
|---|---|---|---|---|
| | | Instrument 1 | Instrument 2 | Instrument 3 |
| Ethylbenzene | 50 | 1.93 | 1.16 | N.D. |
| | 500 | 10.50 | 2.62 | N.D. |
| | 4000 | 32.62 | 4.11 | 1.32 |
| | 8000 | 27.09 | 3.05 | 1.14 |

Slide 4-31

The response factor variability problems discussed during the last several examples do not necessarily limit the usefulness of portable VOC analyzers or preclude uses of tabular response factor data. The problems have been discussed only for the purpose of encouraging caution in the use of the response factor data. Response factors should be used to select appropriate instruments for specific applications, but not used to calculate actual concentration.

To a certain extent, the instrument operators must learn to ignore the concentration scale on the instruments. In fact, the primary use of "readings" below the VOC action levels will be to provide qualitative indications of potential inhalation hazards.

The portable VOC analyzers when calibrated with a reference gas different than the emission compound(s) can be used simply as a classifier. It tells the inspector if a given component in VOC service has fugitive emissions either above or below the regulatory action level (generally 10,000 ppm).

## REFERENCES AND ADDITIONAL READING MATERIAL


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# LECTURE 5

## PORTABLE VOC ANALYZER CHECKOUT AND CALIBRATION

Notes

This section concerns portable VOC instrument checkout and calibration procedures. It will also discuss the support facilities necessary for a portable VOC analyzer program. The calibration procedures are taken directly from Method 21. The checkout procedures, however, are an addition and highly recommended to insure that the instrument taken to the site is in good mechanical and electrical operating condition.

### CHECKOUT PROCEDURES

The checkout procedures discussed in this section are not specific requirements of Method 21. However, the time used for checkout procedures is well spent since there is no need to attempt field work if the instrument is either not working properly or if it will fail soon after beginning. This section will discuss checkout procedures for the three types of analyzers discussed in Lecture 4.

Slide 5-1
Slide 5-2
Lecture 4

#### Flame Ionization Detectors (FIDs)

The first pre-check is to confirm that there is sufficient hydrogen to fuel the instrument burner. If necessary, the instrument's hydrogen tank should be filled.

Slide 5-3

The next step in the inspection procedure is to confirm that the battery is adequately charged. Battery failure has been one of the most commonly reported problems and is due primarily to improper charging practices. Some FIDs have lead acid batteries which should be left on the charger whenever the instrument is not in use. Other portable VOC analyzers have nickel cadmium batteries which should be charged for 10-12 hours (refer to manufacturer's recommendations). Failure to adequately charge either type of battery could lead to a discharge problem which in turn could necessitate installation of a new battery. In all cases, it is advisable to take a spare, fully charged battery to the inspection site.

It is necessary to allow at least a 10-minute warmup period before checking the amplifier electronic linearity. This is an important check since portable VOC analyzers for fugitive VOC detection are used in two quite different concentration ranges. The action level concentrations for leaks from most components in VOC service is 10,000 ppm. However, some units are subject to a no detectable concentration limit which is equivalent to 500 ppm above background.

The next step is a leak check of the sample gas handling system. These checks are made by briefly blocking the sample gas line at various locations and listening for the characteristic "starved pump" sound. If the appropriate pump sound is not heard, then an air leak must be found and eliminated. It is appropriate to start with the sample gas line fitting leading into the instrument case.

Before attaching the probe to the readout assembly, it should be checked for any deposition of material on the particulate filter installed within the instrument. This should be replaced if there is any visible signs of contamination. A check should also be done for any organic deposits or moisture on the surfaces of the probe. If necessary, the probes should be cleaned to remove any deposits. After completing the check for cleanliness, the probe should be reassembled and attached to the readout gauge so the probe leak checks can be completed.

The final pre-check of an FID is to measure the sample gas flow rate. The most common method of checking this is by attaching a calibrated rotameter to the probe. However, for low flow rates a soap bubble flowmeter may be more appropriate. The indicated flow rate should be recorded in a bound notebook which has the instrument's operation and maintenance data. This information is important since the VOC concentration response is directly proportional to sample gas flow rate. Changes are possible due to pump problems or gas flow blockages within the instrument. If there has been a significant change from the baseline levels it may be necessary to either replace the pump or clean the flame arrestors. It is also important to complete a brief leak check to confirm that the readings are not biased low due to air infiltration at the top of the rotameter.

In FIDs, there is a flame arrestor usually mounted between the mixer/burner and the outside of the instrument case. Occasionally this flame arrestor is removed for cleaning. If it is not replaced, the instrument could be operated with a hydrogen flame exposed to the outside air. Obviously, it is critical to prevent this potentially explosive condition and the presence of the flame arrestor is checked before each use.

**Photoionization Detectors (PIDs)**

The pre-check procedures for photoionization analyzers are only slightly different from those which have already been discussed. Just like in the earlier examples, one of the first steps is to confirm that the battery is adequately charged. Slide 5-4

One of the unique pre-checks of photoionization units is to inspect the optical surface of the lamp to determine if there are any deposits. These can absorb the UV light and reduce the capability of the system to detect VOC material. Even a minute coating of material is sufficient to affect the instrument performance. If any of this material is apparent the instrument should be carefully cleaned in accordance with the manufacturer's recommendations. Checks should also be made for probe condition, detector response and the sample gas flow rate.

**Catalytic Combustor Analyzers**

The pre-checks for the catalytic conducting instruments closely parallel those previously discussed for FIDs. The scope of the pre-checks include the battery status check, probe and pre-filter cleanliness check, leak check of the probe, detector response check, and a measurement of the sample gas flow rate. Slide 5-5

## CALIBRATION PROCEDURES

Instruments used to determine compliance of industrial facilities must be accurately calibrated on a daily basis. The calibration precision test, response time, and response factor tests also should be performed to confirm that the instruments are operating properly for the specific application(s). Slide 5-6

Calibration requirements for VOC instrumentation are specified in EPA Method 21. The requirements pertaining to calibration are briefly summarized here, and the complete Method 21 regulations, Reference Volume 1-5. Slide 5-7 Method 21

- The instruments should be calibrated daily.

- The gas concentration used for calibration should be close to the leak definition concentration.
- The calibrant gas should be either methane or hexane.
- A calibration precision test should be conducted every month.
- If gas blending is used to prepare gas standards, it should provide a known concentration with an accuracy of ± 2 percent.

The daily calibration requirement specified in Method 21 gives individual instrument operators some flexibility. The calibration could consist of a multipoint calibration in the lab, or it could be a single-point "span check" at the facility.

Method 21 does not specify where the calibration must take place. Obviously it would be simpler to conduct the calibration test in the agency laboratory rather than after arrival at the plant. Slide 5-8

Although the span checks mentioned above would in most cases qualify as the required daily calibrations; a separate calibration test for organic vapor analyzers should be conducted whenever possible. Calibrations performed in the regulatory agency laboratory as compared to calibrations done in the field are conducted under more controlled conditions because uniform day-to-day calibration gas temperatures and calibration gas flow rates can be maintained in the laboratory. Furthermore, the initial calibration test provides an excellent opportunity to confirm that the entire instrument system is working properly before it is taken into the field. The laboratory calibration data should be carefully recorded in an instrument calibration/maintenance notebook, and this calibration should be considered as the official calibration required by the regulations.

The laboratory calibration is best performed by the personnel assigned primary responsibility for the maintenance and testing of all the agency organic vapor analyzers. This ensures the use of proper and consistent procedures. If instrument problems are identified, the instrument can either be repaired or the field inspector can be issued another unit that is operating properly.

The instruments used in accordance with Method 21 must be calibrated by using either methane or hexane at concentrations that are close to the leak-detection limits. In most cases, the leak-detection limit is 10,000 ppmv, however, for certain sources, it is 500 ppmv above the background levels.

Methane-in-air is generally the preferred calibrant gas for the high concentration range. A hexane-in-air concentration of 10,000 ppmv should not be prepared because it is too close to the lower explosive limit. Also, some hexane can condense on the calibration bag surfaces at this high concentration. If hexane-in-air calibrations are necessary, the chosen concentration should be a compromise between the need for adequate calibration of leak-detection levels and the practical safety and reproducibility problems inherent in the use of hexane. Some VOC instruments, such as photoionization and instruments, do not respond to methane. With these units, a different calibration gas should be used.

The following are some of the various ways to calibrate the portable instrument on site:

- Use certified gas cylinders provided by the source being inspected.
- Use disposable gas cylinders with the appropriate gas composition and concentration.
- Use a gas sampling cylinder with a gas blending system.

Transporting large pressurized gas cylinders has not been listed since most agencies do not have the vehicles necessary for this purpose. It is not safe to transport unsecured, pressurized gas cylinders in personal or State-owned cars. Furthermore, there are specific Department of Transportation (DOT) regulations governing the shipping of compressed gases.

Using the source's gas cylinders is certainly the least expensive approach for a regulatory agency; however, the appropriate gas cylinders are not always available. Also, the use of the source's cylinders prevents the agency from making a completely independent assessment of the VOC fugitive leaks and from evaluating the adequacy of the plant's leak-detection program.

Using disposable cylinders of certified calibration gas mixtures is relatively simple because no on-site blending is necessary and the cylinders are easily transported. The calibration gas mixture may be fed to the instrument directly by using a preset regulator that provides constant gas flow and pressure; or the gas can be fed into a Tedlar® or Teflon® bag, from which it is drawn into the portable instrument.

The response time of an analyzer is defined as the time interval from a step change in VOC concentration at the input of a sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the analyzer readout meter. This time must be less than or equal to 30 seconds and must be determined for the analyzer configuration that will be used during testing. The response time test is required before placing an analyzer in 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. Slide 5-9

The response time of an analyzer is determined by first introducing zero gas into the sample probe. When the meter has stabilized, the system is quickly switched to the specified calibration gas. The time, from the switching to when 90 percent of the final stable reading is reached, is noted and recorded. This test sequence must be performed three times. The reported response time is the average of the three test.

Calibration precision is the degree of agreement between measurements of the same known value. To ensure that the readings obtained are repeatable, a calibration precision test must be completed before placing the analyzer in service, and at 3-month intervals, r at the next use, whichever is later. The calibration precision must be equal to or less than 10 percent of the calibration gas value. Slide 5-10

To perform the calibration precision test, a total of three test runs are required. Measurements are made by first introducing zero gas and adjusting the analyzer. The specified calibration gas (reference) is then introduced and the meter reading is recorded. The average algebraic difference between the meter readings and the known value of the calibration gas is then computed. This average difference is then divided by the known calibration value and multiplied by 100 to express the resulting calibration precision as percent.

## SUPPORT FACILITIES NECESSARY FOR PORTABLE VOC ANALYZERS

There are certain laboratory and shop facilities which are necessary to operate and maintain VOC analyzers. There are a number of possible hazards involved in the maintenance, testing, and calibration of these analyzers. Therefore, it is recommended that an Slide 5-11 Slide 5-12 inspector not try to operate, maintain, and calibrate these instruments in an office environment. In a poorly ventilated office space or building, the emissions of small quantities of potentially toxic or carcinogenic gases could create an inhalation risk. There is also the potential for a major accident due to the careless handling of the a high-pressure hydrogen cylinder or calibration gas cylinder in the crowded office space. A laboratory facility is needed that has proper ventilation hoods, secure cylinder mounts, bench space, and storage space.

A properly designed laboratory hood is important for calibrating and checking portable VOC analyzers. This should be large enough to accommodate the portable instrument and also the calibration gas sources. The hood should be free of any contaminants on the working surfaces and should not be used for chemical storage. The hood ventilation fan should be used to remove any exposure to calibration gases or gaseous emissions from the instruments. It is important to minimize exposure to the calibration gases since these are generally at relatively high concentrations. Also, some of the calibration gases in common use such as benzene and 1,3-butadiene, are suspected carcinogens. Slide 5-13

Secure cylinder brackets are needed for all hydrogen tanks and other gas cylinders. If these cylinders were knocked over the main valve could be broken off and the cylinder would become a dangerous projectile.

A moderate amount of bench space is needed simply for routine instrument maintenance and checks. The following are common examples of this: Slide 5-14

- Sample gas flow rates must be determined daily using soap bubble flow meters and rotameters.

- Photoionization detectors must be disassembled and cleaned regularly.

- Catalytic combustion analyzers must be removed from instrument cases for adjustment of zero scales.

- All types of units must be partially disassembled when excessive quantities of vapor and/or droplets have entered the unit.

Slide 5-15

There should also be adequate storage space with the necessary spare parts and supplies for repairing the instrument. The laboratory or shop area is also a good place to keep the instrument's maintenance and calibration log book since data and notes must be entered on a fairly routine basis.

In summary, some basic laboratory or shop facilities are necessary to operate and maintain portable VOC analyzers. For safety reasons, attempting to calibrate and check out unit in a typical professional office setting is not prudent. If an inspector does not have access to laboratory facilities, it is recommended inspections be restricted to the level 2 type inspection in which source personnel are observed conducting the routine screening tests.

## REFERENCES AND ADDITIONAL READING MATERIAL

1. Joseph, G., and M. Peterson, "APTI Course SI:417, Controlling VOC Emissions from Leaking Process Equipment, Student Guidebook," EPA-450/2-82-015, August 1982.

2. U.S. Environmental Protection Agency, "Portable Instruments User's Manual for Monitoring VOC Sources," EPA-340/1-86-015, June 1986.

3. Engineering Science, "Benzene Equipment Leak Manual," EPA-340/1-40-001, July, 1990.

4. Becker, J.H., et al., "Instrument Calibration with Toxic and Hazardous Materials," Industrial Hygiene News, July 1983.

# LECTURE 6

## LEAK MONITORING PROCEDURES, PROBLEMS, AND ERRORS

Notes

General monitoring techniques as well as specific procedures for different equipment types are described in Method 21. However, there are several potential problems which should be discussed to help prevent errors in monitoring. An inspector should be able to identify, avoid, and correct common screening mistakes. This knowledge is helpful regardless if he or she is personally conducting the monitoring or observing plant personnel. This lecture presents the general screening procedures contained in Method 21 and also discusses problems associated with the use of portable VOC analyzers for this monitoring.

### MONITORING PROCEDURES

Method 21 prescribes a general methodology for monitoring for equipment leaks which is applicable to all types of portable VOC analyzers. The probe inlet should be placed close to the surface of the component interface where leakage could occur. The probe should then be moved around the interface periphery while observing the instrument readout. If an increased meter reading is observed, the interface should be slowly sampled using various probe orientations. If the gauge spikes above 10,000 ppm, the component being checked should be classified as leaking. If the instrument probe can be held at the location of the maximum gauge reading for two times the instruments response time without exceeding 10,000 ppm, the component should be classified as nonleaking.

Slide 6-1
Method 21

As examined in Lecture 2, each equipment type has certain areas which are more prone to develop leaks. Therefore, when screening for equipment leaks it is important to consider the characteristics of the component so that a leak will not be overlooked. Following are examples of the application of the general technique given above to specific types of equipment.

Lecture 2

Valves - The most common source of leaks from valves is at the seal between the stem and housing. The probe should be placed at the interface where the stem leaves the packing gland. The stem circumference should be sampled. Also, the probe should be placed at the interface of the packing-gland-take-up-flange seat and the

Slides 6-2 thru 6-7

peripheries sampled. In addition, valve housings of multipart assemblies should be surveyed at the surface of all interfaces where leaks could occur.

Pumps and compressors - A traverse at the outer surface of the pump or compressor shaft and seal interface should be conducted. If the source is a rotating shaft, the probe inlet should be positioned within 1 cm of the shaft seal interface. A tygon probe extension should be attached to prevent a metal-to-metal contact with the rotating shaft. If the housing configuration prevents a complete traverse of the shaft periphery, all accessible portions should be sampled. All other joints on the pump or compressor housing where leaks could occur should also be sampled. Slides 6-8 thru 6-10

Pressure relief devices - The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, the probe inlet should be placed at approximately the center of the exhaust area to the atmosphere. Slides 6-11, 6-12

Process drains - For open drains, the probe inlet should be placed at approximately the center of the area open to the atmosphere. For covered drains, the probe should be placed at the surface of the cover interface and a peripheral traverse conducted.

Open-ended lines or valves - The probe inlet should be placed at approximately the center of the opening to the atmosphere.

Seal system degassing vents and accumulator vents - The probe inlet should be placed at approximately the center of the opening to the atmosphere.

Flanges and other connections - For welded flanges, the probe should be placed at the outer edge of the flange-gasket interface and the circumference of the flange sampled. Other types of nonpermanent joints (such as threaded connections) should also be sampled with a similar traverse.

A slightly different procedure should be used for equipment designated as "no detectable emissions". The operator should determine the background concentration around the source by moving the probe inlet randomly upwind and downwind at a distance of 1 to 2 meters from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but the distance should not be less than 25 centimeters. The probe inlet should then be moved to the surface of the source and the same survey described in the preceding section conducted. If an increase greater than 5% of the leak definition concentration is obtained, the results should be recorded and reported as specified by the regulation.

For those cases where the regulation requires installing a specific device, or ducting or piping specified vents to a control device, the existence of these conditions should be visually confirmed. When the regulation also requires that "no detectable emissions" exist, visual observations and sampling surveys are required. Examples of this technique are as follows:

Pump or compressor seals - If applicable, the type of shaft seal should be determined. A survey of the local area ambient VOC concentration should be performed and a determination made if detectable emissions exist as described above.

Seal system degassing vents, accumulator vessel vents, pressure relief devices - If applicable, the inspector should observe whether or not the proper ducting or piping exists. Also, her or she should determine if any sources exist in the ducting or piping where emissions could occur in front of the control device. If the required ducting or piping exists, and there are no sources where the emissions could be vented to the atmosphere in front of the control device, then it is presumed that "no detectable emissions" are present.

## PROBLEMS AND ERRORS IN EQUIPMENT LEAK MONITORING

Slide 6-13

One of the main problems in monitoring is locating a leaking source. As noted above, the normal procedure is to traverse the potential leak location with the probe within 1 centimeter. The close location is necessary because of the relatively poor capture effectiveness inherent with the probe. The probe is limited to negative pressure type sample gas capture. This has a very limited distance of effectiveness, and the capture effectiveness decreases very rapidly with distance from the probe. Several diameters away from the probe (maybe even less than a half inch), there can be almost negligible capture. The presence of a strong cross-draft due to ambient wind further reduces the probe capture capability. Therefore, it is very easy to miss a leak unless care is taken to place the probe very close to the component being screened as specified in the method.

It is equally important that the probe be oriented properly. A leak usually leaves the component under positive pressure and persists as a narrow jet a long distance with only limited dispersion and only gradual deceleration. Therefore, the instrument operator must orient the probe so that the positive pressure characteristics of the leak benefit the capture. That is, the probe should be held parallel to the flow in the center of the leaking gas stream. This means that the operator must not only hold the probe very near the component, but must attempt various orientations to assure that a leak is not missed. Slide 6-14

This poor capture capability which is inherent in all types of analyzers makes them especially sensitive to changes in sample gas flow rates. As the flow rate decreases, the ability to draw in the emission plume decreases. This increases the importance of keeping the probe in close proximity to the component and trying various orientations. Slide 6-15

The regulations define a leak as 10,000 ppm or above. A leak can range from 10,000 ppm to extremely high concentrations of over 1,000,000 ppm. The high pressure conditions present in many instances will produce a high velocity plume with substantial mass emission rates. Other process conditions are notable, particularly temperature. High temperatures present in the process stream make for very hot leaking gas streams. This not only presents safety concerns, but problems associated with certain compounds which will condense at ambient temperatures. Slide 6-16

There are several types of problems that prolonged exposure to high VOC concentration can cause. In a flame ionization detector, if hydrocarbon concentrations reach above about 70,000 to 120,000 ppmv, there may not be sufficient oxygen in the sample gas to support combustion in the burner. Therefore, flame-out can occur. Any further screening tests would not indicate any leaks because the unit would not be operating properly. Most instruments have a flame-out alarm, but this may not be heard in the noisy environments of most plants. Slide 6-17

High concentrations of hydrocarbons can also lead to very high detector temperatures and the loss of catalyst in catalytic combustion units. Condensation of nonvolatile vapors on photoionization unit lamp windows can reduce the sensitivity of the instrument. Slide 6-18 Slide 6-19

The condensation of material in the probe and sampling lines can be a problem for all types of instruments. For these reasons, the analyzer operator should monitor the hydrocarbon concentration while slowly approaching the valve stem, pump shaft seal, or other source. If the instrument gauge indicates high concentrations, the specific leak site on the valve stem or pump seal should be approached very carefully. Furthermore, there is little to be gained by maintaining the probe at the leak site for two times the response time if the instrument already indicates a concentration above the leak. To the extent possible, VOC analyzers should be protected against high organic vapor concentrations.

In summary, it is important to be close and properly oriented, but only for a brief time in the case of a leak. As soon as a leak is indicated, the instrument should be withdrawn. Proper procedures should be to come in toward the leak, get close, move around in different orientations to try to find a plume, and once a positive indication is shown that a leak exists, the probe should be moved away to protect the instrument. Slide 6-20

It is also important to remain aware of any liquid spray from equipment, especially pumps, which could result in contamination of probe and sample lines. While approaching a component it is important to visually check for any liquid spray. If some is obvious, an attempt should not be made to use the instrument. Even if no spray is apparent, it is good practice to attach a small section of plastic tubing with some fiberglass to the probe as a prefilter. A fiberglass wool prefilter also will help to protect against droplet intake. Slide 6-21

It is equally important to consider the instrument problems which can be created by adverse weather conditions. Portable VOC analyzers should not be used when it is raining. Droplets inadvertently drawn into the probe can cause minor damage to the various types of sensors. For example, in flame ionization units the water can partially clog the flame arrestors. Droplets can also coat the optical surfaces of the photoionization detector. Slide 6-22

While conducting fugitive VOC screening tests it is important to understand and adhere to all agency and plant safety procedures. Valves in high locations should be avoided unless there is safe and convenient access for the person using the instrument. Standing on a portable ladder while using the instrument is difficult since the 5 to 15 pound instruments can create a balance problem and both hands must be free to hold onto the ladder. For similar reasons, valves that can only be reached by standing on a fixed caged ladder and reaching through the cage should be avoided. Slide 6-23

It is obviously important to avoid hot surfaces and working equipment while walking around the facility. And also, only those portable analyzers and recorders which are rated as intrinsically safe should be taken into these area. Section 9 discussed inspection safety in more detail.

## REFERENCES AND ADDITIONAL READING MATERIAL


1. U.S. Environmental Protection Agency, "Portable Instruments User's Manual for Monitoring VOC Sources," EPA-340/1-86-015, June 1986.

2. Joseph, G., and M. Peterson, "APTI Course SI:417, Controlling VOC Emissions from Leaking Process Equipment, Student Guidebook," EPA-450/2-82-015, August 1982.

3. Engineering Science, "Benzene Equipment Leak Manual," EPA-340/1-40-001, July, 1990.

4. Riggin, R.M., "Guidance Document on the Use of Portable Volatile Organic Compounds (VOCs) Analyzers for Leak Detection," Report Prepared for USEPA contract 68-02-3487 (WA-18), Undated.

5. U.S. Environmental Protection Agency, "Guideline Series - Measurement of Volatile Organic Compounds," EPA-450/2-78-041, September 1979.

6. McInnes, Robert G., et al., "Guide for Inspection Capture Systems and Control Devices at Surface Coating Operations, Final Draft," Report Prepared for USEPA Contract No. 68-01-6316, May 1982.

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# LECTURE 7

## NSPS AND NESHAP EQUIPMENT LEAK RECORDS AND REPORTS

Notes

The required records and reports are essential elements for the demonstration of the compliance efforts of a facility. It is important that an inspector be extremely familiar with the reporting and recordkeeping requirements of the regulations. The evaluation of these reports and the examination of on-site records are vital portions of compliance determinations. This lecture describes the content of required reports for NSPS and NESHAP regulations and introduces examples. Recordkeeping requirements are also discussed.

### REPORTING

#### NSPS

New Source Performance Standards for VOC equipment leaks include: Subpart VV - Equipment Leaks of VOC in the Synthetic Organic Chemical Manufacturing Industry; Subpart GGG - Equipment Leaks of VOC in Petroleum Refineries; and Subpart KKK - Equipment Leaks of VOC from On-shore Natural Gas Processing Plants. All these NSPS standards refer directly to Subpart VV for reporting and recordkeeping requirements. Therefore, NSPS reporting and recordkeeping as discussed in this lecture are those requirements contained in Subpart VV. Slide 7-1

There are two types of NSPS reports. The first is the notification of construction or reconstruction. This requirement is contained in the NSPS General Provisions (40 CFR 60, Subpart A §60.7) and requires that any owner or operator subject to an NSPS furnish written notification of the date of construction or reconstruction within 30 days after work begins.

In addition to the construction notification, the General Provisions require:

- A notification of the anticipated date of initial startup of an affected facility postmarked between 30 and 60 days before the startup date.

- A notification of the actual date of initial startup of an affected facility within 15 days after such date.

- A notification of any physical or operational change to an existing facility which may increase the emission rate of any pollutant to which a standard applies, unless that change is specifically exempted. This notice shall be postmarked 60 days or as soon as practicable before the change is commenced.

**Initial Semi-Annual Reports**

Facilities are also required to submit semi-annual reports beginning six months after the initial startup date, and every six months thereafter. The content of the initial semi-annual report and the subsequent semi-annual reports is somewhat different.

The initial semi-annual report must include an identification of the process unit, the number of valves in gas/vapor service or light liquid service, the number of pumps in light liquid service, and the number of compressors. Slide 7-2

Valves, pumps, and compressors which are designated as no detectable emissions should not be included in the totals listed in the initial semi-annual report.

**Semi-Annual Reports** Slide 7-3

Semi-annual reports are required beginning six months after the initial semi-annual report, and each six months thereafter. The information which is required in the semi-annual report begins with the process unit identification. This should coincide with the identification in the initial semi-annual report. As discussed in Lecture 2, a monitoring program must be established and adhered to by the plant for valves, pumps, and compressors. When a leak is discovered, it must be repaired within 15 calendar days, barring some unavoidable circumstance. The semi-annual report must contain, on a monthly basis, the total number of leaks which were detected and the number of this total which were not repaired in the required 15 day period. In each instance where a repair was delayed, the report should contain an explanation of the delay. If the reason for the delay is that it could not be repaired until a process unit shutdown, then the report should indicate why a process unit shutdown was technically infeasible during the reporting period. The report should then show the dates during the reporting period when process unit shutdowns occurred. Also, if revisions to items reported in the initial semi-annual report have occurred, these should be described and discussed.

Reference Volume 2-1.1 is an example of an NSPS semi-annual report. This is one format of the semi-annual report. Reference Volumes 2-1.6 through 2-1.12 are actually examples of NESHAP reports but the formats shown could also be applicable to NSPS. As these References illustrate, the format of these reports is not specified in the regulations.

There are other reporting requirements contained in the NSPS regulations. The regulations contain two alternative standards for valves, the allowable percentage of valves leaking and the skip period leak detection and repair program. The first alternative specifies a two percent limitation as the maximum percent of valves leaking within a process unit, determined by an initial performance test and a minimum of one performance test annually thereafter.

Slide 7-4

The second alternative standard specifies two skip-period leak detection and repair programs. Under this option an owner or operator can skip from monthly/quarterly monitoring to something less frequent after completing a specified number of consecutive monitoring intervals with the percentage of valves leaking equal to or less than 2.0 percent. Under the first skip program, after two consecutive quarterly periods with fewer than two percent of valves leaking, an owner or operator may skip to semi-annual monitoring. Under the second program after 5 consecutive quarterly periods with fewer than two percent of valves leaking, annual monitoring may be adopted. If an owner or operator elects to comply with either of these alternative standards, a report must be provided within 90 days before implementing the provisions.

The General Provisions of the NSPS regulations require that the owner or operator furnish EPA with a written report of the results of any performance test. Performance tests are required for no detectable emissions equipment and valves complying with an alternative standard. They also may be required for closed vent systems and control devices and equivalent means of emission limitation. Information must be made available to EPA as may be necessary to determine the operating conditions during the performance tests. In addition, the NSPS requires that the owner or operator notify the Administrator of the schedule for the initial performance tests at least 30 days before conducting them.

Finally, it should be recognized that, although NSPS is a federal regulation, enforcement authority may be delegated from U.S. EPA to the States. Reports would then be submitted to State agencies instead of U.S. EPA.

## NESHAP

There are three National Emission Standards for Hazardous Air Pollutants (NESHAPs) for equipment leaks which include Subpart F - National Emission Standard for Vinyl Chloride, Subpart J - Equipment Leaks (Fugitive Sources) of Benzene, and Subpart V - Equipment Leaks (Fugitive Emission Sources). Each of these NESHAPs require that an initial statement be submitted. All subparts require the submittal of semi-annual reports. However, if less than 2 percent of the valves for a vinyl chloride process unit are shown to be leaking by a performance test, then these results must be submitted and a new performance test conducted annually. Slide 7-5

### Initial Reports

The initial report contains two portions. The first is a written assertion that states the company will implement the standards, testing, recordkeeping, and reporting requirements contained in the applicable NESHAP. The second part is information regarding the equipment subject to the regulation. This includes equipment identification numbers and process unit identification for each source as well as a description of the type of equipment (for example, a pump or a pipeline valve). Also, the percent by weight of volatile hazardous air pollutant (VHAP) in the fluid at the equipment and the state of the fluid (i.e. gas/vapor or liquid) is required. Finally, the report must contain a description of the method of compliance to be utilized. The initial report must also contain a schedule for subsequent reports. Slide 7-6

All plants which were in existence on the effective date of NESHAP standards were required to submit an initial report. Therefore all existing facilities subject to the above referenced standards should have already submitted an initial report. All new plants are required to submit an initial report with the application for approval of construction required by the general provisions of Part 61 (NESHAPs).

Reference Volume 2-1.2 is an example of an initial NESHAP report which contains the required assertion along with a discussion of the monitoring schedule. It also contains a list of points to be monitored. Reference Volumes 2-1.3, 2-1.4, and 2-1.5 are portions of initial reports which contain a list of the equipment subject to the regulation with the required information for each component.

**Semi-Annual Reports**

Six months after this initial report and each six months thereafter, the facility must submit reports. These semi-annual reports are very similar to the NSPS semi-annual reports. They must contain the process unit identification and the following information on a monthly basis for each process unit. Slide 7-7

- The number of valves, compressors, and pumps that were detected leaking

- Of these valves, compressors, and pumps that were detected leaking, the number which were not repaired within 15 days.

- An explanation of why a repair was delayed. If the reason for the delay was that a process unit shutdown is needed before repair, then an explanation must be given why a process unit shutdown was infeasible.

The report must also include the dates of all process unit shutdowns during the six month reporting period and a discussion of any revisions to the initial report.

Reference Volumes 2-1.6 through 2-1.12 are examples of NESHAP semi-annual reports. As can be seen, each facility develops and uses its own format for these reports. The regulations do not specify the format of the reports, only the minimum requirements on content. Specific items of note regarding these reports are as follow:

- Reference Volume 2-1.9 contains a pump which was not repaired within the 15 day limit with an explanation of the reason for delay. Although the pump was not repaired within the required time period, the report clearly explains the history of the problem pump. This history begins with the initial leak detection and follows it through until a successful repair was reported.

- Attachment III of Reference Volume 2-1.9 also contains an addition/deletion list which presents another format of the required information describing equipment subject to the NESHAP.

- Reference Volume 2-1.10 contains a report of the monitoring of difficult and unsafe to monitor valves.

As is the case for NSPS, the NESHAP allows: 1) the designation of equipment subject to no detectable emissions limit rather a leak detection and repair standard; 2) an alternative standard based on the allowable percentage of valves leaking; and 3) an alternative skip period leak detection and repair program. All three of these require performance tests along with closed vent systems and control devices. If a performance test was conducted within the 6 month reporting period, then the results of the test must also be included in the semi-annual report.

Reference Volume 2-1.11 contains examples of annual no detactable emissions testing of closed vent systems and valves and updating equipment identification information.

There are certain other aspects of the reporting requirements of a NESHAP. The semi-annual reports must be submitted twice per year beginning six months after the submittal of the initial report. The initial report also must contain a schedule verifying the months when these semi-annual reports will be submitted. The source must then abide by this schedule unless it is amended in subsequent semi-annual reports. Slide 7-8

If an owner or operator of a facility wishes to comply with either of the alternative standards for valves (i.e. the allowable percentage of valves leaking or the skip period leak detection and repair), they must provide notification 90 days before implementation of either of these programs.

There are certain instances described in the regulations where an application for approval of construction/modification is not required. These circumstances are:

- if a new source complies with the standards,

- if the new source is not part of the construction of a process unit, and

- if all information required in the initial report is contained in the next semi-annual report.

**RECORDKEEPING**

The review of records at a facility is an important element of determining whether a facility is in compliance with the standards. The NSPS and NESHAP fugitive leak regulations require that extensive and detailed records be maintained on-site by the facility. The ensuing discussion will highlight the recordkeeping requirements of these regulations. Slide 7-9

Several lists must be maintained in the records at a subject facility. These are: Slide 7-10

- A list of identification numbers for all equipment subject to the requirements.

- A list of the equipment identification numbers of the equipment that are designated for no detectable emissions. This designation must be signed by the owner or operator. A compliance test is required for the designation of equipment as no detectable emissions. Certain information regarding each of these annual tests is to be retained. This information includes the date of the compliance test, the background level measured, and the maximum instrument reading measured at the equipment.

- A list of equipment identification numbers for pressure relief devices required to comply with the standards for pressure relief devices in gas/vapor service.

- A list of identification numbers for equipment in vacuum service.

If a closed vent system and a control device is used to control fugitive emissions, then records are required relating to this equipment. These records must contain: Slide 7-11

- detailed schematics, design specifications, and piping and instrumentation diagrams

- dates and descriptions of any changes in the design specifications

- a description of the parameter or parameters monitored to ensure that a control device is operated and maintained in conformance with their design and an explanation of why that parameter was selected for monitoring

- periods when the closed vent systems and control devices are not operated as designed, including periods when a flare pilot light does not have a flame

- dates of startups and shutdowns of the closed vent systems and control devices

A dual mechanical seal system that includes a barrier fluid system is an alternative for reducing emissions from pumps and compressors. In the instances where a dual mechanical seal system with a barrier fluid system is used, the following information must be included in the records: 1) the design criteria that indicates failure of the seal system, the barrier fluid system, or both, 2) an explanation of the choice of this design criteria, and 3) documentation of any changes to this criterion and the reasons for the changes. Slide 7-12

The records must also contain a list of identification numbers for valves that are designated as unsafe to monitor with: 1) an explanation for this designation, and 2) the plan for monitoring each valve. The same is true for those valves that are designated as difficult to monitor. Slide 7-13

For those valves complying with the skip period provisions, a schedule of monitoring must be kept on file along with a record of the percent of valves found leaking during each monitoring period. Slide 7-14

There are criteria which will allow a facility to be exempted from the NSPS or NESHAP requirements. If a facility claims an exemption then it must maintain a log which contains information, data, and analyses to support their exemption declaration. Slide 7-15

For each compliance monitoring test conducted, a record detailing the results must be retained. This includes the monthly leak monitoring for pumps and valves, as well as the annual no detectable emissions monitoring for pumps, compressors, valves, and closed-vent systems. This also includes any monitoring for alternative standards. Slide 7-16

There are other non periodic circumstances which require compliance monitoring. A pressure relief device must be monitored within 5 calendar days after a pressure release to confirm the conditions of no detectable emissions. In the instance where a pump or valve is in heavy liquid service, a pressure relief device is in light liquid or heavy liquid service, or a flange or other connector is suspected of leaking, this equipment must be monitored within 5 days. If a leak is detected and a repair attempt executed, the component Slide 7-17 must be monitored to determine if the repair attempt was successful. Records must be kept detailing the findings of all such monitoring tests.

If a leak is detected, the equipment must be identified as a leaking component. This is done by attaching an identification tag to the leaking equipment. The tag must be weatherproof and readily visible. A tag may be removed after the equipment has been repaired and retested successfully, except for valves. The tag may only be removed from a valve after it has been repaired and monitored for 2 successive months with no leak detected. Slide 7-18

When a leak is detected, records regarding each leak must be kept and maintained for 2 years. For each leak detected, the following information must be recorded: the equipment ID number, the instrument and operator identification numbers, and the date the leak was detected. Slide 7-19 Slide 7-20

The date of each repair attempt should be recorded along with an explanation of the methods applied in each instance. If the leak was corrected, then the date of the repair should be designated the date of successful repair and entered in the log. If the repair is unsuccessful, then it should be recorded that the maximum instrument reading of the monitoring after the respective repair was above 10,000.

If a leak is not repaired during the 15 calendar days after it is detected, "repair delayed" should be entered and the reason for the delay discussed. If the reason for the delay is that the repair could not be attempted until a process shutdown, then the person who made the decision must sign the log. If process unit shutdowns occurred while the leak remained unrepaired, the dates of these shutdowns must also be recorded. Finally, the expected date of successful repair of the leak should be entered for these delinquent leaks.

Reference Volume 2-1.13 shows an example leak inspection and repair recordkeeping system. Another example form for this purpose was contained as Attachment IV of Reference Volume 2-1.9.

To summarize, records must be kept for two years which contain the identification of: 1) the leaking equipment, 2) the instrument which recorded the leak, and 3) the instrument operator. It should contain the dates of: 1) the leak detection, 2) each repair attempt, 3) the expected repair completion, 4) the process unit shutdowns while the leak remained unrepaired, and 5) the date of the successful repair. For each unsuccessful repair, "above 10,000" should be recorded to designate that the maximum instrument reading was greater than

10,000 ppm (i.e., leaking). And finally, if the decision is made that the repair must be delayed until a process shutdown, then the person making that decision must sign the log.

SUMMARY

Slides 7-21, 7-22

Reporting and recordkeeping requirements are vital to determine compliance with a regulation designed to control VOC or hazardous emissions from equipment leaks. For NSPS regulations, there are two basic types of reports, the notification of construction and the semi-annual reports. These semi-annual reports contain information regarding the findings of the leak detection and repair program. NESHAPs also require the submittal of semi-annual reports, beginning with an initial report which must contain a listing of subject equipment along with equipment type, the percent of volatile hazardous air pollutant, the state of process fluid, and the method of compliance. The semi-annual reports are very similar to the NSPS semi-annual reports. There are alternative standards for both NSPS and NESHAP which allow leak testing on an annual or "skip" basis for equipment which has demonstrated to have a low propensity to leak.

The regulations require that extensive records be kept regarding the identification of equipment. Specific records must be kept for closed-vent systems and control systems, pumps and compressors, valves, skip period valves, and compliance monitoring results. Records are also required for equipment which is exempt from the regulation. There are precise procedures to be followed in the case of an equipment leak. These pertain to the marking of leaks and the associated recordkeeping procedures.

In summary, it is extremely important that an inspector be familiar with the reporting and recordkeeping requirements of the regulations as this is a good indicator of the overall leak detection and repair program as implemented at the facility.

# LECTURE 8

## IMPLEMENTATION DECISIONS AND GUIDANCE

**Notes**

The fugitive emission regulations are a complex set of regulations. Implementing and enforcing these regulations require, at times, additional guidance and understanding not provided in the regulations themselves. In this lecture, information is presented on past EPA guidance on questions that have been raised in implementing these regulations. This information is drawn from EPA policy memoranda on the Benzene Equipment Leak NESHAP. Slide 8-1

In addition, this lecture presents suggestions on way that you, as an inspector, can better enforce the regulations. This is not an exhaustive list of suggestions. The areas discussed cover (1) the relationship of information required to be reported or recorded to determining compliance with the regulations and (2) determinations left to the plant operator.

### EPA POLICY MEMORANDA

This part of the lecture focuses on selected interpretation issues associated with the Benzene Equipment Leak NESHAP. The first item listed in Slide 8-2 is more of a summary document of the rule, but includes discussion of several enforcement issues. The other items in Slide 8-2 are selected topics drawn from a number of EPA memoranda, records of communications, and other correspondence, which have been distributed. Other issues of interpretation are found in these documents. Slide 8-2

#### Enforcement Guideline S-28

This document was prepared to aid in the enforcement and implementation of the benzene NESHAPs. The document summarizes the benzene equipment being regulated under benzene equipment leak NESHAP and the standards to which this equipment is subject, and provides guidance on several issues of enforcement concern.

The following summarizes the document in outline form.

Background

- Four sources of benzene were originally proposed for regulation:

  - equipment leaks
  - maleic anhydride plants
  - ethylbenzene/styrene plants
  - benzene storage vessels

- The latter three were dropped as additional analysis led EPA to conclude that the health risks and potential reduction in the health risks were too small to warrant regulation under Section 112.

- EPA found that fugitive benzene emissions posed a significant risk and should be regulated.

Introduction

- Use of various equipment in industry and their potential to leak.

Scope and Applicability

- Identifies the equipment covered by the standards

- Must be in benzene service

- Exemptions

  - coke by-product plants
  - < 1,000 Mg/yr design production in use of benzene

Standards

- Reviews the standards for each piece of covered equipment.

Equivalent Means of Emission Limitation

- Summarizes procedure for applying for a determination of equivalency.

No Detectable Emissions

- Summarizes equipment for which "no detectable emissions" may be designated, compliance methods, testing, and monitoring.

Reporting Requirements

- Summarizes the reporting requirements (initial report, semi-annual reports).

Recordkeeping Requirements

- Summarizes recordkeeping requirements.

Compliance Issues

- Determining percent benzene content.
- Development of a criterion indicating system failure.
- Development of written plans for monitoring unsafe-to-monitor values and difficult-to-monitor values.
- Selection of monitoring parameters to ensure control devices are operated and maintained in conformance with their designs.
- Granting of waiver from a benzene standard for up to two years.

**Sewers** Reference 1

Issue: Are sewers covered by Subpart V?

Guidance: Sewers and their vents are not covered by Subpart V.

**Oil/Water Separators** Reference 1

Issue: How are oil/water separators analyzed for weight percent benzene? Some companies wanted to determine the weight percent benzene for both the hydrocarbon and water layers combined, which in some cases would exempt some separators via the 10 percent criteria.

Guidance: Hydrocarbon/water separators in the process can be considered to be product accumulators. Since the standard covers accumulators containing either 10 weight percent benzene liquid or 10 weight percent vapor, the vapor in the headspace of separators should be analyzed using the 10 percent criteria. If they are "in benzene service" (i.e., meet the 10 percent benzene criteria), they are subject to the standards.

**Storage Terminals**

Reference 2

Issue: Are storage terminals considered "plant sites" as per §61.110(c)(2)?

Guidance: Storage terminals are considered plant sites subject to the Benzene Equipment Leak NESHAP unless they can be exempted by virtue of either containing no streams with 10 percent benzene or greater or processing less than 1,000 megagrams (2.2 million pounds) of benzene per year.

**Use versus Purchase of Benzene**

Reference 3

Issue 1: Section 61.110(c)(2) of Subpart J states: "Any equipment in benzene service that is located at a plant site designed to produce or use less than 1,000 megagrams of benzene per year is exempt from the requirements of §61.112" (emphasis added). A distillation operation circulated benzene in a closed loop system in quantities greater than 1,000 megagrams per year, but the net usage and recharge purchased totalled less than 15 megagrams in each of two years. Is the term "use" limited to the purchase or conversion that uses up the benzene?

Guidance: The term "use" is meant to reflect the overall quantity used in equipment at a facility and not the consumption (conversion) rate of benzene at a facility. The intent of this exemption was to exclude such facilities as pilot plants and research and development laboratories.

Issue 2: Is the "use" of benzene the actual use or the design use of benzene? — Reference 4

Guidance: The design use is used in determining if a facility is subject to the standard.

**Welded Fittings** — Reference 5

Issue: Are welded fitting considered "connectors"?

Guidance: Welded fittings are "connectors," but they must be fittings for pipes and equipment in benzene service.

**Bypasses of Control Devices** — Reference 5

Issue: A plant has a "vent recovery system" that receives vapor streams from various plant processes, including equipment in benzene service and equipment not in benzene service. When this system fails, certain bypass emissions systems are used. How should a bypass of a control device by treated?

Guidance: The system should be designed and operated to achieve 95 percent control. When the system is not operating, the plant must record this information, but does not need to report it.

**Product Accumulators**

A number of situations have been identified for clarification as to whether the equipment in question is considered to be a product accumulator subject to the Benzene Equipment Leak NESHAP. The background information document for the proposed standards 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.

Issue 1: Are storage vessels considered to be product accumulator vessels and thus subject to the Benzene Equipment Leak NESHAP? — References 5, 6

Guidance: Storage vessels are not included as part of the product accumulator vessel unless they are surge vessels in a process unit and no part of Subpart V applies to them.

A storage vessel is differentiated from an accumulator vessel by the following:

a. Accumulator vessels are typically located in the process unit area (such as reflux drums, product run-down tanks, etc.), whereas storage vessels are isolated from the process unit area.

b. Accumulator vessels usually have continuous purges from their vents whereas storage vessels do not.

Issue 2: Is a distillation column that bypasses through a scrubber a "product accumulator vessel"? — Reference 5

Guidance: A distillation column is not covered. However, a product accumulator vessel associated with this column is covered.

Issue 3: A pressurized process upstream discharges a vapor steam into a vapor surge tank (which is at downstream pressure). The downstream line leads to a vent recovery system. If the vent recovery system is overloaded, back-pressure in the vapor surge tank can approach the upstream pressure and impair the effectiveness of the upstream process. When the pressure in the tank gets too close to the upstream pressure, a pressure control device (sensing tank pressure) opens a control valve that releases vapors (containing benzene) to the air. Is this vapor surge tank considered a "product accumulator vessel"? — Reference 5

Guidance: The tank that is described is probably a "product accumulator vessel."

<u>**Determination of "In Benzene or Vinyl Chloride Service"**</u>

Issue 1: Can units be classified as not "in benzene service" without identifying each valve, flange, connector, etc. — Reference 5

Guidance: Yes, but if the determination is made collectively (groups of equipment), then each piece need not be identified.

Issue 2: Should equipment "in benzene service" during start-up and/or shut-down, but not during normal operation, be classified as "in benzene service"? — Reference 5

Guidance: If the equipment is intended to operate "in benzene service," it is covered. The decision on whether a piece of equipment is "in benzene service" really depends on how frequently the equipment is operated "in benzene service."

Issue 3: A product accumulator vessel is filled almost entirely with a liquid. The liquid contains 2 percent benzene by weight, while the headspace contains 99 percent benzene. If the applicable limit of 10 percent is determined to mean either in the liquid or vapor phase, the regulations would apply because the vapor phase is over 10 percent. However, if a mass balance is performed combining both the liquid and vapor phases, the amount of actual benzene by weight will not bring the total weight percent up to 10 percent and the vessel will not be covered. Is the vessel described above considered to be in benzene service and thus subject to the standard? — Reference 7

Guidance: A source "in benzene service" is defined as a piece of equipment that either contains or contacts a fluid (liquid or gas) that is at least 10 percent by weight. The product accumulator vessel is the only piece of equipment for which the regulations apply if either the liquid or vapor phase is 10 percent benzene. In the definition of product accumulator vessel (§61.241), it is specifically mentioned that an accumulator vessel is in VHAP (benzene) service if the liquid or vapor in the vessel is at least 10 percent by weight VHAP (benzene). This provision is not included in the definition of any other affected facility. For all these other facilities, the 10 percent by weight value is determined by a mass balance only.

[Note: This distinction was made because the accumulator vessels were the only pieces of equipment that ESD believed would have appreciable amounts of benzene in both the liquid and vapor phases. All other equipment would have benzene in only one phase.]

**Insulated Valves** Reference 5

Issue: Most of the valves at a plant are insulated. Most valves, therefore, are covered so that only the stem shows. The rest of the valve is not accessible. How should the plant treat insulated valves?

Guidance: Insulated valves must comply with the standards for valves (§61.242-7).

**Plant Site** Reference 8

Issue: According to the B.F. Goodrich Company, their Calvert City complex contains two separate and distinct plant sites. Goodrich agrees that the ethylene plant is subject to the Benzene Equipment Leak NESHAP, but feels that the Carbopol plant should not be. Goodrich claims that the Carbopol plant is in a separate chain of command from the ethylene plant, deals with a separate raw material and product, and has received a separate construction permit. Additionally, the Carbopol plant does not use benzene in a quantity approaching 1,000 megagrams per year, since only small quantities are consumed in the process each year. The EPA Regional Office points out that both the Carbopol and ethylene plants are part of the same Calvert City complex and correspondence. Is the Carbopol plant a separate plant site from the ethylene plant?

Guidance: Although "plant site" is not defined in the promulgated rules, the term was defined in the proposed benzene regulations as an entire refinery or chemical plant, i.e., all benzene process units under common ownership at the same geographical location (46 FR 1169, January 5, 1981). Based on this definition, the ethylene and Carbopol plants should be considered to be the same plant site.

Review of the economic analysis for the Benzene Equipment Leak NESHAP also supports this interpretation - the pieces of equipment are in one area and can be dealt with cost-effectively as a unit. When similar situations arose during the economic analysis for the standard, plants were considered to be on the same plant site.

## INSPECTION GUIDANCE

This part of the lecture presents guidance on certain aspects of the regulations that require you, as an inspector, to apply additional insight, effort, or knowledge in the enforcement of these regulations. The first area discussed deals with information that is reported and determining compliance with the regulations on the basis of that information. The second area discussed deals with determinations that are made by the plant operator in implementing the regulations.

<u>Reporting/Enforcement</u> Slide 8-3

The regulations require each owner or operator of an affected facility to report certain information on the status of the components subject to the regulations. The information that is reported may not be sufficient to determine whether an owner or operator is complying with the regulation. For example, an owner or operator is not required to report repair data associated with pumps, compressors, and valves (only the number that leaked are required to be reported). This makes it more difficult to determine whether the owner or operator is complying with the repair provisions of the regulations. Inspection of the actual records are required to determine the actual compliance of the plant with all aspects of the regulation.

Another example is the lack of recordkeeping and reporting requirements for sampling connections and open-ended lines and valves. Compliance determinations for these equipment can only be done by visual inspection at the plant. A walk-through of the plant looking for uncapped (for example) open-ended lines may be necessary to ensure that the plant is in compliance with the standard for open-ended lines.

The main points for you to be made aware of are: (1) not enough information is required to be reported for you to determine compliance with the entire regulation from the reports, and (2) not enough information is required to be recorded for you to determine compliance with the entire regulation from the records. Some inspection of the facility itself will be required.

**Plant Operator Determinations**

Slide 8-4

The regulations allow plant operators to determine several items in complying with these regulations. These items include: (1) determining which components are in VOC, benzene, or vinyl chloride service; (2) setting the criterion for "leaks" at pumps and compressors with dual mechanical seals with barrier fluids; and (3) setting monitoring system of operating conditions for control devices. As an inspector, you should evaluate such plant determinations for their reasonableness and accuracy.

If a component is designated as not in benzene service, for example, it is excluded from the standards. As an inspector, you should evaluate the procedure used to make that determination. Was it made on the basis of engineering judgement or a test? If on engineering judgement, is it clear from the process that this is an accurate determination without question? If you are unfamiliar with the specific plant operations, you may wish to contact other inspectors who are familiar with that type of plant. If the determination was made on the basis of a test, was the test done properly? Ask for a copy of the test report and determine if procedures appeared to be followed properly. If you have doubts about the accuracy of the testing (or the engineering judgement), request a sample and have the sample tested independently.

A plant is required to design a criterion that indicates failure of the seal system, the barrier fluid system, or both, for certain types of pumps and compressors. It may be beyond the inspector's level of experience or expertise to evaluate the criterion selected by the plant operator and the sensor used to detect that criterion. The inspector need not simply accept the plant's determination. To help make an independent determination, the inspector could again talk with other inspectors who are familiar with similar systems or with vendors who manufacture and install such systems.

The third example of plant operator set conditions involves the plant owner monitoring the control devices to ensure that they are operated and maintained in conformance with their design. For most control devices, the operating parameters that should be monitored to ensure conformance to their design are fairly uniform and straightforward. However, there could arise situations in which a plant operator wished to monitor an "other-than-usual" parameter. The inspector is encouraged to question such situations and talk with the vendor of the control device for independent assurance.

In summary, there are several aspects of complying with these regulations that are left up to the regulated. It is not necessary for the inspector to simply accept the plant operator's determinations. The inspector should arrive at an independent determination that what the plant operator has decided upon is correct and acceptable. This may require independent confirmation through additional testing or through conversations with other inspectors or vendors.

**REFERENCES**


1. Record of Communication. Raymond Allen to Cliff Janey. October 23, 1984.
2. Record of Communication. Raymond Allen to Bill Davis. October 3, 1984.
3. Letter. A.M. Davis, EPA, to P.S. Advani, Texaco. August 20, 1984.
4. Record of Communication. Tom Diggs to Sabino Gomez. September 21, 1984.
5. Memorandum. F. Dimmick, OAQPS, to R. Meyers, SSCD. September 19, 1984.
6. Record of Communication. Raymond Allen to Tanya Murray. September 25, 1984.
7. Memorandum. E.E. Reich, EPA, to T.J. Maslany, EPA, Region III. February 8, 1985.
8. Memorandum. E.E. Reich, SSCD, to J.T. Wilburn, EPA Region IV. January 10, 1985.

# LECTURE 9

## INSPECTION PROCEDURES

Notes

Compliance determinations with equipment leak standards are not simple matters due to the complexity of these standards and the many compliance options available to a facility. An equipment leak standard may include hundreds, or even thousands of subject emission points. This creates a difficult situation for an inspector attempting to evaluate the compliance status of a facility.

Slide 9-1

Because of the complexities associated with these standards, it is imperative that an inspection be conducted in a systematic fashion. This section is intended to provide a guideline for these inspections. It will present a method for conducting a fugitive equipment leak inspection and provide an inspection checklist.

### TYPES OF INSPECTIONS

An inspector can conduct a "Level 2" or "Level 3" type inspection. A Level 2 inspection involves the determination of the adequacy of the equipment leak detection and repair program and the success of the plant in the implementation of this program. It also involves the determination of proper equipment design, usage, and monitoring. This type of inspection is comprised of applicability reviews, reports and records inspections, surveys of plant procedures, surveys of equipment usage, a walk through of the facility, and the observation of monitoring and testing by plant personnel. A Level 3 type inspection also involves all of these elements with the addition of monitoring/testing conducted by the inspector.

There are varying opinions as to the effectiveness of a Level 3 inspection. In many instances, even if an inspector monitors a piece of equipment and finds it leaking, this does not indicate a violation of the standard. For example, consider the situation of an inspector carrying an analyzer, testing a valve which is covered under the monthly monitoring program and finding a leak. The presence of a leak at this time does not indicate that the leak was present during the previous monthly inspection, or that plant personnel would not have located and repaired the leak during the next monitoring period.

An inspector could check a representative sample of the equipment and compare the findings with the history of the leak checks conducted by the plant. If the inspector's test find a large percentage of leaking valves, pumps, etc. and the plant's reports and records consistently show very low percentages of leakers, then the monitoring and testing procedures utilized by the plant should be examined closely. Another manner of evaluating the screening procedures used by plant personnel is to have plant personnel responsible for the program monitor all the components in a process unit, or in a specific area of a process unit, while the inspector follows and monitors the identical equipment. After completion, the results of both evaluations should be compared. If discrepancies exist, then the inspector should note this in the inspection notebook and closely examine the technique of the plant person who conducted the monitoring.

An inspector may carry his own monitor specifically to test equipment which is designated as no detectable emissions or for those plants utilizing the allowable percentage of valves leaking provision. He or she could spot check no detectable emissions equipment. A concentration of 500 ppm above background or greater indicates a violation. It would also be a violation if greater than 2 percent of the valves are found to be leaking for those process units complying with the allowable percentage alternative standard. However, an inspector should remember that the regulations require facilities complying by either of these standards to conduct performance tests annually, or at other times as requested by the Administrator. Therefore, the inspector could simply request the plant to conduct such a test under his or her supervision.

There are other reasons for conducting a Level 3 type inspection at a facility. One is that the use of the portable VOC analyzer helps an inspector develop a greater appreciation for some of the field problems which are inherent in the screening programs. It also helps to convince the source personnel that the inspector has an active interest and concern with their screening program, and that the inspector is competent in all aspects of the equipment leak regulations.

However, for the reasons discussed above, it is not usually recommended that a Level 3 type inspection be conducted for equipment leak regulations. Therefore the remainder of this section will be dedicated to a procedure to be followed for a Level 2 inspection.

## INSPECTION ELEMENTS

There are four basic elements contained in an equipment leak inspection program. These are a pre-inspection records search which includes an applicability check and a review of submitted reports; an on-site inspection which includes a records check, an equipment survey, and an assessment of plant procedures; post-inspection data sorting; and additional inspections. There are 5 questions which an inspector should be able to answer at the conclusion of an inspection. Slide 9-2

1. Are in-plant records being properly kept and semi-annual reports being properly submitted?

2. When detected leaks are not repaired in the required time frame, are the delays justifiable?

3. Can the plant's personnel demonstrate, in general terms, the capability to carry out the work practice standards required by the regulation?

4. Is all equipment in the facility that should be subject to the standard being treated as such?

5. Does the facility's closed vent system and control device (CVSCD) meet the requirements of the applicable regulation?

### Pre-Inspection Records Search

Since any inspection requires labor and expense, minimizing the inspection time spent in the plant is important. The inspector should conduct a thorough search of the agency files on the facility to be inspected. This will help determine the types of process units, the number of process units, and the compliance history and trends of this facility. The inspector should be as informed as possible about the operation of these process units and the potential sources of emissions. The more the inspector knows, the better he or she will be able to communicate with plant personnel. Reference 1

Sources subject to an equipment leak NSPS are required to submit a notification of construction which gives general facility information and an initial semi-annual report which contains information regarding the quantity of subject equipment at the plant. Sources subject to a NESHAP are required to submit an initial report along with their application for approval of construction. This initial Slide 9-3 report contains general facility and process unit information as well as a list of all subject equipment with details of individual components. The inspector should review the initial reports and first determine if a facility is claiming an overall exemption to the regulation.

There are provisions contained in the regulations which exempt enfire facilities. To review, Subpart VV, the NSPS for equipment leaks from SOCMI plants, contains the following exemptions:

- any affected facility that has the design capacity to produce less than 1,000 Mg/yr is exempt;

- if an affected facility produces heavy liquid chemicals only from heavy liquid feed or raw materials, then it is exempt;

- any affected facility that produces beverage alcohol is exempt; and

- any affected facility that has no equipment in VOC service is exempt.

Subpart J, the NESHAP for equipment leaks of benzene, also contains facility exemptions which are as follows:

- any equipment in benzene service that is located at a plant site designed to produce or use less than 1,000 megagrams of benzene per year is exempt; and

- any process unit that has no equipment in benzene service is exempt.

Other types of permits and reports, such as those for other air regulations, and those for wastewater, hazardous waste, or toxic substances permits should be obtained. Agency files should also be examined closely to obtain any other compliance information, correspondence, complaints, etc. regarding the facility. The information contained in the initial reports should be compared with these other sources of information to assess the consistency between the details reported. This comparison should be conducted in all situations, but especially where an exemption is being claimed.

NESHAP Section 61.11 allows EPA (or an equivalent State agency with delegated NESHAP authority) to issue waivers of compliance to subject facilities for up to two years after promulgation of a new NESHAP. This waiver, in essence, is a schedule by which the source is required to achieve full compliance with a NESHAP. The waiver includes intermediate dates with corresponding increments of progress toward achieving full compliance. A key element of the early inspections of a new NESHAP is to determine whether the subject facilities are meeting the terms of their waiver schedules. Since all current equipment leak NESHAPs became effective years ago, it is unlikely that many, if any, facilities have waivers which are still applicable. However, as new NESHAPs are promulgated (i.e., polymers), then this will be an important issue to consider.

It is important that the inspector keep detailed records for each inspection. An inspection notebook should be initiated during the pre-inspection time period so that all information is contained in a central location for the entire inspection. The notebook may be used to form the premise of the inspector's report and as evidence in legal proceedings, therefore it is critical that the inspector substantiate the facts with tangible evidence; i.e., pertinent observations, photographs, copies of documents, descriptions of procedures, unusual conditions, problems and statements from facility personnel. Reference 1

After determining that a facility is subject, the initial reports should be evaluated for completeness. The initial semi-annual NSPS report should contain process unit identification and descriptions, and the number of subject valves, pumps and compressors. The initial NESHAP report should contain a statement that the requirements of the regulation are being implemented, along with process unit identification, identification of all subject equipment, equipment type, percent of VHAP, the state of the fluid, and the method of compliance. If the initial report, the notification of construction or reconstruction, or the initial semi-annual report is incomplete, then the inspector should document this in the inspection notebook. Reference 2

NSPS and NESHAP sources are also required to submit semi-annual reports. The inspector should evaluate the most recent semi-annual reports for completeness and compliance with the requirements. Recall that the following information should be contained in these reports: Slide 9-4 Lecture 7

- process unit identification;
- number of valves, pumps, and compressors for which leaks were detected;
- number of valves, pumps, and compressors for which leaks were not properly repaired

- for each delayed repair, the facts that explain the delay and where appropriate, why a process unit shutdown was technically infeasible;
- dates of unit shutdown during the reporting period; and
- results of all performance tests conducted during the reporting period (if applicable).

The inspector should document any deficiencies relative to omission of required information. These semi-annual reports should be compared with each other and with the initial or initial semi-annual reports to determine the consistency of information. Any inconsistencies should be noted and investigated further during the plant visit.

Reference Volumes 2-2.1, 2-2.2, 2-2.3, and 2-2.4 are example reports which contain errors, inconsistencies, or suspicious areas common for NSPS and NESHAP reports. Students should review these reports and locate these instances. Reference Volume 2-2.5 is a summary of many of these problem areas of the reports. After completing this exercise, students should then refer back to the actual reports contained in Section 7 (Reference Volumes 2-1.1 through 2-1.12) and review these to determine if any problem or potential problems exist.

Ref. Vols. 2-2.1 through 2-2.5

Ref. Vols. 2-1.1 through 2-1.12

During the review of the reports from the facility, any unclear information or question areas should be highlighted so that plant personnel can be questioned or plant records checked. A complete and well organized list of all questions should be made in the inspection notebook and carried on site during an inspection.

The overall plant compliance will be determined by a complete inspection of records, equipment, and the leak detection and repair program. From pre-inspection activities the inspector should already possess a general understanding of the plant under investigation, the processes employed, the products produced in addition to being familiar with all applicable regulations and knowing what type of information is required to determine compliance with each. This helps to select those units suspected or detected as being compliance problems. It is meaningful to gain an impression of the overall situation through the review of the annual reports and other information, but it is equally important that an inspector not prejudge a facility based totally on its reports. The compliance determination should be finalized only after the on-site inspection, the post-inspection data review, and, if needed, follow-up inspections.

## On-Site Inspection

The Clean Air Act establishes the inspector's authorization to enter a plant for the purpose of inspection. Upon presentation of credentials, the inspector is legally authorized to enter into the plant to inspect any monitoring equipment or methods, conduct leak screening tests and access any records required to be maintained at the site.

Reference 2

Once the inspector has identified himself or herself and been granted entry onto the plant site, an initial interview should be conducted. The objective of the interview is to inform the facility official(s) of the purpose of the inspection, the authority under which it will be conducted, and the procedures which are to be followed. A successful initial interview will aid in obtaining cooperation of the plant officials in providing relevant information and assistance.

After the initial interview, the inspector should continue with the inspection of the facility. This will include a review of the plant records, an equipment survey, and an evaluation of plant procedures. The recommended first step is the records review.

### Records Review

Slide 9-5

The primary objective of the record inspections is to minimize fugitive emissions through requiring adherence to the recordkeeping requirements of the regulation. Records which are required to be kept by the facility (and not reported) should be reviewed by the inspector during the on-site inspection. The inspector should determine what information needs to be obtained to document compliance. In particular, the inspector should identify missing information, incomplete data or reports and inconsistencies in the available background material and specifically seek to extract this information from on-site facility reports for the purpose of making a compliance determination. Likewise, if noncompliance is suspected, the inspector should concentrate efforts on obtaining necessary documentation for verification.

The first step in the records review should be to determine if the records are complete according to the regulations. If a plant has claimed an exemption for one or more process units the following records are required:

- an analysis demonstrating the design capacity of the process units;

- an analysis demonstrating that equipment is not in VOC or VHAP service, and

- a statement listing the feed or raw materials and products from the affected facilities and an analysis demonstrating whether these chemicals are heavy liquids or beverage alcohol (NSPS only).

In this instance the inspector should evaluate the information contained in the required records and verify that the facility or process unit continues to meet the criteria for exemption.

For facilities with subject equipment, the following discussion describes items which should be checked in the completeness review. Reference 2

The plant should have the following information pertaining to all subject equipment in permanent log:

- a list of identification numbers for equipment subject to the standard;

- a list of identification numbers for equipment designated to meet the "no detectable emissions" compliance option including the owner/ operator's signature authorizing this designation;

- a list of identification numbers for pressure relief devices which are required to meet the "no detectable emissions" standard;

- the dates of each "no detectable emissions" compliance test, including the background level measured during each test and the maximum instrument reading measured at the equipment during each test; and

- a list of identification numbers for equipment in vacuum service.

The plant should have the following information in a two year log regarding leaks located on pumps, compressors, valves, PRVs in liquid service, flanges, and other connectors:

- the instrument and operator identification numbers and the equipment identification number;

- the date the leak was detected and the dates of each attempt to repair the leak;
- repair methods applied in each attempt to repair the leak;
- "above 10,000" if the maximum instrument reading after each repair attempt is equal to or greater than 10,000 ppm;
- "repair delayed" and the reason for the delay if a leak is not repaired within 15 calendar days after discovery of the leak;
- the signature of the owner or operator (or designate) whose decision it was that repair could not be effected without a process shutdown;
- the expected date of successful repair of the leak if a leak is not repaired within 15 calendar days after discovery of the leak; and
- the date of successful repair of the leak.

The plant should have the following information pertaining to their closed vent system and control device (CVSCD) in a permanent log:

- detailed schematics, design specifications, and piping and instrumentation diagrams;
- the dates and description of any changes in the design specifications;
- a description of the parameter or parameters monitors [see 61.242-11(e)] to ensure that the control device is operated and maintained in conformance with its design and an explanation of why that parameter (or parameters) was selected for monitoring;
- periods when the CVSCD is not operated as designed, (this includes periods when vents that should be controlled are bypassed to the atmosphere, a flare pilot does not have a flame, etc.); and
- dates of startups and shutdowns of the CVSCD.

The plant should have the following information pertaining to unsafe and difficult to monitor valves in a permanent log:

- a list of all valves which are designated "unsafe to monitor" with explanations of each valve; and

- a list of all valves which are designated "difficult to monitor" with explanations of each valve;

For valves complying with the "skip period leak detection and repair" compliance option, the plant should have a permanent log containing:

- a schedule for monitoring; and

- the percent of valves found leaking during each monitoring period.

Pumps and compressors that are equipped with a dual mechanical seal system must have sensors to detect failure of the seal system, the barrier fluid system, or both. For each pump or compressor, the design criterion (or parameter chosen to monitor) and an explanation of that criterion should be in a permanent log.

After determining the completeness of the records, a check for consistency and validity should follow. An inspector should take along a few of the most recent semi-annual reports so that comparisons can be drawn between the information contained in these reports and the information in the on-site records. If any equipment is complying by an option of the regulations which requires annual testing, then it is advisable to bring semi-annual reports which contain test results. The records for leaking pumps, compressors, and valves should be compared with the numbers in the last several semi-annual reports. Any inconsistencies between the reports and records should be noted. Slide 9-6

If a facility uses one or more closed vent systems and control devices to control emissions, then special records are required in this instance. The records must contain a description of the parameter or parameters monitored to ensure that control devices are operated and maintained in conformance with their design and a description of the reasons for this choice. The records must also contain design specifications, instrumentation diagrams, etc. for the systems and control device. Finally, the records must contain a log of periods when the closed vent systems and control devices are not operated in accordance with the design specifications.

Notes

The test data pertaining to no detectable emissions equipment or valves complying with percentage of valves leaking provision which was reported should be compared with the test information contained in the records. Again, any inconsistencies should be noted. A test for a process unit complying with the two percent leakage that indicates greater than two percent leakers is a violation. An instance where such a test was conducted and not reported should be noted and appropriate action taken.

Slide 9-7

Examination of the logs may reveal noncompliance due to improper or inadequate recording procedures. Facilities are in direct noncompliance under the following situations:

Reference 2

- failure to report leaks and dates of repairs;
- failure to report the reason for delaying repair of leaks past an allotted time frame;
- failure to develop a schedule to observe visual emissions from flares;
- failure to perform emission testing for control devices (except in the case of flares); and
- failure to record periods when the control device is not operating.

## Equipment Survey

Slide 9-8

All equipment which is subject to the regulation should be identified in the records, whether it is complying with an equipment standard, a leak detection and repair program, or through the use of a closed vent system and control device.

A major problem which confronts the inspector is determining if equipment exists in the facility which is subject to the standard but is not listed in the in-plant records and therefore is not being monitored and/or does not meet the equipment specifications. This may be the most difficult part of an inspection. One method of addressing this problem is to request a process unit material balance with a corresponding simplified flow diagram. This information could then be reviewed in detail to determine if there appears to be equipment which should be listed and is not. If such areas exist, then the on-site inspection or follow-up inspection should address this issue.

The NESHAP standards require that each subject component be marked in such a manner that it can be distinguished readily from other pieces of equipment. The inspector should spot check several pieces of equipment contained in the listing to determine if they are marked in a conspicuous manner.

The equipment which has been retrofitted with specified controls or replaced with leakless equipment should be checked to verify that they are in compliance with the appropriate equipment standard. This evaluation should begin by identifying such equipment during the records review. This consists of sampling connectors, open-ended lines and valves, and product accumulators (NESHAPs only). It also would consist of any equipment which is controlled by a closed vent system and control device.

Several pieces of each type of equipment should be chosen as candidates for spot checks to determine if they are designed and being used as required. To review, sampling connectors are required to be equipped with a closed-purge system or closed vent system, except for in-situ sampling systems. Open-ended lines and valves are required to be equipped with a cap, blind flange, plug, or a second valve. Product accumulator vessels are required to be equipped with a closed-vent system capable of capturing and transporting any leakage from the vessel to a control device. Any equipment which is not in compliance with the applicable requirements should be noted in the inspection notebook.

**Plant Procedures**

An inspector should also evaluate several plant operating procedures during the inspection. Some of these procedures will be indirectly observed while conducting other portions of the inspection, and others will need direct attention to measure the appropriateness and effectiveness. For example, during the reports and records inspection, the inspector should develop a perception of the effectiveness of the tracking system for monitoring and repairing leaks and the system for recording and reporting data. The comparisons of reports and records should give an idea of the interconnection of the data and the efficiency with which it is transferred from the records to the reports. Slide 9-9

A key element of the facility inspection is evaluating the leak monitoring program. This activity includes interviewing plant personnel, observing facility personnel calibrate leak detection equipment, and spot-checking a representative sample of equipment sources for leaks. This should be done by observing personnel perform leak detection monitoring on each type of equipment subject to the standard. By these observations the inspector verifies compliance with leak detection program as well as demonstrates to the regulated industry the agency's determination to actively pursue continuous facility compliance with the regulations.

The timely scheduling and prompt execution of monitoring is important, but equally important is the competency of the personnel conducting the monitoring. There are several steps an inspector can take to determine if the monitoring is being conducted in accordance with the regulation. The inspector should first interview the plant personnel that calibrate the portable hydrocarbon detectors and conduct the required leak patrols. During this interview, the inspector should discuss the applicable regulations, the plant procedures and schedules for monitoring, the recording of monitoring results, general information regarding VOC portable analyzers, requirements of Method 21, and any other areas the inspector feels are appropriate. The purpose of this interview is to determine if plant personnel have received adequate training to perform the work practice standards required by the regulation.

The instruments used to determine compliance of facilities must be calibrated on a routine basis. The calibration precision tests, response time and response factor tests reveal whether the instruments are operating properly for the specific applications. The inspector should witness the calibration procedures and note any deviations from Method 21. The inspector should record the instrument response time, the response factors, and calibration precision test.

As discussed in Lecture 5, a number of other factors can be important such as: probe cleanliness, probe leakages, gas flow rates, improper warm-up period, incorrect zero or meter adjustment. The inspector should verify that the plant procedures include proper check-out evaluations of the analyzer before use. Lecture 5

The inspector should also observe plant personnel performing actual leak detection measurements. This observation can serve two purposes. First it allows the inspector to evaluate the technique and knowledge of Method 21, and second, it provides an opportunity to spot check equipment. The plant personnel should be able to correctly monitor fugitive emissions from all the equipment types at the plant site. Additionally, the plant personnel should be able to correctly determine background concentrations. Any deviations from the Method 21 procedures discussed in Lectures 5 and 6 should be noted. Lectures 5, 6

The spot checks should include monitoring of a few equipment items for leaks. The inspector should concentrate the field monitoring on the following: Reference 3

- recently leaking devices;
- "no detectable emission" devices;
- closed vent systems and control devices (insure compliance with minimum temperature, residence time, efficiency and no detectable emissions);
- flares (no visible emissions as determined by Reference Method 22)
- exempt devices (verify compliance).

Each dual mechanical seal system with barrier fluid system is required to be equipped with a sensor that monitors the chosen criteria to detect a system failure. This sensor must be checked daily or be equipped with an audible alarm. The inspector should verify that the sensor has an alarm which is working properly or that the sensors are being monitored daily. Lecture 7

If a control device is being used to control VOC or VHAP emissions, then records must be kept regarding this equipment. The inspector needs to observe several items in this area. The first is the identification of the control device and the manner in which the owner or operator is monitoring its operation. Following are several questions which should be answered for different types of control devices. Reference 2

- What type of control device is used in the facility's CVSCD?
- What is the claimed control device efficiency?
- Is the efficiency measured (tested) or calculated? Obtain a copy of any of these test results or calculations.
- For incineration devices, what is the combustion temperature during the inspection (from the field or control room)?
- Describe the control device and the critical parameters which demonstrate compliance (e.g., adsorber pressure

drop/regeneration cycle time; scrubbing fluid flow rate/pressure drop; final temperature leaving condenser).

- For flares, during normal operation what is the net heating valve and exit velocity of the flaregas? Is the velocity and net heating value of the flaregas measured (tested) or calculated? Obtain copies of these test results and/or calculations. Check the flame indicating device (probably a thermocouple readout) in the field or control room for proper operation. Observe the flare for visible emissions.

The inspector should evaluate the parameters chosen and the rationale for this selection to determine if these parameters are appropriate to monitor proper operation for the type of control device. Appendix B to Ref. Vol. 2-3

The inspector should then review the monitoring data to ascertain if the control device is being operated according to its design. The records must also contain design specifications, instrumentation diagrams, etc. so that this comparison can be drawn. The records are to contain a log of periods when the closed vent systems and control devices are not operated in accordance with the design specifications. The duration and frequency of noncompliance episodes should be noted. The inspector should compare his findings regarding such periods (based on a review of the monitoring data) with the instances recorded in the log. Any inconsistencies should be noted in the inspection notebook.

**POST-INSPECTION**

Upon completion of the compliance inspection, the inspector begins the final task of determining facility compliance. The inspector should begin preparing the inspection report while all the events of the inspection are still fresh in his or her mind. The inspector should prepare the report before he or she conducts another leak detection inspection. When two or more inspections are done at one time, it becomes difficult to mentally separate one from another. The facility data contained in the initial report, the semi-annual reports, as well as results of the facility record review and the inspection provide the inspector with the information to determine compliance with the regulations. Additional information, elaboration or clarification may come from the inspector's field notebook. If the inspector feels that it is needed, letters may be issued or phone calls made requesting additional information. The instance may occur where compliance cannot be determined based on the initial inspection and subsequent Slide 9-10 Reference 2 information requests, and a return visit to the plant is necessary. These follow-up type inspections should be abbreviated in nature and focus on the question or problem areas.

The post-inspection process should begin by reviewing the applicability determination to ensure that the facility as a whole and all individual process units are properly classified. The equipment listings should also be reviewed.

There are two fundamental questions which an inspector should consider during this post-inspection data sorting.

1. Is the recordkeeping system adequate to track monitoring, leaks, and repairs?

2. Are the monitoring staff, equipment, and procedures adequate?

The answers to these questions and rationale for these answers should be contained in the inspection report. If the response to either of these is no, suggestions should be made to proper plant personnel to aid in correction of the existing problems.

The next phase of the post-inspection process is to write the inspection report. The report organizes and correlates all evidence gathered during the inspection into a concise and useable format. The report serves to record the procedures used in gathering data, gives factual observations and evaluations drawn in determining facility compliance. The inspector's report will also serve as part of the evidence for any enforcement proceeding or compliance-related follow-up activities. Reference 2

The inspection results should be organized in a comprehensive, objective and accurate report. The recommended report elements are listed below:

- Introduction
- Compliance Status for Regulated Equipment
- Data
- Summary

After an inspection, the inspector should prepare for the next inspection while the facility's processes are still fresh in his or her mind.

This can be accomplished by preparing a list of items to be checked and information to be reviewed or gathered during the next inspection.

There are several suggestions to be considered for additional inspections. The pre-inspection preparation should basically be the same for each inspection. The inspector should review all the information contained in the facility's file including the intitial and semi-annual reports. The semi-annual reports which have been submitted since the last inspection should be reviewed most carefully. The past inspection reports should also reviewed. If any items were noted in these reports which required action by the facilty, then the semi-annual reports should be examined with these specific areas in mind. There also are items to consider regarding the on-site inspection. Due to the large number of records which are required, it may be impossible to review all records on each visit. If this is the case, it is a good idea to spot check a different portion of the records during each inspection. It is also suggested that the inspector check a different area of plant by general walk-through and equipment spot-checks in an effort to eventually cover the entire affected facility. Slide 9-11

**CHECKLIST REVIEW**

Reference Volume 2-3 contains checklists designed to assist in the inspection of a facility subject to the benzene NESHAP. Due to the similarity of the NESHAP and NSPS standards, these checklists could be easily modified for NSPS inspections. There are two checklists, an inspection preparation checklist and an inspection checklist. Ref. Vol. 2-3 Reference 2

The preparation checklist contains sections initial report review for completeness and review of semi-annual reports. The inspection checklist also includes facility information, a records checklist, a general information gathering checklist, a table for recording vessels and non-floating roof tanks not listed as product accumulator vessels, a benzene stream identification table, and a field/control room inspection checklist. If an inspector covers all areas in the checklist, this should be an excellent foundation for an inspection.

It should be noted that no checklist can replace a knowledgeable, experienced inspector. For this reason the inspector should be extremely familiar with a great deal of background information. To conduct an inspection where all compliance related issues are uncovered, it is crucial that the inspector possess a good working knowledge of the applicable standard and all associated background information. This is especially true for equipment leak standards due to the complexity and many compliance alternatives. Therefore, an inspector should not depend on any checklist as an inspection tool without first researching and understanding all aspects of the regulations.

## REFERENCES AND ADDITIONAL READING MATERIAL


1. Joseph, G. and M. Peterson.; "APTI Course SI:417, Controlling VOC Emissions from Leaking Process Equipment, Student Guidebook," EPA-450/2-82-015; August 1982.

2. U.S. EPA, "Portable Instruments User's Manual for Monitoring VOC Sources," EPA-340/1-86-015, June 1986.

3. Engineering Science; "Benzene Equipment Leak Inspection Manual," EPA-340/1-90-001, July 1990.

4. McInnes, Robert G. et. al.; "Guide for Inspecting Capture Systems and Control Devices at Surface Coating Operations, Final Draft," Report Prepared for U.S. EPA Contract No. 68-01-6316; May 1982.

5. Weber, R.C. and K. Mims,; "Project Summary, Evaluation of the Walkthrough Survey Method for Detection of Volatile Organic Compound Leaks," EPA-600/S2-81-073; July 1981.

6. Gordon, Robert J., et. al.; "Inspection Manual for Control of Volatile Organic Emissions from Gasoline Marketing Operations," EPA-340/1-80-012; January 1990.

# LECTURE 10

## INSPECTION SAFETY

**Notes**

### INTRODUCTION

Safety is an important issue in equipment leak inspections. This section discusses the importance of selecting safe portable VOC monitors and recorders. Also the procedures for recognizing and avoiding typical inspection hazards during leak screening tests are addressed.

### SELECTING AND USING VOC ANALYZERS

If an inspector is going to use a portable VOC detector, then it is very important that the instrument itself be safe and that he or she is knowledgeable of safe procedures for using the analyzer. Hazardous locations are divided into three classes: Class I, Class II, and Class III. Each class is divided into two divisions (Division 1 or 2) according to the probability that a hazardous atmosphere will be present; and also into seven groups depending upon the type of hazardous material exposure. Groups A through D are flammable gases or vapors, and Groups E, F, and G apply to combustible or conducting dusts. Class I, Division 1, Groups A, B, C, and D locations are those in which hazardous concentrations of flammable gases or vapors may exist under normal operating conditions. Class I, Division 2, Groups A, B, C, and D locations are those in which hazardous concentrations of flammables may exist only under unlikely conditions of operation.

Reference 1

Only instruments which are rated intrinsically safe for Class I, Division I and Division 2 areas should be used. Intrinsically safe basically means that the instrument will not provide a source of ignition if the instrument is used properly. It is also important that instrument recorders meet the same safety requirements as the instrument itself. It is not difficult to identify instruments rated as intrinsically safe because they will have a clearly marked seal.

Slide 10-1

Although an inspector need only look for the intrinsically safe seal, it is important that he or she be aware of the characteristics which allow an analyzer to receive this classification. As mentioned earlier, these areas have potentially flammable or explosive vapor concentrations and it is extremely important that the analyzer not produce any sparks which are exposed to the surrounding air. An

Slide 10-2

intrinsically safe VOC analyzer must have encased battery packs, encapsulated amplifiers, and have specially designed electrical circuitry. In addition, flame ionization instruments must be equipped with flame arrestors.

Certain operating procedures and safety precautions must be observed when any portable VOC detection device is used. The first thing that must be done is to read the operating and service manual carefully before using the device in the field. Also, to maintain the intrinsic safety which is built into certain detectors, it is important that the operating and service manual be consulted before trouble-shooting or servicing. The inspector should always check the instrument to confirm that all protective features have not been disabled or removed. Slide 10-3

Mixtures of hydrogen and air are flammable over a very wide range of concentrations. Therefore, safety precautions should be taken when refilling the hydrogen supply tank. This should be carried out in a safe area to ensure that there are no sources of ignition.

Many typical hazards can be easily avoided if the inspector uses sound judgement during the leak screening tests. There are several fundamental points which are worthy of reference. There may be equipment (especially valves) in difficult or awkward locations. The standards themselves recognize that this is a common situation as they allow the designation of valves as difficult to monitor and unsafe to monitor. A good rule is not to attempt to monitor equipment which is located more than 6 feet above secure platforms. Slide 10-4

There may be instances where an inspector needs to climb a ladder. In these situations, the inspector should never attempt to hold an analyzer while climbing or descending a ladder. Both hands must be free for climbing.

The simple matter of walking around the plant while carrying the instrument can present problems due to the possibility of slippery surfaces. Care should be taken to select walkways which appear to be secure. An inspector should not work in or around slick areas.

Equipment with rotating or moving parts which are left unprotected present a safety hazard and special care must be taken to keep support straps and other parts of the analyzer away from such danger. Also a rigid probe should not be placed in contact with a moving part such as a rotating pump shaft. A short, flexible probe extension tip may be used. Most pump shafts have shaft guards that protect against entrapment in the rapidly rotating shaft. With some instruments, it is difficult to reach through the guard to the location of the shaft and shaft seal. The guard should not be removed under any circumstances, and those pumps without guards should be approached very carefully. If there is any question concerning the safety of the measurement, it should not be performed.

Another hazard which exists is the presence of extremely hot equipment and hot exhausts. An inspector should avoid work in close proximity to hot equipment, but be especially careful not to place the umbilical cord from the detector on a heated surface such as a pipe, valve, heat exchanger, or furnace.

## INHALATION HAZARDS

The normal procedure for testing a leak at equipment is to place the probe within one centimeter of the equipment. This close location is necessary because of the relatively poor capture effectiveness inherent in the probe designs discussed in Lecture 6. This brings the inspector into the immediate vicinity of the leak because of the short length of most probes. If a leak is present, the VOC emission plume concentrations are usually very high. Also, there are normally a number of fugitive VOC leak sites around the equipment being checked, thus increasing the possibility of contacting a high concentration plume.

Slide 10-5
Lecture 6

This can be especially hazardous because many of the fugitive VOC compounds have very poor warning properties therefore providing little warning of their presence. Concentrations encountered for odor, taste, and irritations are usually well above the permissible exposure limits. The risks are significant because some VOC compounds also have serious toxic effects.

Slide 10-6

There are several steps which can be taken to avoid these inhalation risks. One is to survey areas before entering and refrain from entering spaces with poor natural ventilation where high level concentrations can collect. It may be helpful to identify risky areas by leaving the instrument on while walking through the facility to detect any intermittent fumigation from VOC leaks in the general area.

Slide 10-7

During the monitoring of a leak with a VOC analyzer, direct contact with high concentrations can be partially avoided by not standing directly above the portable analyzer probe. However, because some contact is inevitable, respirator protection approved by plant and agency safety officials should be worn at all times.

A respirator is essential to inspector safety, but it is important to realize that wearing a respirator does not eliminate all inhalation hazards. Respirators have many limitations. Both cartridges and canisters for organic vapor suffer breakthrough quickly and are not equally effective for all types of organic compounds. The wearer should consult published tables of relative breakthrough times before using a particular respirator. Also, organic vapor air purifying respirators become less effective when the air temperature and/or the relative humidity increases. While monitoring a leak, the inspector could exceed the safe operating range of the respirator and even saturate the respirator cartridge. All screening tests should be terminated when the concentration of organic vapor exceeds the maximum safe concentration of his or her specific respirator. Slide 10-8 Reference 2

In addition, many organic compounds emitted as fugitive leaks are skin absorbable. Respirators do not provide any protection against these materials. Slide 10-9

The respirators may create an inhalation hazard of their own. If the respirator face pieces have been sprayed by organic liquids and decontamination of the face pieces is not complete, there may be organics remaining. These face pieces should be carefully inspected for remaining contamination before using. If there is a questions concerning the adequacy of decontamination, the respirator should be discarded.

## GENERAL SAFETY POLICIES

There are other general safety policies which should be followed. The first is to plan ahead and obtain all necessary personal protection equipment prior to leaving for the inspection site. Equipment should not be borrowed from the plant. All the safety equipment, especially respirators, should be checked to confirm that they are in good working condition. The inspector should be aware of and conform to all applicable plant and agency safety policies. If plant specific policies are not known, then the inspector should take the time to discuss these with plant personnel before proceeding through the plant. Slide 10-10

Inspectors should not work alone. Because agency coworkers are rarely present, the inspector should insist that someone from the plant accompany him or her at all times to ensure that the inspector does not inadvertently enter unsafe areas, to assist in the even of accidental gas releases within the facility, to get help if the inspector is injured and to provide general assistance and advice regarding safety. Slide 10-11

Inspectors rarely have the opportunity to acclimate to heat stress. Heat exhaustion and stroke can result from the physical exertion of carrying the instruments and from exposure to hot process equipment. Therefore, regularly scheduled breaks should be taken to drink fluids to reduce the risk of heat stress. Slide 10-12

As noted in Lecture 6, it is best to calibrate the analyzer at a laboratory facility at the inspector's office before leaving. However, in the event that this is not possible and compressed calibration gas cylinders must be taken to the inspection site, then the inspector must comply with all DOT regulations regarding the transport of such cylinders. Slide 10-13 Lecture 6

**REFERENCES AND ADDITIONAL READING MATERIAL**


1. Joseph, G., and M. Peterson, "APTI Course SI:417, Controlling VOC Emissions from Leaking Process Equipment, Student Guidebook," EPA-450/2-82-015, August 1982.

2. U.S. Environmental Protection Agency, "Portable Instruments User's Manual for Monitoring VOC Sources," EPA-340/1-86-015, June 1986.

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