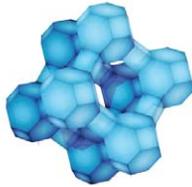


Precautions and safe practices



Handling of zeolite molecular sieve adsorbents in process units

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The advice provided in this brochure may not be applicable to all operations. Actual operating experience with a unit should be considered before implementing any advice provided in this brochure. Each owner is at all times responsible for the operation and maintenance of their units.

SECTION I

The nature of adsorbents and their operation

Understanding adsorbents

In order to handle, start up, and operate adsorbents in a safe and appropriate way, it is important to have a basic understanding of their nature and their properties.



The adsorbents discussed in this document are typically zeolite molecular sieves combined with other materials, both inert and active. Zeolite molecular sieves are aluminosilicates with a well-defined crystalline structure. This crystalline structure has channels and cavities which offer an enormous internal surface area (hundreds of square meters/gram). Entry into its rigid cavities, where molecules are adsorbed, is through the precisely dimensioned openings, or pores. Many types of adsorbent crystals can be manufactured with a number of different pore sizes. Due to the nature of this internal surface area, the molecular sieve adsorbent will attract and collect molecules from the gas or liquid to which it is exposed. This is referred to as **adsorption**. Not all molecules are attracted by the surface to the same degree. For those that are the right size to enter, the attractive forces diminish with diminishing polarity of the adsorbed molecule. This results in a **selectivity** of some molecules over others. Water and ammonia are the most polar molecules and will be preferentially adsorbed over molecules such as CO₂, H₂S, paraffins, olefins, etc.

A more polar molecule can actually **desorb** or **displace** a less polar molecule which had been previously adsorbed. When a more polar molecule is adsorbed, heat is released causing the temperature to rise and to further desorb adsorbed species. This crucial characteristic significantly impacts the safe handling of adsorbents.

When unloading or handling unloaded adsorbents, there is potential for adsorbed materials to be displaced or desorbed. This can happen when adsorbents are exposed to moisture either intentionally (being purposely wetted to abate dust or to deactivate the adsorbent) or unintentionally (from ambient air, rain, or snow). Any molecules which have been adsorbed during the cooling and/or conditioning step can be released to the atmosphere as they are displaced by water. Even very small amounts of certain materials can accumulate to dangerous concentrations in enclosed environments. A particular example of this hazard is in “sour” applications where trace levels of H₂S in the feed stream can accumulate to dangerous levels in the molecular sieve. ***H₂S can be deadly even when present in very low concentrations.***

Theory of operation

Adsorbents are used to dry, purify and separate a wide variety of gases and liquids. They do so by:

- Strongly attracting certain types of molecules, and
- Screening out molecules larger than their pores.

Polar molecules such as water and methanol are *strongly* attracted by adsorbents. In contrast, nonpolar molecules, such as methane and ethane, are much more *weakly* attracted. When a mixture of water (polar) and methane (nonpolar) is passed over

adsorbents, the water is adsorbed, even though both are small enough to pass easily through the pores.

Water can also be removed from a strongly attracted fluid such as methanol by using adsorbents with pore openings smaller than the methanol molecule, but larger than the water molecule.

When molecules are adsorbed, heat is released. In most systems, the temperature of the process stream rises only a few degrees. However, when a high concentration (greater than 0.5 volume %) of a strongly attracted molecule is adsorbed, the temperature can rise more than 100°F.

At low temperatures (less than 150°F), adsorbents have a relatively high capacity for adsorbed species. At high temperatures (300-650°F), the capacity is much lower. When adsorbents become saturated, the adsorbed molecules can be driven off by heating the adsorbents to 300-650°F with a gas stream. This operation is called **regeneration**. After regeneration, the

adsorbent is cooled down to the normal process temperature with a low temperature stream before returning to service. In some applications, adsorbents are regenerated by reducing pressure, rather than heating. Continuous operation is maintained by cycling two or more vessels between adsorption and regeneration.

Follow the precautions in **Section II** whenever loading fresh adsorbent into a vessel. During the start-up and operation of an adsorption system, follow the precautions covered in **Section III**. In process units, adsorbents are exposed to liquids or gases from which they pick up various materials, some of which can be hazardous (i.e. H₂S, NH₃, CO₂, various hydrocarbon and sulfur-containing compounds). Before opening a used adsorbent vessel to the atmosphere, install appropriate blind flanges, and remove any potentially hazardous materials, as detailed in **Section IV**.

For general technical questions, contact your UOP representative.

For 24-hour Product Safety Emergency Assistance:

In USA:	UOP	847.391.2123
	CHEMTREC	800.424.9300
In Canada:	CANUTEC	613.996.6666
In Europe:	BIG	32 14 58.45.45
In other countries:	CHEMTREC	1.703.527.3887

SECTION II

Loading fresh adsorbent

Read and understand this section thoroughly before loading fresh adsorbent. Observe all shipping container precaution labels. Make sure that the product Material Safety Data Sheet is available at the work site and reviewed prior to handling the product.

Preparation

Adsorbents are typically supplied as pellets, beads or granules. In their fresh, unused state, adsorbents present minimal risk when appropriate protective equipment is used. Appropriate protective equipment includes gloves, long sleeve shirts and pants or coveralls to protect against skin exposure; safety glasses, goggles or face shield to protect the eyes; and dust masks or respirators if it is expected that dust will be generated. When exposed to water, the heat of adsorption can cause adsorbents to get quite hot.

Care should be taken to avoid contact with moist skin, mucous membranes and eyes.

Note: Some special adsorbents may contain toxic or flammable materials. These adsorbents will have special precautions on the labels of the shipping containers and in the Material Safety Data Sheets. In such cases, always follow the special precautions provided by UOP.

If flammable vapors such as hydrocarbons are present in the loading area, grounding is especially important to avoid discharge of static electricity that could cause an explosion or fire. Even conductive footwear and conductive walking surfaces may not prevent electrostatic buildup on the human body. For example, removal of outer garments in low humidity conditions can generate sparks.

Confined spaces

If entry to the vessel is required, confined space safe work practices must be followed. Many countries have specific regulations on confined space work. Personnel should review these regulations and ensure that they are followed. Among the precautions and practices that are called for are:

- Removing hazardous materials from the vessel prior to entry
- Isolating the confined space from sources of hazardous materials or energy by installing blind flanges to inlet and outlet nozzles and decoupling pumps and instrumentation
- Providing adequate ventilation to prevent accumulation of flammable materials, combustible dusts, toxic contaminants or an environment that is oxygen deficient or excessive
- Testing for oxygen, flammable gas, and suspected toxic materials prior to entering the vessel
- Using safety attendants outside the vessel to monitor
- Communicating with personnel in the confined space
- Having notification and response procedures in place for emergency situations such as injury or loss of consciousness to personnel within the confined space

- Equipping personnel entering the vessel with the appropriate safety equipment, this may require use of safety harnesses and/or self-contained breathing apparatus (SCBA)
- Training personnel authorized to work as safety attendants, rescue personnel or persons entering the confined space
- Conducting pre-job discussions with personnel involved with the work about the potential hazards in the confined space

Loading

Adsorbents are normally shipped in 55-gallon sealed drums or 35-50 cubic-foot bags. A vacuum may exist inside the removable-top drums. First, loosen the vent screw on the lid and break the vacuum. Then remove the top.

Take care when moving adsorbent containers. Proper lifting techniques and equipment should be used. Full drums can weigh more than 300 pounds; full bags more than 2,100 pounds. During loading, the containers must normally be lifted to the top of the vessel. Sometimes, several drums are dumped into a large hopper and this is lifted. This activity requires that standard elevated work practices be used, such as isolating the area under the lifting path and using ropes or posting signs and keeping personnel clear of the area.

Occasionally, pneumatic trucks are used to transfer adsorbent into the vessel through a hose. Keep the hose outlet pointed away from personnel. Static electricity can build up during transfer operations. Therefore make sure that the transfer and receiving system are electrically grounded to help dissipate any static charge.

SECTION III

Start-up and operation of adsorption systems

Read and understand your equipment manufacturer's operating instructions, your employer's safety practices and this section before starting up and operating an adsorption system.



Major operating hazards and precautions

During start-up and operation of any adsorption system, it is critical to stay within the pressure and temperature limits supplied by the equipment manufacturers. Excessive temperatures can cause equipment failure and result in a life-threatening fire or explosion.

Three things can cause excessive temperatures in an adsorbent system.

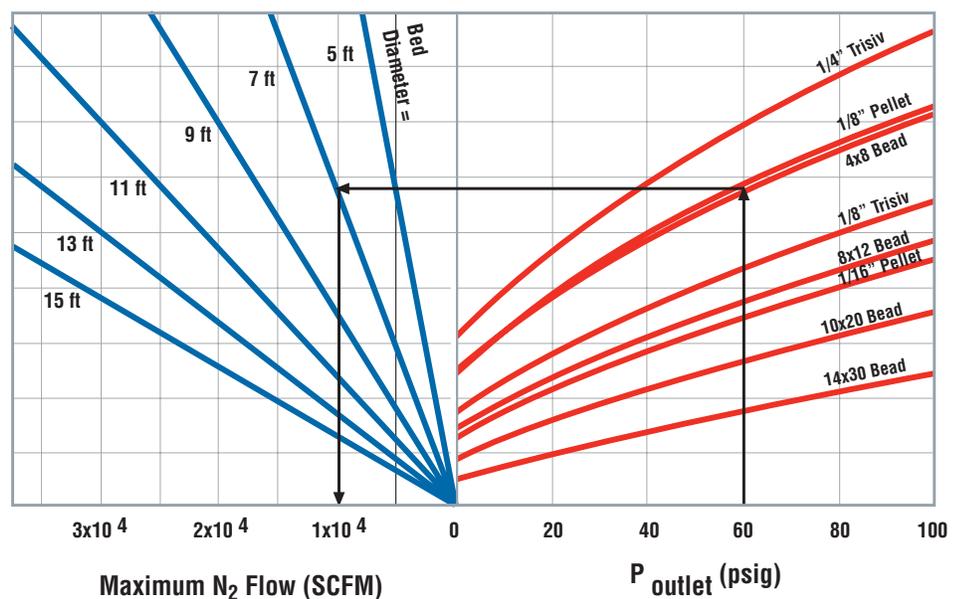
1. Introducing a flammable or reactive fluid into a vessel containing air.
2. Introducing a high concentration of a reactive, strongly adsorbed material into fresh or regenerated adsorbent.
3. Using a highly reactive fluid to heat or cool the bed. (Examples of reactive fluids would include ethylene, propylene and other olefins.)

Initial exposure to a process stream

Guidelines to avoid temperature excursions:

1. After loading the air must be removed using a nitrogen purge before introducing the process stream into an adsorbent vessel. The amount of available nitrogen is typically inadequate to provide the gas velocities needed for effective flow distribution within the adsorbent bed. The repetitive pressurization and depressurization of the bed with nitrogen is an alternative way to purge the bed void volume. The nitrogen purge gas should flow down (top to bottom) through the vessel to preclude lifting the bed and support material due to high velocities. If downward flow is not possible, see **Figure III-1** for guidance in setting the flow rate or contact your UOP

Figure III-1



representative for specific recommendations for your unit. Continue purging until the oxygen content of the outlet mixture is less than 0.5 volume %.

2. Do not introduce reactive, strongly adsorbed fluids (such as ethylene, propylene and other olefins) into a fresh or regenerated bed without proper preparation. The heat of adsorption can increase the temperature sufficiently to start a self-sustaining, heat-releasing reaction. If unchecked, the temperatures can increase enough to rupture the vessel and create a life-threatening situation. For these systems, always use the special procedures provided by the adsorbent supplier in the process design. These procedures involve exposing a fresh or regenerated bed to an inert stream such as nitrogen to which a low concentration of the reactive fluid is added. The concentration of the reactive fluid is slowly increased until the outlet temperature drops back down and approaches the inlet temperature. If the process stream is **ethylene**, refer to the UOP Bulletin, entitled, **Safe Practices for use of Molecular Sieves in Ethylene Purification**.

3. Do not use extremely reactive fluids to heat or cool a bed. The elevated temperatures during regeneration could start a hazardous heat-releasing reaction.

4. Never change the regeneration gas or feed stream specified in the process design to another fluid without first consulting with your UOP representative. Such a change could create the hazardous conditions discussed in items 2 and 3 above.

Complete the introduction of the reactive fluid and bring the vessel up to normal operating pressure. Establish normal flow and closely monitor any intermediate and outlet temperature indicators until each bed has completed one adsorption step. If a readily adsorbed component in the process stream is present at more than 0.5 volume %, both temperatures will rise. However, if either temperature rises more than 150°F above the inlet temperature, **stop the process immediately**. This condition indicates that a heat-releasing reaction may have started.

Heat releasing reaction

In the event of a heat releasing reaction, stop it by taking the following steps:

- 1.** Close the valves on the lines leading into and out of the vessels to stop the flow of fluid into the adsorbent.
- 2.** Open the valve on the flare line to vent the bulk of the reactants from the vessel to the flare for combustion.
- 3.** Purge with nitrogen to the flare to remove the remaining reactants and cool the bed.
- 4.** Contact UOP for assistance.

When one adsorption step is completed on each bed without excess temperature rise, the system is ready for normal processing.

Regeneration

Once the adsorbent bed is saturated, it is no longer effective and must be regenerated. This is normally done by passing a gas stream over the

adsorbent at 300-650°F. The actual temperature is set by the design of the unit.

Because of heat losses, the bed outlet temperature should always be lower than the temperature of the inlet during heating. If the outlet temperature starts to increase above the inlet temperature, **stop the heating step immediately**. This condition indicates that a heat-releasing reaction may be occurring. Close the inlet and outlet valves to the vessel being heated, depressurize it to the flare, and purge it with nitrogen. Contact UOP for assistance.

During regeneration, the adsorbent bed may be as hot as 650°F. Always check the cooling outlet temperature after regeneration to ensure the bed is cool before exposing it to the feed stream. Failure to cool the bed before returning it to service could result in **downstream equipment damage** or possibly initiate a **heat-releasing reaction** in the case of reactive feed streams. Both consequences can create a safety hazard. The adsorbent has high heat capacity and low thermal conductivity. It can stay hot for weeks if a shutdown occurs before the bed has been completely cooled. For systems with automatic switching, always check following a shutdown to ensure that a hot bed is not switched from cooling prematurely.

SECTION IV

Deactivation of spent adsorbent for unloading

Read and understand this section thoroughly before opening a used adsorbent system to the atmosphere.



Preparation of spent adsorbent for unloading

Adsorbents exposed to a gas or liquid stream will adsorb various compounds from the process stream. Trace compounds can be concentrated on the adsorbent during its use. They may be toxic, flammable or explosive. Exposure of spent unregenerated or inadequately regenerated adsorbent to ambient air may generate heat and desorb toxic material creating a hazardous environment. Failure to remove flammable regeneration gases such as natural gas from the adsorbent following regeneration with an inert gas such as nitrogen can also result in a fire hazard.

Adsorbed species remaining after inadequate regeneration and inert gas purging can be displaced by atmospheric moisture or liquid water resulting in release. If reactive species such as olefins or partially polymerized material are present on the adsorbent when exposed to air, combustion resulting in fire or release of toxic materials could occur. Therefore it is critical to remove or deactivate any potentially hazardous adsorbed materials or take special precautions prior to and during removal of spent adsorbent from the vessel.

When the adsorbent is properly regenerated by a clean, nonreactive, weakly adsorbed gas such as natural gas, toxic or reactive materials will normally be removed. However, occasionally inadequate removal of

hazardous materials can occur due to restricted heating gas and inert purge flow in portions of the bed due to such things as agglomerated or damaged adsorbent or a bed support failure. Therefore, when dealing with toxic materials such as hydrogen sulfide in an adsorbent bed special precautions need to be taken. Since less toxic compounds such as carbonyl sulfide (COS) and other sulfur compounds can react under certain conditions to form the more toxic hydrogen sulfide (H₂S), care needs to be exercised with all sulfur compounds in adsorbent beds.

Three methods can be used for preparation of a spent bed for unloading depending on the potential hazards present and availability of materials for the preparation process. ***If you encounter any difficulties or have questions about using the following procedures, contact your UOP representative.***

Procedure A – Gas regeneration followed by nitrogen purge

For adsorption systems processing and regenerating with clean (free of toxic or reactive materials) and weakly adsorbed gases such as natural gas, regeneration followed by nitrogen purging is normally used. The advantages of using this technique are:

1. Avoids an extended effort to dry out the vessel internals and associated piping following use of liquid water using Procedure B.

2. Avoids potential damage to and degradation of the insulation properties of internal liners that would be exposed to liquid water using Procedure B.

3. May allow possible recovery and reuse of a portion of some used adsorbents.

The disadvantages include:

1. May require a significant quantity of nitrogen to achieve satisfactory LEL especially where heating gas flow is restricted due to such things as damaged adsorbent, bed support failures or the presence of liquid hydrocarbons in the gas stream.

2. After regeneration, inert gas purging and removal from the vessel, any remaining flammable material on the adsorbent can be displaced by moisture picked up from the air or due to exposure to liquid water. Sources of ignition (flame or spark) must to be kept away from the removed adsorbent to prevent ignition of any flammable material displaced by moisture from the adsorbent.

Procedure for regeneration with a clean, weakly adsorbed gas followed by Nitrogen purge. ***This procedure is not to be used for Adsorption systems processing or regenerating with streams containing toxic or reactive materials. For these situations, use Procedure B or C or the special unloading procedure discussed in Section V.***

1. Regenerate the bed (heat & cool) with an appropriate gas. If the gas normally used to regenerate the bed is unavailable or contains toxic compounds use nitrogen or an alternate gas. Your UOP Adsorbent representative will help select an alternate gas and determine the proper operating conditions. Test the bed outlet heating gas for the presence of any unexpected toxic material such as Hydrogen Sulfide.

2. Completely cool with the clean gas used for heating, then isolate the vessel and depressure to atmospheric pressure. Install blind flanges on all inlet and outlet lines except the flare line. Connect a nitrogen purge source at the opposite end of the vessel.

3. The amount of available nitrogen is typically inadequate to provide the gas at velocities needed for effective flow distribution within the adsorbent bed. The repetitive pressuring and depressuring of the bed with nitrogen can improve the effectiveness of the purge step. It is best to pressure up and depressure down flow through the bed to avoid lifting the adsorbent or support balls. If downward flow is not possible for the purge step, contact your UOP representative for specific recommendations.

4. Continue to pressure and depressure the vessel to flare with nitrogen until the outlet mixture contains less than 10% of the lower explosive limit (LEL) for any flammables. The lower explosive limit in air of several common fluids is shown in **Table 1**.

Table 1
Lower Explosive Limit* of Some Common Fluids

Fluid	Volume % in Air
Methane	5.0
Ethane	2.9
Propane	2.1
<i>n</i> -Butane	1.6
Hydrogen	4.0
Benzene	1.4

*Lowest concentration of vapor in air that is capable of propagating a flame through a mixture.

Procedure B – Water flood

For adsorption systems processing streams containing toxic or reactive compounds, the water flooding technique is the most effective method for removing toxic materials and removing or deactivating reactive compounds. The advantages of the water flooding technique include:

1. Most effective removal of adsorbed compounds other than water.
2. Helps overcome problems of poor removal of potentially hazardous materials due to heating gas channeling and deactivate reactive polymer accumulations that otherwise might react or combust when exposed to air.
3. Helps deactivate adsorbent so that no temperature rise occurs due to water pickup from the atmospheric air or liquid water.

Disadvantages include:

1. Requires an adequate source of safe and clean water that will not damage vessel internal surfaces.
2. Adsorbent will not be recoverable and will be more difficult to handle wet.
3. Internal liners may be damaged and are very difficult to dry out to recover insulation properties.
4. Used water needs to be disposed of in an environmentally acceptable manner.

Procedure for regeneration followed by water flooding

1. Regenerate the bed (heat & cool) with an appropriate gas. If the gas normally used to regenerate the bed is unavailable or contains toxic compounds at hazardous levels, use nitrogen or an alternate gas. Your UOP Adsorbent representative will help select an alternate gas and determine the proper operating conditions.
2. Completely cool with the clean gas, then isolate the vessel and depressure to atmospheric pressure. Install blind flanges on all inlet and outlet lines except the flare line at the top of the vessel. Attach a water line to the bottom of the vessel. Be sure that the water used is from a safe source and compatible with the vessels materials of construction.

3. As the vessel fills with water, displaced gases are vented to the flare. The temperature in the vessel due to adsorption will not exceed the boiling point of water. To avoid overfilling the vessel and flooding the flare line, monitor the filling rate and the liquid level. This can be done with a properly calibrated differential pressure gauge. About 14.7 psi is equal to 34 feet of water. If a differential gauge is not available, calibrated gauges can be mounted at the top and bottom to determine the pressure differential.

4. After the vessel is completely filled, shut off the water source and the flare line and open a vent line to the atmosphere at the top of the vessel to break the vacuum during draining. Drain to an approved disposal location.

5. Pressurize the vessel with nitrogen and establish sufficient flow to allow gas monitoring to ensure the outlet is below 10% of the LEL and free of toxic material. If the outlet gas is above the required LEL or contains toxic materials, repeat the water flood procedure and outlet gas monitoring until satisfactory results are achieved.

Procedure C – Steam purging

Another procedure nearly as effective for removing toxic or reactive compounds is to use heating followed by a saturated steam purge. The advantages for steam purging are:

1. Next to water flood is the most effective for removal of toxic or reactive materials.

2. Deactivates the adsorbent so that no temperature rise occurs due to adsorption of water from atmospheric air.

3. When done properly (to avoid condensation), damage to the internal liner may be minimized and excessive time to dry out after dumping may not be required.

Disadvantages for steam purging are:

1. Requires a sufficient quantity of steam availability to achieve good flow distribution across the bed.

2. Requires a sufficient quantity of inert cooling gas.

3. May not effectively remove toxic or flammable materials where resistance to flow exists due to problems such as adsorbent agglomeration, damage or a bed support problem.

Procedure for steam purging

1. Heat the bed, but do not cool it to avoid steam condensation in the vessel. If the gas normally used to regenerate the bed is unavailable or contains toxic compounds at hazardous levels, use nitrogen or an alternate gas. Your UOP Adsorbent representative will help select an alternate gas and determine the proper operating conditions.

2. Isolate the vessel and depressure to atmospheric pressure. Install blind flanges on all inlet and outlet lines except the flare line at the bottom of the vessel. Connect the steam source to the top of the vessel.

3. Open the steam line at the top and the outlet to the flare at the bottom. Condensate will be drained from the flare line knockout drum. Maximize the steam flow within the pressure drop limits of the adsorber. The minimum theoretical amount of steam required is 20 pounds of water per 100 pounds of adsorbent.

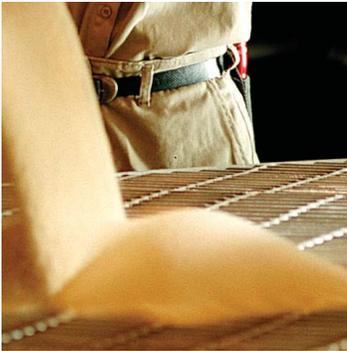
4. To ensure that an adequate amount of steam has been provided, do a brief purge with nitrogen down flow and check the outlet to ensure the LEL is low enough and that toxic material is not present.

5. Once a satisfactory level is achieved, reconnect the steam and purge for at least 2 more hours. After the steam purge is completed cool the bed down flow to the flare with nitrogen to an outlet temperature below 120F.

If you encounter any difficulties or have questions about using the above procedures, contact your UOP representative.

Unloading and handling of spent adsorbent

Read and understand this section thoroughly before opening a used adsorbent system to the atmosphere



Preparation

Ensure that one of the appropriate procedures was followed in Section IV. Always assume that some hazardous or toxic material might remain on the adsorbent in the vessel regardless of what preparation procedure was used. Unless you are a trained professional operating under inert atmosphere procedures, **do not** enter the vessel while used adsorbent remains inside. Hazardous materials may be released during unloading of spent adsorbent creating a toxic flammable or reactive environment.

Be prepared for these situations. Limit access and contact with spent adsorbent. Have fire-fighting equipment available, and test the area around the unloaded adsorbent for flammable, or suspected toxic materials to establish whether you have a safe environment. If monitoring or experience indicates the environment may contain toxic materials in excess of safe levels, use self contained breathing apparatus.

Unloading

Generally, a nitrogen purge is not used during removal of a typical adsorbent from a process vessel. ***If nitrogen is used during dumping of a typical adsorbent, then personnel working near any open port on the vessel should wear self contained breathing apparatus to protect against possible asphyxiation from nitrogen.*** Contact with the used adsorbent should be avoided. Workers unloading the used

adsorbent should wear long gloves, long sleeve shirts and pants or coveralls to protect against skin exposure, safety glasses, goggles or face shields to protect the eyes, and dust masks or respirators.

Normally there is a stainless steel screen on top of the adsorbent bed. Inert balls lie on top of the screen. To make unloading easier, secure the screen to the top of the vessel. This can be done without entering the vessel. Remove the loading port and secure the screen using a harpoon-type tool with a long handle.

Next open the dump port and allow the adsorbent to flow out. Once the adsorbent no longer flows out freely, remove the remaining portion using a rake, hoe, shovel or vacuum truck. Never enter the vessel to remove the remaining adsorbent.

If at any time during unloading, materials on the adsorbent start to burn or react (as indicated by a large heat release), stop unloading. Evacuate personnel from the area. Properly trained personnel with self contained breathing apparatus can then return to stop the reaction or put out the fire. To stop the reaction or put out the fire, use water from fire hoses to flood the adsorbent outside the vessel. Contact UOP for assistance.

Note: Hazardous gases may be desorbed from spent material as a result of the heat release or fire, or as a result of spraying the adsorbent with water.

Special unloading procedure using regeneration, nitrogen purge and shipping containers suitable for water flood

If the stream processed by the adsorbent beds contains toxic materials such as hydrogen sulfide, but can not be water flooded or steam purged in the vessel, regeneration with a clean gas such as natural gas followed by the nitrogen purge technique previously discussed can be used, **but only with the following additional precautions.**

1. Special metal shipping containers supplied with tight fitting, removable covers with threaded taps on the top and on the side near the bottom need to be obtained. The top tap will be connected to a vent line suitable for elevated temperatures (250°F minimum) and chemically resistant that can be attached to the plant flare line. The bottom tap with screen will be connected to a safe and clean source of water with a tee for an instrument air line. This point will also be used to drain the water and supply an instrument air purge after draining the water.

2. All personnel involved in the removal and preparation of the adsorbent containers must be trained and outfitted with self contained breathing apparatus.

3. All beds that the spent adsorbent is removed from must be adequately regenerated with a clean gas prior to the nitrogen purge step.

4. Until all the removed spent adsorbent has been water saturated and purged outside the vessel as discussed below, personnel without self contained breathing apparatus must not be allowed in the area of the removed or stored spent adsorbent.

5. After completion of the regeneration and nitrogen purge steps described in Procedure A, removal of the spent adsorbent into the special shipping containers can begin. As the adsorbent leaves the vessel, numerous samples should be taken in 1 pint containers and quickly capped. Each container of adsorbent is then individually opened in a small glove box in a vented hood and filled with water while the glove box atmosphere is tested for the toxic compound of interest.

6. If detectable levels of toxic material are found using the test above, move the containers filled with spent adsorbent to a convenient location and connect the taps as follows. The top tap will be connected to a vent line suitable for elevated temperatures (250°F minimum) and chemically resistant that can be attached to the plant flare line. The bottom tap with screen will be connected to a safe and clean source of water with a tee for an instrument air line. This point will also be used to drain the water and supply an instrument air purge after draining the water.

7. The containers will then be filled with water at the bottom to desorb any toxic compounds into the flare line. The heat rise due to adsorption of water is limited to the boiling point of water or about 212°F by vaporization of the added water. Once the container is filled with water to the top of the container (also above the top of the adsorbent, but not filling the jumper line), the water should be shut off and the container and line to the flare should be purged with instrument air to remove any toxic compounds from the container top and jumper line to the flare.

8. Shut off and remove the flare jumper line and drain the water to an appropriate location. Remove the water addition line and purge line and replace the plugs in the top and bottom taps and prepare for shipping. Repeat the same procedure for the rest of the containers.

9. If no toxic compounds are found in the tests during removal from the vessel, the container of removed adsorbent can be filled with water without a vent to flare by personnel wearing self contained breathing apparatus to ensure no toxic material remains on the adsorbent. Also, ensure that no source of ignition is present in the area so that any displaced hydrocarbons will not be ignited.

Once all the adsorbent has been removed from the vessel, prepare the atmosphere in the vessel for safe entry. Remove the nitrogen purge line (if used) and attach an air mover so that air is expelled out of the bottom of the vessel below the bed support. Check the outlet air and air in the vessel for the presence of any toxic or flammable gases. Leave the air mover on at all times during vessel entry. Once the exiting air and air in the vessel is confirmed to be safe to breathe, workers may enter the vessel following the confined space work practices as outlined in section VII to inspect the bed support. ***However, if the adsorbent has been to exposed to toxic material and steamed, and the adsorbent is observed underneath the metal bed support or in the inert support material (typically balls) used to substitute for a metal bed support, self contained breathing apparatus should be worn to remove the remaining adsorbent and inert balls.*** When the adsorbent is disturbed during removal, toxic vapors could be released where poor flow existed during steaming. Extra care should be shown with internally insulated vessels. Hydrocarbon and toxic vapors may be slow to outgas from the internal insulation. Never use a plant air supply to purge the vessel since the supply could become contaminated or be hooked up to another source by mistake.

Disposal

Either dispose of spent adsorbent immediately or store it in a manner that will not impact the environment until disposal can be arranged. It is recommended that spent adsorbent be stored in containers such as drums or portable luggers. If containers are not feasible, spent adsorbent should be stored on an impermeable surface such as concrete, asphalt or plastic sheeting that is heat and chemical resistant. It is recommended that spent adsorbent be protected from rainfall to prevent the possibility of generating contaminated storm water runoff. If water flooding has been used during unloading operations, additional spill prevention and controls such as temporary dikes may be needed to contain free liquid that may be generated when the spent adsorbent is unloaded.

In its fresh unused state, adsorbent is considered non-hazardous for purposes of disposal. However the adsorbed material on the spent adsorbent may change the classification for purposes of disposal. Refer to national, state and local regulations to determine proper disposal of spent adsorbent. For any questions concerning disposal of used adsorbent, contact your local UOP representative.

In summary, adsorbent can be handled and operated safely if proper safety precautions are followed. If in doubt about the safety of your adsorption system, please contact your local UOP representative.

Key points

1. Prepare adsorbent per one of the recommended procedures.
2. Limit access to the area.
3. Unload from outside the vessel.
4. Should reaction occur in the adsorbent during unloading, stop unloading immediately.
5. Dispose of adsorbent immediately or store safely until such time as it is possible.

**IN CASE OF A MEDICAL OR
FIRE EMERGENCY RELATED
TO UOP ADSORBENTS, CALL
+1-847-391-2123**

Find out more

For more information, contact your local UOP representative or our Des Plaines office.

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