9.0 Equipment Cleaning and Repair

Introduction

The following sections provide an overview of procedures and techniques used to prepare phosgene equipment for maintenance and return the equipment to service, and offer information on issues that might arise during the repair work itself.

Because phosgene is a highly toxic material, use extraordinary caution when working on or entering equipment used in phosgene service. Cleaning and maintenance are potentially hazardous activities that should be performed only by workers who are thoroughly familiar with the dangers involved and the precautions necessary for safe performance of the work. For this reason, the importance of proper training, an understanding of hazard recognition, and a soundly reviewed and approved planned approach to each job cannot be overemphasized.

The information provided in this section should not be considered as a directive or as an industry standard that readers must adopt or follow. Instead, the information is intended to provide helpful ideas and guidance that users may wish to consider in a general sense (See Section 1.1 *Preface and Legal Notice*). Also included is a reference list of useful resources.

Contents

9.1 Preparation for Inspection or Repair

When a phosgene system is to be cleaned or repaired, empty the system of process liquids and gases containing phosgene. Safety should always be the primary consideration when clearing phosgene process equipment. The use of air-supplied respiratory protection (See e.g., Section 4.5 on Personal Protective Equipment (PPE) for additional information) is necessary for any activity where exposure to phosgene is a concern. Clear appropriate areas of unprotected personnel and provide proper barricading whenever performing work requiring breathing air.

Prior to beginning any equipment and piping decontamination for inspection and repair, consider developing a detailed plan for the cleanout that includes, but is not limited to the following safety precautions: barricading the work area; limiting access control; identifying locations of lockouts and line breaks; identifying where blinds are to be inserted and purge points; identifying services like inert gas for purging, point source ventilation and vacuum systems, additional lighting and breathing air. Use appropriate protective equipment, at a minimum breathing air, and a standby person.

Following equipment shutdown, companies have transferred remaining liquids and gases to other process equipment in the plant either by pumping or by pressuring off with a dry, inert gas, such as nitrogen, supplied at a pressure higher than that on the equipment to be cleared and equipped with adequate backflow protection devices to protect supply header. Once this has been accomplished, companies have found it useful to valve in the system and vent the remaining pressure to a destruction or decomposition device, such as a caustic scrubber. During depressurization, the frosting of piping, etc. that has been in liquid phosgene service indicates it still contains liquid. External application of heat can expedite the clearing process and may be a necessity when cold weather retards or even prevents evaporation of phosgene at atmospheric pressure. However, heating a closed system containing liquid phosgene may produce thermal expansion of liquids and excessive pressure and has a potential for overpressure of lines and equipment so close monitoring helps protect against potential risks.

After the equipment has been depressurized and is liquid-free, companies have pulled the equipment under vacuum and installed steel slip blinds at the isolation points to prevent phosgene from leaking back through the blocked valves from other parts of the system (note: if plans call for the use of purging for clearing purposes, the vent line would be left unblinded). Caution: Vacuum systems are able to handle only a limited quantity of liquid. Use precautions to prevent and/or detect the potential for liquid phosgene in the vacuum system. Small pieces of equipment, such as small instrumentation, may not be provided with piping to the vacuum or purge systems. In this instance, equip connections with double blocks and bleeds on both ends (See Section 6.2 Materials of Construction). Consider locating the blinds as close as possible to the isolating block valves because a leaking valve may fill the space between the blind and the valve with liquid phosgene, which will then be released when the blind is removed. An alternative is to install processes with double block and bleed arrangements so the space between one valve and the valve with the slip blind can be checked for phosgene and evacuated if necessary prior to removal of the blinds. It may be advantageous to connect the vacuum to a high point on the system, rather than at a drain valve if at all possible, because low points are prone to pluggage. In systems containing only vapor, purging phosgene containing lines may be considered through a low point or drain valve. This can be more effective in decontamination since phosgene gas is heavier than air and can collect in low points and there is low potential for collection of liquid phosgene. When removing full face blinds or plugs located on bleed valves where the vacuum connection would be made, exercise appropriate caution because liquid phosgene can be trapped behind them. Before installing blinds, it may be important to verify that the system is under vacuum by reading an appropriately ranged pressure gauge or by cracking open a bleed valve.

After blinds are installed, companies have used a dry, inert gas to purge the remaining phosgene vapors to the vent system. For larger systems which are solid-free, the use of heated inert gas can sometimes be more effective at purging. Once the system is clear, the vent line itself can be blinded, disconnected, or isolated with a valving system such as a double block and bleed system to help complete the isolation. For difficult-to-clear equipment, additional options for consideration include flushing with water, weak aqueous ammonia, caustic or anhydrous ammonia (only done after the blinds have been installed and the system vented to avoid contamination of ammonia and caustic in phosgene containing equipment, such as connecting piping/equipment, liquid collection systems, and vacuum systems). Water flushing, following the use of ammonia or caustic, serves an important function to help eliminate those contaminants. If use water for flushing and cleaning, then take precautions to insure adequate drying complete prior to introducing phosgene to minimize acidic corrosion due to reaction of residual moisture and phosgene. Remove moisture from crevices and under solid residue in the equipment and lines. There are potential hazards associated with the use of ammonia and caustic, such as intense heat from reaction. Dispose of the resulting vent or waste stream in an environmentally responsible manner consistent with relevant requirements.

Prior to beginning maintenance work, plant operations personnel can help verify that the equipment has been cleared of phosgene by cracking open a bleed valve and checking for the presence of phosgene using a, phosgene detection device. The system may need a slight positive pressure in order to check for the presence of phosgene. It is important that the system is depressurized completely before maintenance opens any equipment flanges, disconnects any piping, or loosens the first bolt on any pipe flanges. Also, phosgene is known to leach out of carbon steel pipe even after purging with inert gas. Several cycles of purging may be necessary to effectively remove the phosgene.

As part of the evaluation, keep in mind that process solids that come into contact with, or are suspected of coming into contact with, phosgene may contain trapped phosgene. When solids are agitated, crushed, or blasted, there is potential for phosgene to be released.

The preceding information on clearing relates to equipment being removed from service for relatively major repairs expected to take a considerable amount of time. Aspects of the information may be useful to address minor repairs, such as gasket replacements, instrument replacements, leaking plugs and valve packing, as well as some valve replacements. Even after the equipment has been cleared of liquid, depressurized, and pulled under vacuum, use appropriate precautions during the performance of repair work. *(See e.g., Section 4.5 on Personal Protective Equipment (PPE) for additional information).*

If phosgene equipment requires welding or burning, evaluate use of special preparation procedures because phosgene impregnated into the surface of the metal can be liberated by the high localized temperatures produced. This process can involve washing out the equipment with hot water and/or steaming it out to remove the residual vapors. Some companies utilize a procedure to soak the equipment in a caustic solution bath to further decontaminate phosgene.

In preparation for vessel entry, companies have cleared the inert gas used for purging by flushing with atmospheric air. For example, an air horn or similar air-moving device has been used. Flexible ducts connected to a vacuum source discharging to a destruct system may be useful if the exiting air is contaminated. Follow proper confined space entry practices. See 29 CFR 1910.146(c)(4).

9.2 Equipment Repairs

The repair of equipment that has been in phosgene service merits special precautions to avoid accidental exposure. The additional risk associated with repairs must be fully considered before attempting repairs while equipment is in service. Even after clearing, it is possible for phosgene vapors or liquid to remain trapped in gaskets and valve packing, behind pluggage in piping, inside damaged level displacers or agitator gearboxes, etc. This phosgene can be released during disassembly for repairs or, for example, simply by operating a valve. For this reason, performing repairs using appropriate PPE even on "cleared" equipment reduces potential risks.

At times, equipment that is still contaminated must be transported from the unit to another location for decontamination. In such cases, consider the feasibility of blinding off or plugging all process-exposed sections. If this is not possible, another option is to transport the equipment by a person wearing appropriate PPE and clearing all other personnel from the route.

If equipment must be taken to the facility's shop or sent out of the plant for repair, consider decontaminating the equipment as soon as possible using special procedures to eliminate the possibility of an unexpected release. The procedures may require disassembly and cleaning using steam, hot water or other cleaning agents as appropriate. Vendors who handle such equipment must be thoroughly knowledgeable of the hazards of handling phosgene, use appropriate PPE including use of dosimetry badges, and phosgene decontamination procedures used for disassembled small pieces of equipment including gaskets, packing and PTFE lined pieces. Some companies have used the practice of placing permeable materials (gaskets, packing or PTFE lined piping) that have been in phosgene service into either a bucket of ammonia water or a plastic bag with a small amount of ammonia water in order to contain/neutralize any residual phosgene that may be present.

If welding or cutting on phosgene equipment, gas release might be possible. If so, review whether the welder has air-supplied respiratory protection, appropriate PPE, and whether the area has been barricaded and cleared of unprotected personnel.

After welding on piping or equipment in phosgene service, risks can be reduced by evaluating whether the work was done properly and will not result in premature or unexpected failures. To this end, all welds can be tested prior to placing the piping or equipment in service. *(See Section 6.3 for further information on testing).*

A number of companies require that all parts and materials to be used in phosgene service are designed and specifically approved for such use. *(See Section 6.3 for further information on parts and materials).* A detailed procedure for cleaning and packaging repaired valves for phosgene service serves an important function because failure of these valves to properly seal when required could have significant consequences.

Threaded fittings used in phosgene service (e.g., plugs, pressure gauge nipples) create increased potential for leaks and are necessarily thinner because of the requirement to taper the joints for threading. As a result, threaded fittings tend to be generally avoided if at all possible, but when they must be used, some risks can be reduced by coating the threaded fitting with approved pipe sealant before being installed in order to help avoid leakage. As one example, a number of companies employ fluoropolymer-based thread sealants in their phosgene service. Where threaded fittings cannot be avoided, some companies have utilized back welding of threaded connections to have a tight and leak free connection.

If a vessel used in phosgene service must be inspected or repaired internally, OSHA guidelines for vessel entry are available. If the vessel has been cleared by dry-gas purging only and has not been washed out, evaluate appropriate PPE to protect against the possible presence of ferric chloride and hydrochloric acid coating the interior surfaces.

9.3 Preparation for Service

A phosgene system that has been open to the atmosphere needs to be extensively dried before being returned to service. Severe internal corrosion to steel piping and other equipment can result if significant moisture is allowed to remain inside the system. Drying the system to an appropriate dew point temperature before the system’s return to practice helps prevent this possibility. Drying has been done using a purge of dry inert gas, such as nitrogen. Heating the purge gas will facilitate the procedure.

If a steam exchanger is used, consider whether the gas pressure is higher than the steam pressure on the exchanger. This action will help prevent moisture from contaminating the purge gas if the exchanger leaks. To aid evaporation, consider keeping the phosgene system maintained as close to atmospheric pressure as possible (or slight vacuum) during the drying process. External heating of the equipment being dried can help aid in the drying process. Nitrogen bleeds have been established at dead legs, including instruments such as pressure transmitters and differential pressure flow transmitters. Dew points can be taken at a number of different locations to help ensure the entire system has reached the desired dew point. When equipment is contained inside a containment building, precautions must be in place to avoid asphyxiation hazards with nitrogen purges. Some companies use dry air to dry equipment inside containment buildings.

Equipment that has undergone minor repairs using the vacuum method described in the previous sections (Section 9.1) may contain a small amount of atmospheric moisture. It may not be practical or possible to purge this moisture from the system or, if it can be purged, to obtain a dew point due to contamination with phosgene. Such equipment can sometimes be returned to service without problems. However, companies may wish to keep the frequency of this type of repair to a minimum and to do whatever drying is possible under the circumstances to reduce the potential risk of corrosion.

Small sections of piping that need to be dried before installation have for example been flushed with acetone and then nitrogen purged. Another method has been to steam purge internally until the piping is very hot then purge immediately with nitrogen.

Note the importance of removing grease, oil and other foreign material from lines and equipment before returning to service. Piping components contaminated with oil, grease, or other hydrocarbons are potentially reactive with phosgene. Products of reaction could lead to unexpected pressure buildup in a closed system.

When drying is complete, check that all atmospheric bleeds have been plugged, capped or blinded to prevent phosgene leakage or a release due to accidental valve operation. To reduce risks, the system can be checked for leaks (after removing any blinds) by first pressurizing it with a dry, inert gas to operating pressure, blocking it in, and watching for a pressure drop. This process will help indicate any large leaks, but small leaks might only be found through other methods. Options that have been used include those such as checking each flange, etc. with a soap and water solution and watching for bubbles or by charging the system with a sensitive gas such as helium or helium/nitrogen combination and then leak checking flanges, etc., with an appropriate electronic leak detection device. (*See Section* 6.11 Inspection and Testing and specifically Section 6.11.3 Commissioning for more details on returning new or repaired equipment into phosgene service).After all leaks have been repaired and the equipment passes pressure tests, it can typically be depressurized and returned to service.

It is possible for leaks to occur after equipment has been returned to service, especially if the equipment is in liquid phosgene service. Frequent equipment checks for several hours after startup help identify such leaks. The use of special washers such as a disk spring to prevent loosening of bolting due to thermal cycles on the equipment can be helpful in preventing leakage. A desirable attribute of an appropriate disc spring is that it should apply clamping pressure along a continuous arc pattern, rather than concentrating it at one point.

9.4 Preparation for Salvage or Disposal

Decontaminate equipment in phosgene service before salvage or disposal.

References

[1]OSHA Permit-required confined spaces 29 CFR 1910.146(c)(4)
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9797&p_table=STANDARDS