APPENDIX C

Breathing Air Systems

BREATHING AIR SYSTEMS

INTRODUCTION

While OSHA regulations allow a respiratory protection program based on workplace conditions, EPA and NIOSH have published recommendations that breathing air systems be used to provide the "maximum feasible level" of respiratory protection for workers that are occupationally exposed to airborne asbestos fibers. The higher level of protection offered by breathing air systems such as Type C pressure demand supplied air respirators make them attractive for some asbestos removal projects. Before providing breathing air on an asbestos removal project, it is important to understand some basic requirements. A breathing air system should provide the following:

- **A continuous sufficient supply of quality breathing air,**
- **Adequate reserve or escape time,**
- **Breathing air temperature control,**
- **A continuous carbon monoxide (CO) monitor and alarm**

This section provides a review of breathing air systems including a discussion of theoretical and practical issues relating to air compression, purification and distribution. This information tends to be technical in nature and is primarily provided as a reference or resource to project designers.

CONTINUOUS SUFFICIENT SUPPLY OF QUALITY BREATHING AIR

A continuous sufficient supply of quality breathing air means the air pressure, volume and quality requirements necessary for proper respirator operation are supplied directly to each respirator. The minimum OSHA requirement for quality breathing air is air that meets at least Grade D criteria established by the Compressed Gas Association, Inc. (CGA). Grade D air is a minimum standard; other guidelines exist which are more stringent. Producing and supplying breathing air is accomplished by the combined effect of compression, purification, and distribution processes. Persons interested in the operation of any breathing air system for use with supplied air respirators should be familiar with the principles of air compression.

Compression – Consider the theoretical compression process apart from the mechanical influence of compressors. Atmospheric air carries water vapor and contaminants. In atmospheric air, water vapor is not usually considered a contaminant. In compressed air for breathing purposes, however, water vapor should be considered a major contaminant which also traps and carries other contaminants. **In order to produce breathable air, water vapor must be properly processed out of the compressed air.**

When a parcel of air is compressed, its volume decreases while its absolute pressure and temperature increase *(Figure C-1)*. Air temperature always rises with compression. Even at low pressures, there are substantial temperature elevations. The contaminants and water vapor are also compressed with their concentration increased. Compressing air also reduces its ability to hold water vapor. However, increasing the temperature increases the ability to hold water vapor. Because of these two opposite effects, water

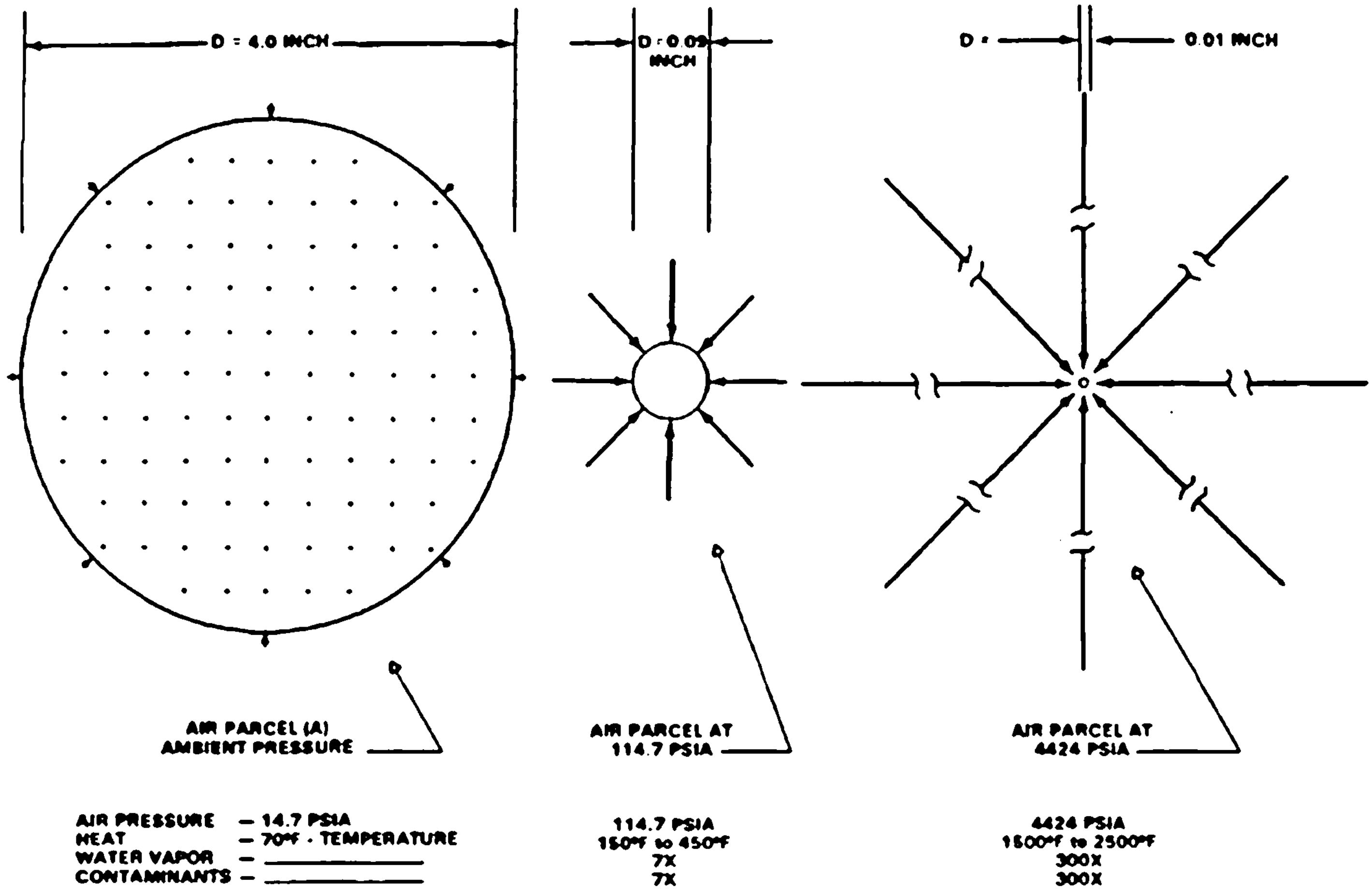


Figure C-1 – THEORETICAL AIR COMPRESSION vapor will not condense immediately upon compression, but most certainly will condense as the air temperature decreases.

When a parcel of compressed air is held for a time at its higher pressure, the heat eventually dissipates. Once compressed air has cooled back to ambient temperature, a large amount of the water will have condensed. Condensed water can be mechanically collected and drained. Any further reduction in temperature of the air parcel will result in additional water condensation.

Mechanical compression requires a compressor of some type. Additional heat from the drive motor and friction will be added to the air during the compression process. The compressor may also add wear particles such as metal, carbon, etc. In addition, the compressor may also add lubricant oil as either liquid oil or oil vapor. If the compressor operates at excessive temperatures, it may actually form carbon monoxide (CO) within the machine, although such CO formation is rare.

The use of a compressor may be limited to purposes for which it was originally designed and built. For instance, a compressor built to power other industrial air machines may not need heat, water, and oil removal. In fact, some compressors actually have "oilers" in the output air to increase the oil being carried in the air. An unsuitable compressor for breathing air could easily overpower the finest air purifier assembly resulting in excessive costs to maintain the required air quality.

The real effect of water as a contaminant of breathing air can be understood by tracing its pathways through a mechanical compressor. The machine will draw outside air with water vapor through a remote intake pipe to the compressor. If the machine is properly designed for breathing air applications, it will have an aftercooler to cool the compressed air and to condense most of this water. The water can be mechanically removed from the aftercooler using a drain trap. This leaves some water vapor still in the compressed air. Most of the water vapor will be removed along with any other contaminants by the air purifier assembly that is downstream of the compressor.

Purification – Ordinary compressed air cannot be used to supply breathing air to work crews working in hazardous atmospheres. **Ambient breathing air, when pumped through an ordinary compressor, is not fit for human respiration.** Even if the compressed air is filtered to remove dust and other particulates, it still contains the contaminants in ordinary atmospheric air plus the localized contaminants near the compressor intake, plus any contaminants (oil vapor) and wear particles added during compression.

The compressor intake is especially vulnerable to all types of carbon monoxide sources. Sources of CO, such as transient motor vehicles and other mobile internal combustion engines, are especially hard to control on the typical asbestos abatement job. These contaminants are concentrated by the compression process. For these reasons, compressor-based breathing air systems will **not** provide protection unless the air is purified.

Purification of air is a precise technology which has developed over many years. Purification is considerably more than filtration. Filtration is simply capture and removal of particulates by a filter and is a small part of the overall purifying process.

Purifiers are based primarily on the design and use of adsorption. Adsorption of vapor and chemical contaminants is done by proper design and use of the class of materials known as **adsorbents.** The common adsorbents used in the design of air purifier assemblies may include molecular sieves, silica gel, activated alumina, and activated charcoal.

Adsorption is the adhesion in a thin layer of molecules to the surface of solids or liquids with which they are in contact. Adsorbents are porous-type materials with large quantities of interconnected, submicroscopic internal voids, pores, or capillaries. This internal porous structure gives these adsorbent materials very large surface areas in contact with the gases to which the adsorbent is exposed. These adsorbents can hold onto, or adsorb onto their active surfaces, selected contaminants. These adsorbents are not all equally effective with all contaminants. Furthermore, water can decrease the efficiency of many adsorbents, making them ineffective in removing the intended contaminants. For the adsorbent design to be effective, the appropriate types, quantities, and sequence of adsorbent materials must be selected.

The effectiveness of all adsorbents increases with increasing pressure. As the pressure of the air increases, the density of the air increases. More dense air exposed to any adsorbent material simply means that more of the air is pushed into more intimate contact within the adsorbent. Therefore, **as air pressure increases, less adsorbent is needed to do the same job.**

Adsorbents must be periodically replaced. Adsorbent cartridges can be equipped with a color change reaction that will show the progress of adsorbent use. Such cartridges can be monitored based on color change through a clear canister. Adsorption canisters may also be replaced on a simple operational time basis.

The carbon monoxide catalyst is used to eliminate carbon monoxide. On the catalyst surface, carbon monoxide, in concentration ranges of 10 ppm to 600 ppm, is brought into contact with oxygen in the air. The carbon monoxide is oxidized to carbon dioxide (CO_2). The end result is that dangerous CO is changed to CO_2, which is not harmful in these low concentrations. Theoretically, catalysts should last forever; but, in practice, they permanently adsorb trace chemicals and become "inactive." Most manufacturers recommend yearly replacement of their catalyst-type filters.

Even very small amounts of water vapor on the catalytic adsorbent "poison" the catalyst and reduce its activity. For such a catalyst to operate for a reasonable period of time, the air entering the catalyst must be very dry, below 5 percent relative humidity.

The most effective way to dry air to these conditions is to use drying adsorbents before the air reaches the catalyst. For pressures under 200 psi, the heatless air regenerated dryer has evolved as the simplest and most rugged method to continuously regenerate the required adsorbent material. It consists of airline plumbing, two central air dryer towers, and a tower switching system. In action, this system has one tower drying the airstream while the other tower is "off-cycle." Some of the dry air output of the operating tower is split off and sent in reverse through the "off-cycle" tower. Water previously adsorbed is released and vented to the atmosphere. In this way the off-cycle adsorbent material is renewed or regenerated.

A typical adsorbent design containing activated alumina in each tower can usually operate for several years before the activated alumina must be replaced. Replacement of activated alumina only one time every few years is inexpensive when compared to a throwaway canister design which would need new activated alumina every eight hours.

Before compressed air reaches the alumina for water vapor removal, oil must first be removed. The active media in the oil adsorption prefilter is chosen for its ability to selectively retain oil and oil vapor. It can be formulated with a color change reaction and placed into a clear canister for visual determination of the filter media remaining. The oil vapor adsorption prefilter may quickly be saturated if "slugs" of oil and water come from the compressor. Removal of liquid "slugs" just prior to the oil prefilter is accomplished by a coalescing filter and drain trap.

Grade D breathing air is specified by OSHA 29 CFR 1910.134(d)(1) as that listed by the Compressed Gas Association Specification G-7.1. Most established American manufacturers of both high and low pressure breathing air purification systems design and test their systems to produce Grade D or better breathing air.

Distribution – Breathing air must be delivered to the respirators in a continuous and sufficient supply. This means that proper air pressure and air volume requirements must be maintained through the purification and delivery processes. Required air pressure can be ensured:

- by measuring and controlling the air pressure within the air delivery system at the entrance to the respirator hoses.

- by maintaining the required pressure under all flow conditions when all the respirators are being used.

Two factors which affect the respirator pressure during air flow are (1) the inside diameters of hoses and their connectors, and (2) the overall length of

air supply hose. In low pressure systems, respirator hose line pressures must typically be maintained in the 65-100 pounds per square inch gauge (psig) range. OSHA and NIOSH prohibit the hose length from the respirator manifold to the worker to exceed 300 feet.

A test of the low pressure distribution system can be conducted by: (1) laying out the required length of air transfer hoses; (2) connecting all respirator manifolds; (3) attaching the maximum number of respirator hoses and respirators to be used; (4) pressurizing the system; and (5) with all respirators in use, checking the pressure at the respirator manifolds.

Should the pressure at the manifolds be less than the required respirator pressure, increasing the pressure may be accomplished by using extra large diameter supply hoses, or increasing compressor pressure combined with use of a control regulator at the respirator manifolds. If the required respirator pressure cannot be maintained, the hose lengths should be shortened to increase pressure, or a larger capacity system used.

ADEQUATE RESERVE AIR OR ESCAPE TIME

Providing for adequate reserve air or escape time is a necessary function of the breathing air system. The OSHA respirator standard [29 CFR 1910.134(d)(2)(ii)] states, "A receiver of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in event of compressor failure and alarms to indicate compressor failure shall be installed in the system."

This poses the question of how much reserve time, and therefore how much stored air, is necessary. If a work crew were told an escape test is going to be conducted at a specified time, such a test might show that only 10 to 20 minutes were required. The escape time required under actual workplace conditions could be considerably longer. Complex airline routing and tangling, work on scaffolding or in restricted access areas, and the work crew shower requirements can all lengthen escape time. For a crew size of 10 workers, actual egress times have been measured at 30 to 50 minutes and more. Therefore, for most asbestos projects, a reserve time specification of 50 minutes to 1 hour is needed. Certain special asbestos jobs with more complicated egress conditions may need escape time of more than one hour.

Breathing air stored in pressurized cylinders is used as the method to obtain the required escape time. Using high pressure (2000 to 4000 psi) reserve air storage does not adversely affect specification, choice, or the use of low pressure breathing air systems. The cost of providing a high pressure standby reserve system with a low pressure breathing air system is minimal. Rental is the normal arrangement for suppliers of such high pressure tanks. Since this reserve should be used only for the occasional emergency compressor stoppage, the actual cost of the air used on a job site should also be minimal.

TEMPERATURE CONTROL OF BREATHING AIR

Asbestos removal during warm weather can create extremely hot working environments for abatement workers. Typically, the heating, ventilation, and air conditioning is shut down, the area is sealed off with plastic sheeting and water sprays are employed. It is not unusual to see workplace ambient temperatures of 100° to 120°F with relative humidities in the 90 to 100 percent range. Asbestos removal work is hard physical labor. The asbestos worker is clothed with disposable garments which inhibit evaporation of sweat, therefore reducing the transfer of heat from the body.

In the typical asbestos work site, cool breathing air will aid in cooling the asbestos worker. The lung serves as a source of heat transfer. Cooling methods using cool breathing air can also be used to provide cool air externally to the worker. This can be accomplished simply by directing the cool exhaust from the respirator exhalation valve down inside the asbestos worker's protective clothing. Three common methods are available to cool the breathing air. These are the aftercooler, a vortex tube, and adiabatic cooling.

Aftercooler – Hot compressed air exiting a compressor may be cooled by an aftercooler or heat exchanger. These heat exchangers may transfer the heat either to the ambient air (air cooled) or to locally available cold water (water cooled). For the downstream air purifier assembly to function properly and give good control to process high-quality breathing air, excess heat, water, and oil must be removed. This is accomplished by first removing heat, and then removing the condensed water and oil.

The efficiency of the air cooled aftercooler will be affected by the ambient air temperature. Because of this fact, the air cooled aftercooler will not function as efficiently on the hottest days, when worker cooling is most needed. Therefore, the best type of aftercooler choice to ensure that worker cooling is available when needed may be the water cooled aftercooler.

Vortex Tube – The vortex tube (for cooling or heating) is another available method of worker temperature control. The vortex tube is simple, lightweight and inexpensive. It is a tube of approximately one-half to one inch diameter and six to twelve inches in length. Air is admitted into the side of the tube and split into two separate airstreams, each exiting at opposite ends of the tube. One airstream is hot, the other is cold. Either of these two airstreams may be directed into the worker's disposable suit or hood to provide external temperature control to the worker.

The disadvantage of the vortex tube is that it uses a comparatively high volume of air, approximately 15 to 20 cfm per worker. Compared to the air used by a pressure demand type respirator, each vortex tube will use as much air as would be needed to supply four or five pressure demand respirators. Therefore, the use of vortex tube cooling will require increased capacity for both the compressor and the breathing air purifier.

Adiabatic Cooling – Adiabatic cooling is available when sufficient cooling capacity has been designed into each of the multistage compression steps found internally in a high pressure compressor. Provided that the high pressure compressor cooling design is adequate, cool or ambient temperature air will be produced at the high pressure compressor outlet. This air is delivered to the air reserve tanks and then into the asbestos work area via high pressure airlines at a pressure of 1000 to 4000 psig. A regulated control panel in the work area drops the high pressure air down to the required respirator line pressure (typically in the 65 to 100 psig range). The air temperature drops dramatically with this rapid air expansion at the control panel and the resulting cold air is directed into the respirator lines. Adiabatic cooling in this manner is very simple, lightweight and reliable, provided the compressor has been initially designed to be adequate for such cooling.

CONTINUOUS CARBON MONOXIDE (CO) MONITOR AND ALARM

Providing a continuous CO monitor and alarm is a good practice. **The CO monitor should be specified as a part of the overall breathing system or breathing air purifier assembly.** The CO monitor must be kept in calibration and the alarm tested daily.

Low Pressure Breathing Air System Alarm Response – When the alarm sounds, the breathing air system should immediately be switched to the high pressure standby air reserve system. Depending on the capacity of the reserve system, the workers should exit the work area. The outside supervisor should check off all workers as they leave the work area to make certain that all workers have exited the work area. With sufficient high pressure reserve or when using a high pressure breathing air system with sufficient in-line reserve capacity, CO alarms and unexpected compressor shutdown may be handled without disruption in the asbestos removal work.

Remember, air being processed in a low pressure air system is almost immediately being delivered to and breathed by the workers. Therefore, when using the low pressure system, there is an immediate need for switch over to the high pressure reserve air when the CO alarm sounds. If only the minimum high pressure reserve is available, the workers should exit the area. If additional reserve air capacity is available, the workers should exit when the reserve supply approaches the minimum acceptable amount.

High Pressure Breathing Air System Alarm Response – Immediately stop the air flow from the compressor into the in-line reserve air bank by shutting the output air valve. (Note: If so arranged, this step may be automatically accomplished through relays in the CO monitor.)

Immediately test the air for CO in the supply output from the air bank to the workers. If the air test shows no carbon monoxide in the air from the air bank going to the workers, then the workers may continue to work. They may work as long as no further air from the compressor is being admitted into the air bank, and provided more air time is stored in the bank than the required one-hour reserve time. When, and if, the one-hour reserve level is reached, the workers should exit the work area.

TYPES OF BREATHING AIR SYSTEMS

There are two general types of breathing air systems in regular use for asbestos removal. These general types are categorized according to the pressure levels at which they are designed to operate:

- Low pressure system,
- High pressure system.

THE LOW PRESSURE SYSTEM

The typical low pressure system is shown in *Figure C-2* and consists of:

- A low pressure compressor,
- An aftercooler assembly with water removal traps,
- An air purifier assembly,
- A standby high pressure air reserve assembly,
- A surge-tank or in-line air volume tank,
- A distribution hose and distribution manifold with connections for respirator hose lines.

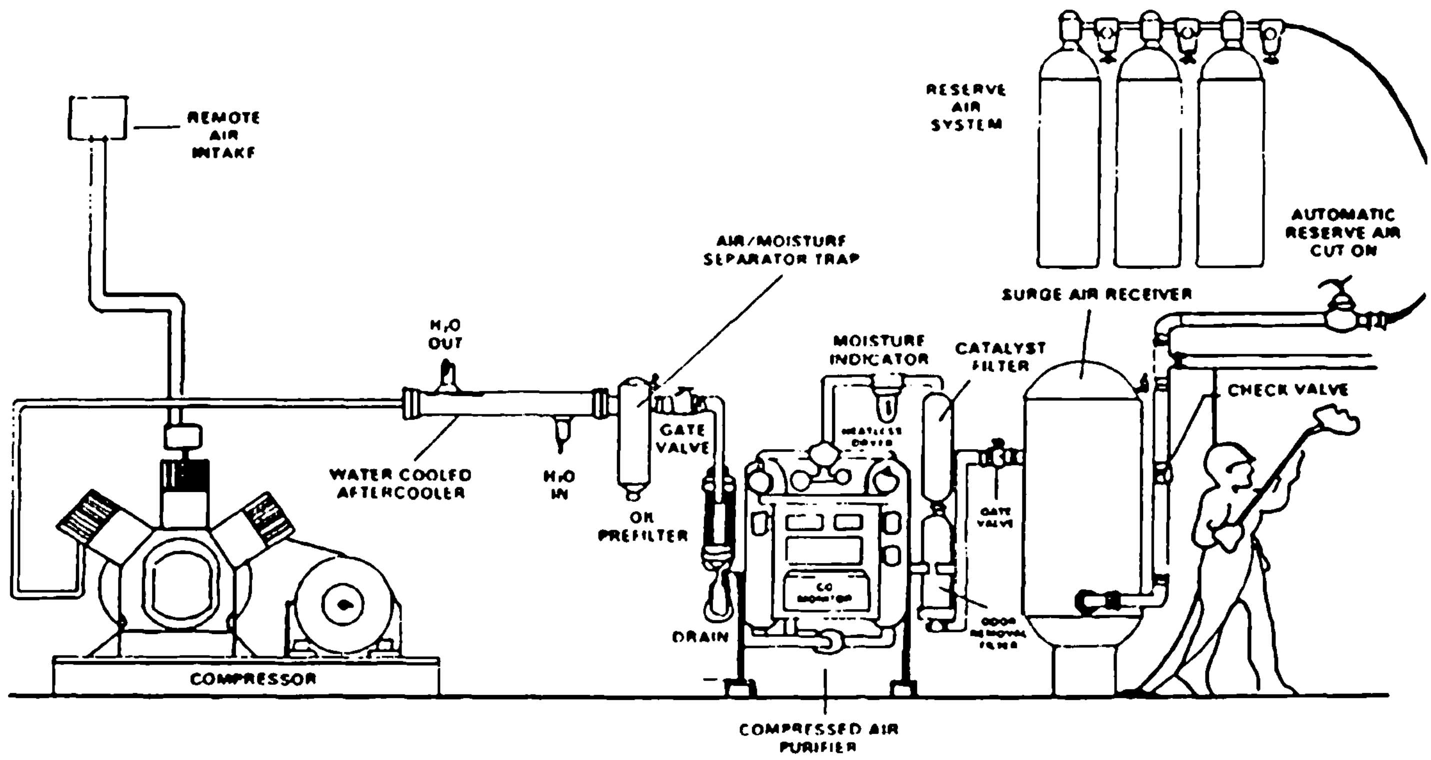
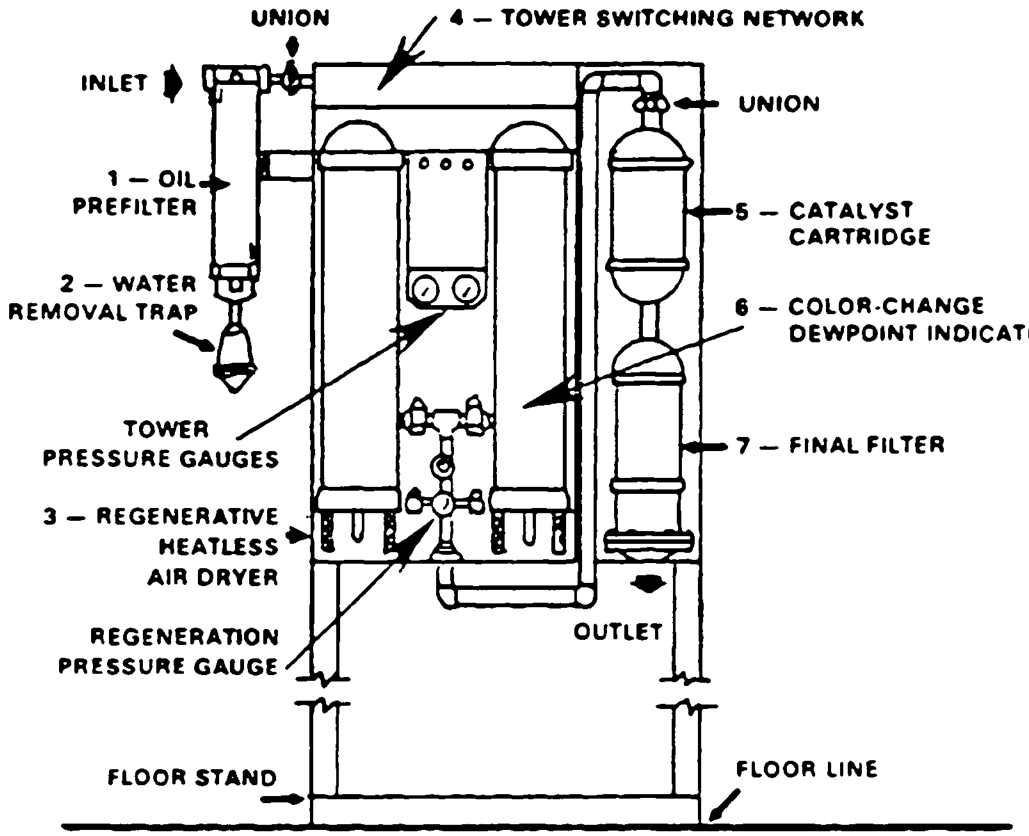


Figure C-2 – TYPICAL INSTALLATION OF LOW PRESSURE BREATHING AIR SYSTEM

Low Pressure Breathing Air Compressor – The low pressure breathing air compressor produces pressures between 100 and 200 psi. It has sufficient flow capacity to provide the flow needed for the respirators being used. The compressor should also be equipped with sufficient interstage and aftercooling capacity to reduce the air temperature to within 10°F of the ambient air temperature. The low pressure compressor should be equipped with suitable moisture removal traps to be able to remove 60 to 85 percent of the water/oil condensed within the machine. Water removal may be either automatic and continuous or manual and periodic.

Aftercooler Assembly with Water Removal Traps – The aftercooler assembly is used immediately following the low pressure breathing air compressor. The aftercooler and its water trap may be incorporated physically in the compressor. The purpose of the aftercooler assembly is to assure that the air temperature is reduced to within 10°F of ambient air temperature. Such a reduction in temperature forces condensation of water/oil in the airstream. The cyclone-type water separator or water trap is also a part of the aftercooler. This separator or water trap is used to allow removal of the water/oil mixtures condensed by the action of the aftercooler in the airstream. Aftercoolers may either be ambient air cooled or water cooled.

Air Purifier Assembly – The purpose of the purifier network is to purify the air to **at least** the required Grade D air quality. A diagram is provided in *Figure C-3.* A detailed discussion of its operation was provided previously in this section.



1. Oil Prefilter — removes oil mist, particulates, and entrained water. Color-change replacement notice
2. Water Removal Draintrap — removes condensed water-oil mixtures
3. Dual Regenerative Heatless Air Drying Towers — reduce water vapor content, action is to regenerate its own adsorber material
4. Tower Switching Network — acts with plumbing to provide timed dryer tower switching to effect regeneration
5. Catalyst Cartridge — removes CO by catalytic conversion to CO_2
6. Color Change Dewpoint Indicator — Color change visually shows the performance of the drying towers
7. Final Filter - effects odor removal

Figure C-3 – TYPICAL LOW PRESSURE BREATHING AIR PURIFIER ASSEMBLY

Standby High Pressure Reserve System – The only effective method to store sufficient air for an industrial sized asbestos removal work crew is through the use of high pressure storage tanks. Such tanks are available for rental at low rates, and they can be delivered directly to the asbestos abatement work site.

Surge Tank or In-line Air Volume Tank – A surge tank provides air storage capacity so that short-term peak flow conditions will not deplete the air supply.

Distribution Hose and Manifold with Connections for Respirator Hose Lines – Once air is processed through the low pressure air purifier it is directed into the delivery airline and is immediately available to the worker.

THE HIGH PRESSURE SYSTEM

The high pressure breathing air system shown in *Figure C-4* is composed of four major components:

- A high pressure compressor,
- An air purifier assembly,
- A high pressure air storage bank,
- A high pressure control and distribution panel.

High Pressure Compressor – The function of the high pressure compressor is the same as that in the low pressure system. The low pressure compressor utilized one or two successive compression steps or stages to compress the air up to 100 to 200 psi. The high pressure machine pumps the air to pressures of 2000 to 4000 psi utilizing from three to five successive stages of compression.

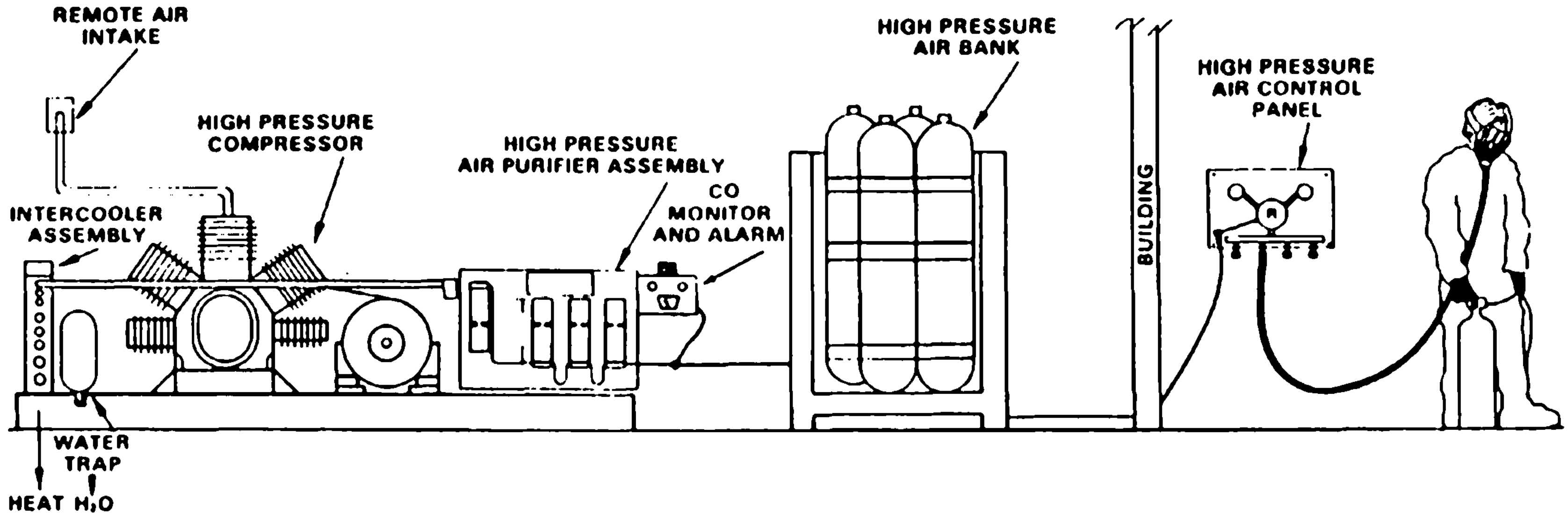


Figure C-4 – TYPICAL HIGH PRESSURE BREATHING AIR SYSTEM

Each time the air is processed through a compression stage, its density and its pressure are increased, and its volume is decreased. The air temperature increases sharply through each compression stage due to the adiabatic process. Following each stage of compression, the air is put through an intercooler that transfers considerable heat out of the air. Once the compressed air temperature is brought down, it cannot hold the moisture that it carried before that stage of compression, and the water vapor and other vapors condense. Following each intercooler stage is a cyclone-type liquid trap. The liquid trap is a vertical cylinder with a drain valve in the bottom. The air is introduced tangentially near the top of the trap, and creates a spinning vortex within the trap. The higher density condensed liquids are thrown against the cylinder walls of the trap. They drain down along the walls of the trap and can be removed from the compressor through the drain valve in the bottom. Even though water has been condensed and removed, the air is saturated. In this state, further compression or cooling will remove additional water.

The air from the preceding compressor stage is now carried into the intake of the next compressor state. Here it is again compressed, cooled, and water is again extracted. This process of compression, cooling, and condensate removal is repeated for every succeeding state within the high pressure compressor. High pressure makes it possible to take out considerably more heat and moisture from the air than could be extracted by low pressure compressors.

These methods do not require replacement adsorbent cartridges nor the maintenance associated with such cartridge changes. Another result of such processing is to reduce the water vapor and other contaminants that must be removed by the adsorbent purifier. **Therefore, one of the major effects of high pressure mechanical processing**

in the breathing air compressor is to reduce the required size and weight of adsorbent material needed in the high pressure purifier assembly.

Air Purifier Assembly – The high pressure purifier assembly *(Figure C-5)* is made up of an aftercooler, a combination coalescing filter/drain trap, and a number of successive purifier containers that hold adsorbent materials.

The function of the aftercooler is similar to that of the intercoolers. Following the aftercooler, the air is put through a combination mechanical coalescing filter element/drain trap. Vapor is not removed in mechanical drain traps. There are some very tiny drops of condensed materials, called aerosols (water, oil, etc.) which act almost like vapor and also move through ordinary drain traps. In order to mechanically remove these aerosols, they are forced, in the coalescing element, to impact or squeeze together and to form big drops out of the aerosols. These coalesced liquid drops can now be drained from the airstream.

The air now moves into the adsorbent section of the purifier. Adsorbent materials to be used in high pressure adsorbent chambers are the same as used in low pressure designs: molecular sieves, silica gel, activated alumina, and activated charcoal.

Following the coalescing filter trap, there are usually two to four successive additional disposable adsorbent containers. These are usually replaced on a machine time basis, but color change or other indicators are available. Since cartridges cannot regenerate themselves, it is especially important that they are changed on a scheduled basis. Failure to do so could allow adsorbents to reach saturation and permit contaminants to enter and contaminate the high pressure air storage bank.

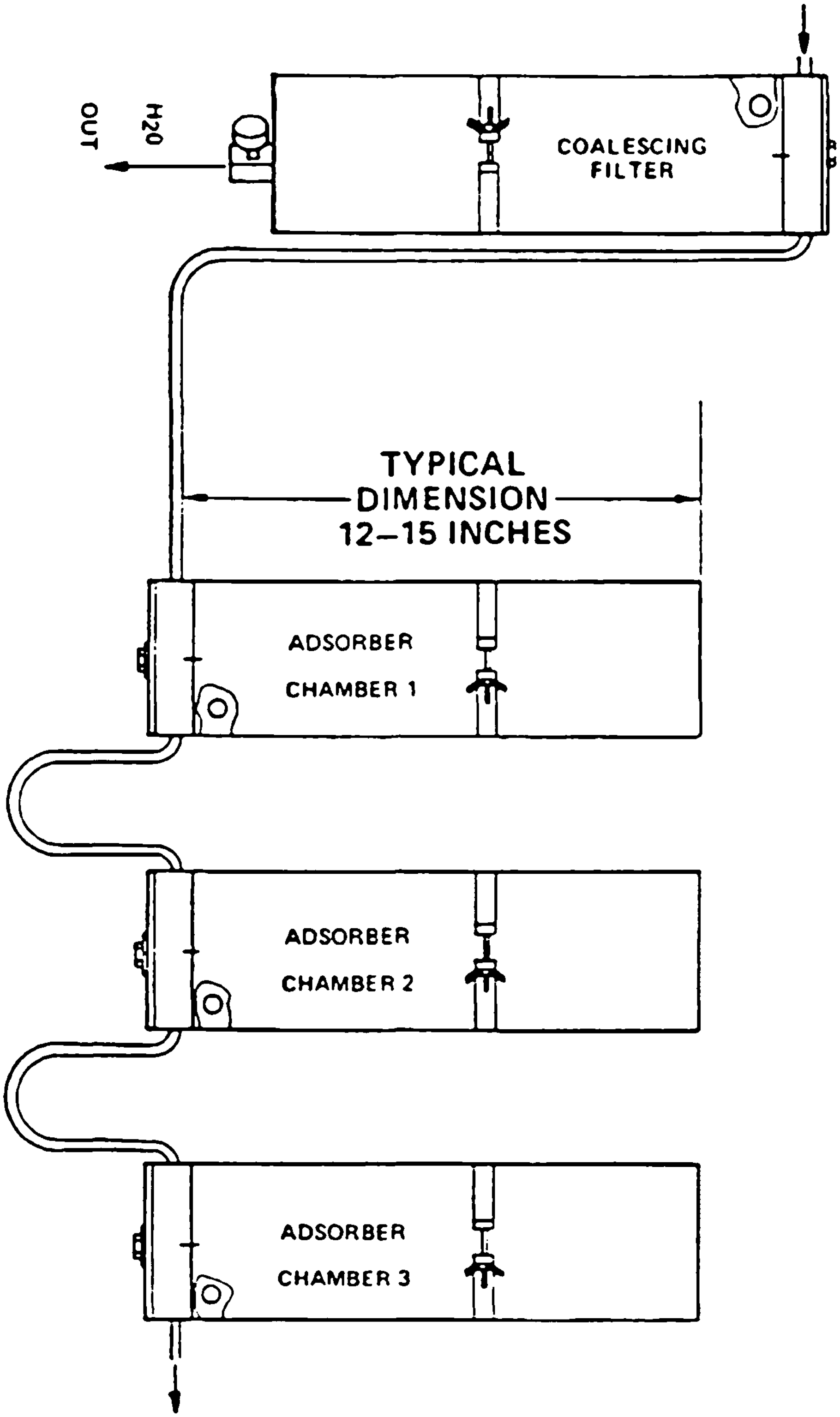


Figure C-5 – TYPICAL HIGH PRESSURE PURIFIER ASSEMBLY

Continuous CO Monitor and Alarm – Air passing from high pressure purifier should be continuously monitored by an electric carbon monoxide alarm. Should carbon monoxide be produced in the compressor or induced into the compressor air intake, it will be detected by the CO monitor. The CO alarm will visually and/or audibly warn if the CO level goes above the required level. Visual warning is accomplished by meter and by a green/red system of lights. High decibel audible alarms are also available.

High Pressure In-line Air Storage Bank – High-quality air, Grade D or better, is now pumped directly into the high pressure storage bank. The function of this high pressure storage bank is to act as an air reservoir, so that:

- The peak air flow demands can be met without concern for or limitation by the maximum compressor output.
- The compressor and purifier can be sized for lower flow rates than the peak flow rates required.
- A greater capacity (typically three to six hours) than the minimum required for escape (typically one hour) can be used to allow routine or emergency maintenance of the system to be accomplished without interrupting the work crew.

High Pressure Control and Distribution Panel – Air is delivered into the work area from the high pressure air storage bank through high pressure lines. These lines can be flexible or rigid and may be several hundred feet in length. This high pressure line is led into the building to a distribution panel. The panel has a high pressure gauge that may be marked off in pressure units or it may be rated in time units (hours) for any size work crew. Each worker with a respirator attached to the panel can at all times see exactly how much working reserve time (and escape time) is available.

As with the low pressure breathing air system manifold, this panel also contains a regulator and low pressure gauge. The panel reduces the pressure of the air to the pressure suitable for the respirators in use. Low pressure respirator hose line lengths are limited to not more than 300 feet by OSHA from this panel.

COMMON PROBLEMS WITH BREATHING AIR SYSTEMS

To properly design and specify breathing air systems it is important to anticipate and eliminate potential problems before they arise during an asbestos removal project. At a minimum, understanding common problems associated with breathing air systems can prepare the designer to consider precautions which will minimize worker health and safety risks. The most common of these problems generally effects either the quality or sufficient supply of air.

The problems associated with poor-quality air occur during the air intake, compression and filtration stages. While the breathing air system is designed to purify the air prior to delivery, it is essential that ambient air near the intake be as pure as possible. **If an intake is located near a source of carbon monoxide (CO) it can contaminate the air supplied to respirators.** Intake lines should be located away from the exhaust of gasoline or diesel compressors. Automobile exhaust is another source of CO which can be avoided by placing the inlet away from exhaust streams. The possibility of CO problems is also controlled by a properly functioning CO monitor.

Another problem with intake air occurs when air is drawn from a confined space or other area which may be oxygen deficient. The breathing air system will not improve the oxygen concentration of the ambient air. Precautions should also be taken to assure that the intake air is not contaminated by asbestos fibers.

Other air quality problems are introduced during the compression stage. Oil can be introduced by malfunctioning or improperly designed systems. The presence of oil in the air supply is commonly characterized by an oily scent or taste. Breathing oil-contaminated air can lead to serious health problems such as lipoid pneumonia.

The purification stages can also be a source of breathing air system problems. Excessive moisture levels can reduce the effectiveness of the adsorbents and deliver moisture-laden air that can fog the inside of respirators' face plates. A common problem is a lack of adsorbents or inadequate adsorbents.

Another air-quality problem results when the air supply is too hot for the job. Many asbestos abatement projects use breathing air systems as a source of cooling for workers in hot environments. When the supply air is too hot it does not provide adequate cooling for the workers, which can lead to heat stress. In mild cases, heat stress can lead to exhaustion and dizziness. This is particularly problematic for workers working on or near scaffolding or those in the vicinity of burn or shock hazards. In extreme cases, heat stress is a severe health hazard which can cause loss of consciousness or even death.

Besides providing adequate quality of air, breathing air systems must also provide a continuously sufficient volume and pressure of air. The most common problems associated with insufficient air supply to respirators involve the lack of adequate air supply pressure, respirator damage or selecting the wrong respirator.

Malfunctions of the breathing air system can occur when the air supply is not under enough pressure when it is supplied to the respirator. The cause of the problem can sometimes be traced to an over-extended low pressure supply line that is longer than 300 feet. Another possibility is that not enough air is flowing from the compressor to satisfy peak flow demands, such as when the entire crew breath intake coincides. The system must be able to supply at least 4 cfm per person to meet peak flow demands. A malfunctioning or poorly-designed filtration system can also cause a drop in pressure. The same is true for high pressure systems with an improperly adjusted regulator or with inadequate flow.

The ability of a system to deliver sufficient air supply can also be affected by a damaged respirator. Damage to the exhaust valve can restrict the air flow or cause leaks during exhaling. Regulator damage can cause the free flow of excess air. These problems can be avoided through regular inspection of respirator use in the work area during abatement. During these inspections, the inspector should listen for constant flow, watch system pressure and be on the lookout for excessive pressure drops.

A serious malfunction of the compressor or no reserve or inadequate reserve air supply can lead to a total cutoff of air supply. It should be noted that some air reserves are not fail safe. Some require electrical power to operate. Additional problems occur when the tank valves are left closed or the tanks are empty. Proper attention to inspection and safety checklists can reduce the likelihood of such an event.

The air supply distribution system can also be a source of problems. Unrestrained hoses carrying pressurized air can be a "whipping" hazard if open ended or broken. However, hoses should never be secured to ladders or scaffolding. One must safeguard against the hazards of handling hoses on or near ladders or scaffolding. Improper safety practices with air hoses can lead to trips, falls or destabilization of ladders or scaffolding.

REVIEW QUESTIONS

1. What is the minimum OSHA requirement for breathing air using the grade criteria established by the Compressed Gas Association Inc.?

2. What effect does compression have on an air volume, temperature and concentration of contaminants?

3. Adsorbents will:

   A. remove all contaminants.
   B. become more effective as they are exposed to water vapor.
   C. periodically require replacement.
   D. change color when exposed to light.

4. Which of the following is not a common problem with breathing air systems?

   A. carbon monoxide contamination
   B. cool breathing air
   C. oil in the air supply
   D. excessive moisture

5. What is the minimum reserve time recommended for for a high pressure reserve air system?