

# **PRECAUTIONS AND SAFE PRACTICES**

**for**

**Handling Activated Alumina  
Adsorbents in Process Units**

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## SECTION I

# THE NATURE OF ALUMINA ADSORBENTS AND THEIR OPERATION

### UNDERSTANDING ALUMINA 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.

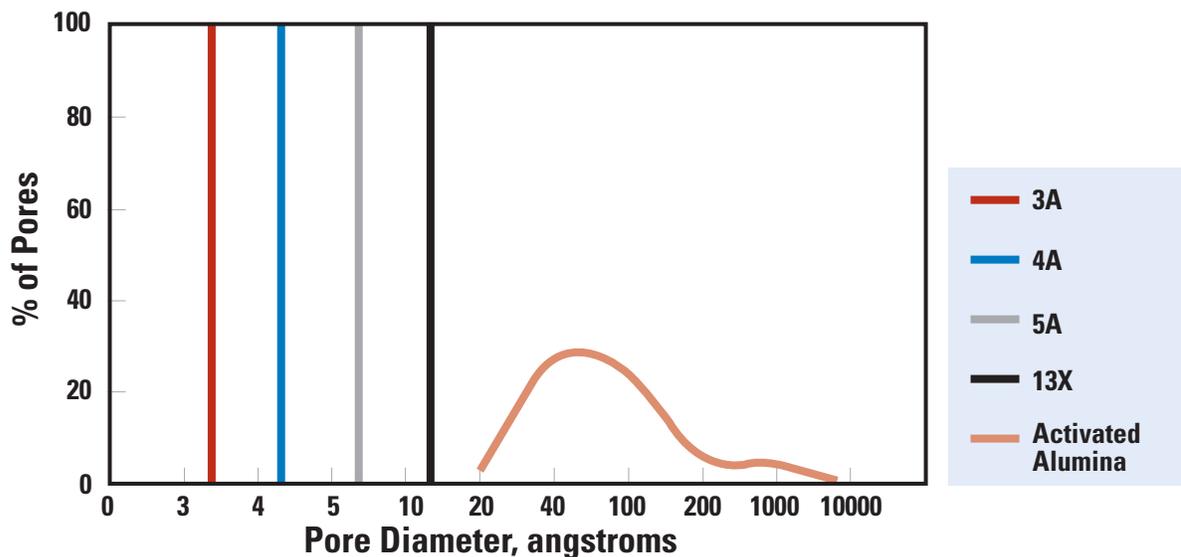
The adsorbents discussed in this document are typically activated aluminas combined with other materials, both inert and active. Activated aluminas are porous materials consisting of alumina and combined water in various proportions resulting in various structures (or phases). Being essentially amorphous (or non-crystalline) the pore structure is not uniform. Activated alumina's pore system contains mesopores and macropores, but, unlike molecular sieve, does not contain a large fraction of micropores. Since activated alumina is not microporous, the size of the molecule to be adsorbed has little influence on its adsorptive selectivity. **Figure I-1** shows the pore size distribution for various molecular sieves and a typical activated alumina. Molecular sieves are microporous; that is they contain pores less than 20 angstroms. The pores in alumina are predominantly mesopores in the range of 20 to 500 angstroms, with some greater than 500 angstroms (macropores). The non-uniform pore distribution provides

large pathways to the internal surfaces of the activated alumina structure.

Activated alumina relies on relatively weak forces to adsorb molecules. Activated alumina's utility as an adsorbent is largely determined by its surface functionality, which can be modified by thermal treatment or the addition of promoters during manufacture. Due to the nature of this internal surface area, the activated alumina adsorbent will attract and collect molecules from a 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. This results in a **selectivity** of some molecules over others. Some molecules react with the alumina and/or a dopant in the adsorbent. The reaction product remains on the adsorbent. This is called **chemisorption**.

When a molecule is adsorbed, heat is released causing the temperature to rise and to further desorb adsorbed species. This is a very important characteristic of adsorbents that needs to be taken into account to ensure their safe handling. When unloading or handling unloaded adsorbents,

**FIGURE I-1**  
**PORE SIZE DISTRIBUTION**



it must be realized that there is potential for adsorbed materials to be displaced or desorbed. When adsorbents are exposed to moisture (either from ambient air, rain, snow or from being purposely wetted to abate dust or to “deactivate” the adsorbent), molecules that 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 H<sub>2</sub>S in the feed stream can accumulate to dangerous levels in the activated alumina. **H<sub>2</sub>S can be deadly even when present in very low concentrations.**

### THEORY OF OPERATION

Alumina adsorbents are used to dry, and purify a wide variety of gases and liquids. They can do this because they strongly attract certain types of molecules, and they react with certain types of molecules.

Polar molecules such as water 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 into the pores.

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 (38°C).

At lower temperatures (less than 150°F or 65°C), adsorbents have a relatively high capacity for adsorbed species. At high temperatures (300-650°F or 150-345°C), however, the capacity is much lower. When adsorbents become saturated, the adsorbed molecules can be driven off by heating the adsorbents with a gas stream at 300-650°F (150-345°C). 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. In the case where aluminas are used for chemisorption, the adsorbent is not regenerable and the adsorbed species remain as reaction products of the original molecules and the alumina and/or any dopants present.

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 contained within cylindrical vessels. There, they are exposed to liquids or gases from which they pick up various materials, some of which can be hazardous (i.e. H<sub>2</sub>S, NH<sub>3</sub>, CO<sub>2</sub>, various hydrocarbon and sulfur-containing compounds). Before opening a used adsorbent system 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 contact:

<b>In USA:</b>	<b>UOP</b>	<b>847.391.2123</b>
	<b>CHEMTREC</b>	<b>800.424.9300</b>
<b>In Canada:</b>	<b>CANUTEC</b>	<b>613.996.6666</b>
<b>In Europe:</b>	<b>BIG</b>	<b>+32.14.58.45.45</b>
<b>From other Countries:</b>	<b>CHEMTREC</b>	<b>202.483.7616</b>

## 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

Activated alumina adsorbents are typically supplied as 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.

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 and communicate 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 the 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 (200 liter) sealed drums or 35-50 cubic-foot (1-1.5 cubic meter) 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 weigh more than 300 pounds (135 kg); full bags more than 2,000 pounds (900 kg). 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 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 the receiving systems 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.

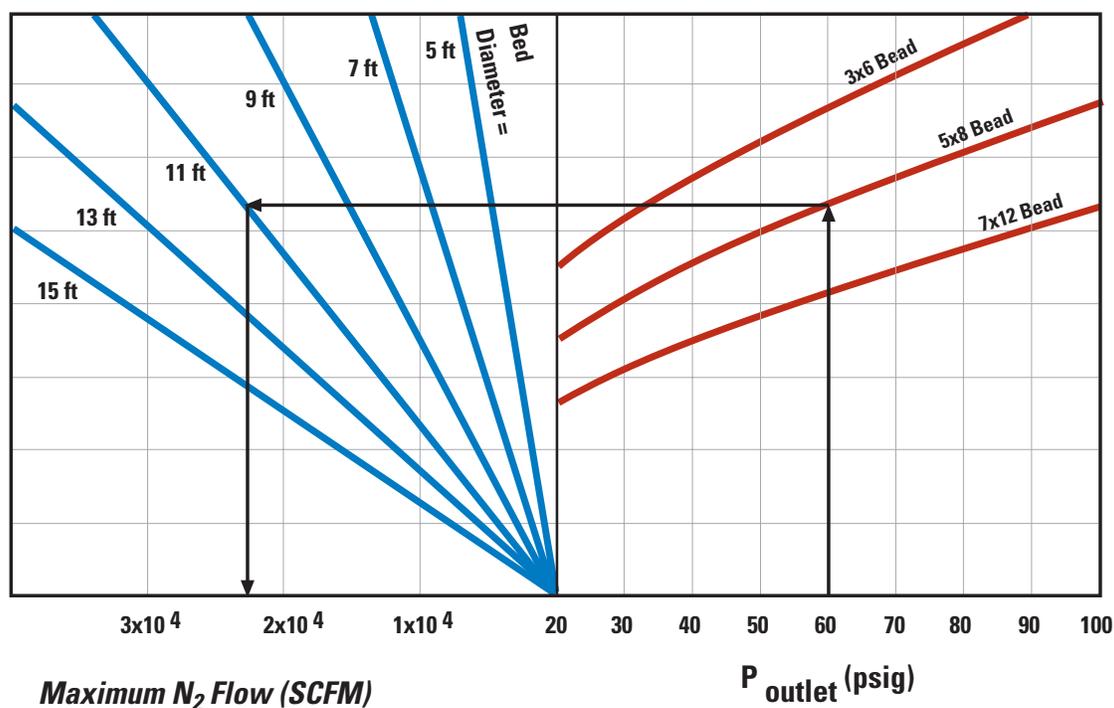
1. Introducing a flammable or reactive fluid into a vessel containing air.
2. Introducing a high concentration of a reactive, strongly adsorbed material into fresh or regenerated adsorbent.
3. Using a highly reactive fluid to heat or cool the bed. (Examples of reactive fluids would include ethylene,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

### INITIAL EXPOSURE TO A PROCESS STREAM

Temperature excursions are not as much a concern with alumina adsorbents as with molecular sieve adsorbents. Nonetheless, it is prudent to avoid such occurrences. Some guidelines to avoid temperature excursions:

1. Before introducing the process stream into an adsorbent vessel after loading, remove the air using a nitrogen purge. 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 be downflow (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 representative for specific recommendations for your unit. Continue purging until the oxygen content of the outlet mixture is less than 0.5 volume %.

**FIGURE III-1**



2. Do not use extremely reactive fluids to heat or cool a bed. The elevated temperatures during regeneration could start a hazardous heat-releasing reaction.
3. 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 (65°C) above the inlet temperature, stop the process immediately. This condition indicates that a heat-releasing reaction may have started.

Stop the reaction 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 with no 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 (150-345°C). 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, 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 (345°C). 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 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.*

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 adsorbent to ambient air may generate heat and desorb toxic materials creating a hazardous environment. While the adsorbent is regenerated prior to unloading, there are various reasons why there may be residual adsorbed material remaining on the adsorbent. Some potential causes would include:

- ▶ Bed channeling
- ▶ Adsorbent agglomeration
- ▶ Coke formation due to reactive species
- ▶ Liquid carryover
- ▶ Inadvertent contamination after regeneration
- ▶ Incomplete regeneration

Adsorbed species can be displaced by atmospheric moisture or liquid water and heat will be released. If reactive species such as olefins or other hydrocarbons are present, an uncontrolled reaction could occur resulting in fire and/or release of toxic materials. Therefore, it is important to remove any potentially hazardous adsorbed materials and render the adsorbent unable to pick-up any more such material. This procedure is referred to as **deactivation**. There are several alternative means to accomplish this deactivation, as described below. Deactivation should be done before the vessel, piping or valve bodies are opened to the atmosphere, or before any attempt is made to remove adsorbent or other materials from the vessel.

### INERT GAS (NITROGEN) PURGING

Nitrogen purging is done to remove the residual process gas from the void volume of used adsorbent beds.

1. Regenerate the bed: heat and cool it with a gas. If the gas normally used to regenerate the bed is unavailable or contains toxic components at hazardous levels, use nitrogen or an alternative nontoxic gas. Your UOP activated alumina adsorbent representative will help select an alternate gas and determine the proper flow rate, temperature and pressure.
2. Completely cool the bed with gas, then isolate the vessel and depressurize it. Install blind flanges on all inlet and outlet lines except the flare line. Connect a nitrogen source at the opposite end of the vessel.
3. 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 be downflow (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 representative for specific recommendations for your unit.
4. Continue to pressurize and depressurize the vessel to the flare with nitrogen purge gas 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**. Also purge until free of toxic materials. Then, proceed to one of the alternative deactivation methods described below.

**TABLE 1**  
**LOWER EXPLOSIVE LIMIT\* OF SOME COMMON FLUIDS**

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

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

## ADSORBENT DEACTIVATION

There are several options for deactivating the spent adsorbent. All involve the saturation of the adsorbent with a displacement fluid.

### WATER FLOOD

Water is the preferred material for deactivating the adsorbent. Unlike nitrogen, water is more strongly attracted to the adsorbent than nearly any of the potentially hazardous materials which may be present. The simplest method is to fill the bed from the bottom up with liquid water, after preparing the adsorbent bed.

**Note:** *Water flood should not be done without doing Step 1 (regeneration) below.* Water flood is not recommended to be used for spent chloride adsorbents. The chloride salts, which form during operation, are water soluble and the adsorbent may lose its mechanical integrity causing difficulty of unloading and disposal.

**Important:** *This procedure renders the adsorbent unfit for re-use. Furthermore, water flooding of an internally lined vessel may cause damage to the liner. Once wet, the liner is difficult to dry out.*

1. Regenerate the bed: heat and cool it with a gas.  
If the gas normally used to regenerate the bed is unavailable or contains toxic components at hazardous levels, use nitrogen or an alternative nontoxic gas. Your UOP activated alumina representative will help select an alternate gas and determine the proper flow rate, temperature and pressure.
2. Completely cool the bed with gas, then isolate the vessel and depressurize it. Install blind flanges on all inlet and outlet lines except for the flare line at the top of the vessel. Attach a water line to the bottom of the vessel. Be sure that the water is obtained from a safe and appropriate source and is compatible with the materials of construction of the equipment.
3. As the vessel fills with water, displaced gases are vented to the flare. To avoid overfilling the vessel and flooding the flare line, monitor the water filling rate and the liquid level. This can be easily done with a properly calibrated DP indicator if one is available, or alternatively, calibrated pressure gauges can be temporarily mounted at the top and bottom of the

vessel. (Note: 14.7 psi is approximately equal to 34 ft of water.)

4. After the vessel is completely filled, shut off the line to flare and open a vent port or vent valve to break the vacuum on the vessel during draining. Then drain the water to an approved disposal location.
5. Pressurize with nitrogen and establish sufficient flow to allow for gas monitoring to ensure the outlet of the vessel is below 10% of the LEL and is free of toxic materials. If the nitrogen leaving the vessel is not less than 10% LEL or contains toxic materials, repeat the water flood procedure and gas monitoring, as necessary, to achieve these results.

### WATER VAPOR DEACTIVATION

There are several drawbacks to the water flood procedure above: internal vessel liners (if present) can be damaged, the adsorbent cannot be reused, the waste water that is generated must be disposed of, and in water-sensitive applications (i.e. cryogenic or turbo-expander facilities) residual liquid water must be completely removed. The following procedure avoids most of the problems associated with the use of liquid water. However, it requires the use of nitrogen as a carrier fluid for vaporized and entrained liquid water.

1. Regenerate the bed: heat and cool it with a gas. If the gas normally used to regenerate the bed is unavailable or contains toxic components at hazardous levels, use nitrogen or an alternative nontoxic gas. Your UOP activated alumina adsorbent representative will help select an alternate gas and determine the proper flow rate, temperature and pressure.
2. Completely cool the bed with gas, then isolate the vessel and depressurize it. Install blind flanges on all inlet and outlet lines except the flare line. Connect a nitrogen source at the opposite end of the vessel.
3. Start a flow of nitrogen at the highest rate possible. Introduce water into the nitrogen purge (carrier) gas by either the injection of steam through a restricting orifice, or the injection of liquid water with a metering pump and atomizer. Nitrogen saturated with water vapor will generally not contain enough water to allow for complete deactivation of the adsorbent bed within an acceptable time frame. Most of the

required water will be entrained as small droplets within the nitrogen purge gas. For purposes of estimating the amount of water, nitrogen and time required to accomplish this Water Vapor Deactivation, the following nomographs, **Figures IV-1a and b**, may be helpful. Please contact your UOP representative with any questions regarding this procedure.

4. After sufficient water has been introduced into the bed to accomplish deactivation, monitor for LEL and toxicity, as described above in Inert Gas (Nitrogen) Purging Step 4. Repeat the process as necessary until this standard (less 10% LEL and no toxicity) has been met.

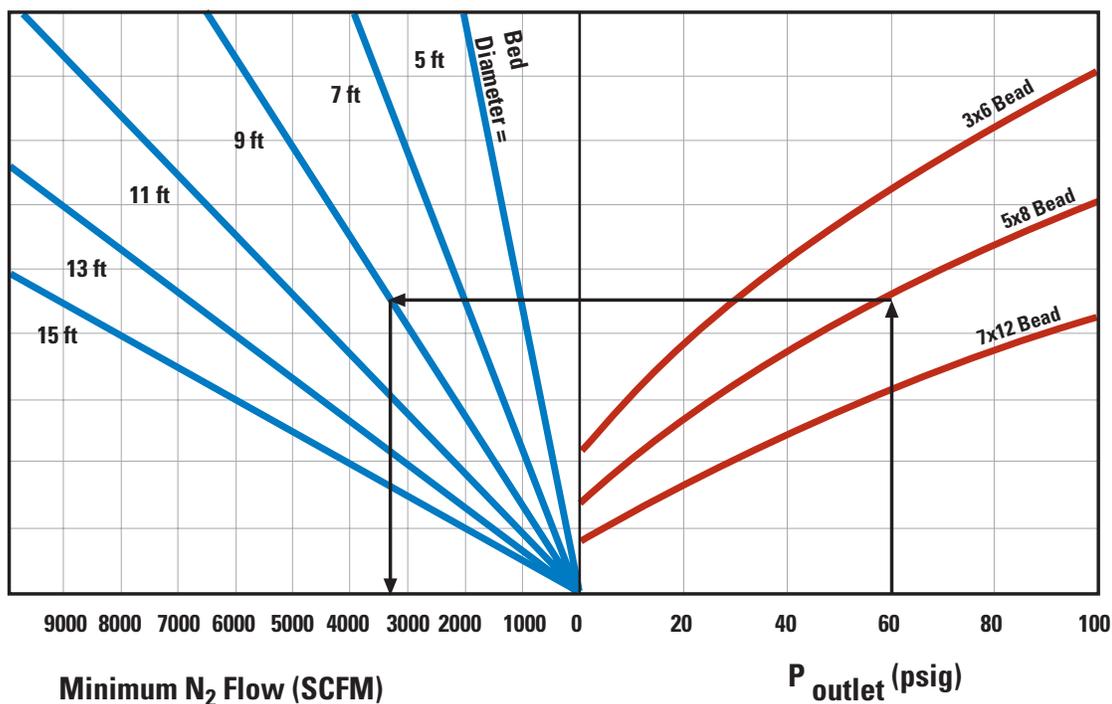
### STEAM DEACTIVATION

Another means of achieving deactivation, which avoids most of the problems associated with the generation of liquid water, uses only saturated steam. To prevent condensation of liquid water in the bed, it must first be preheated with regeneration gas, or hot nitrogen purge

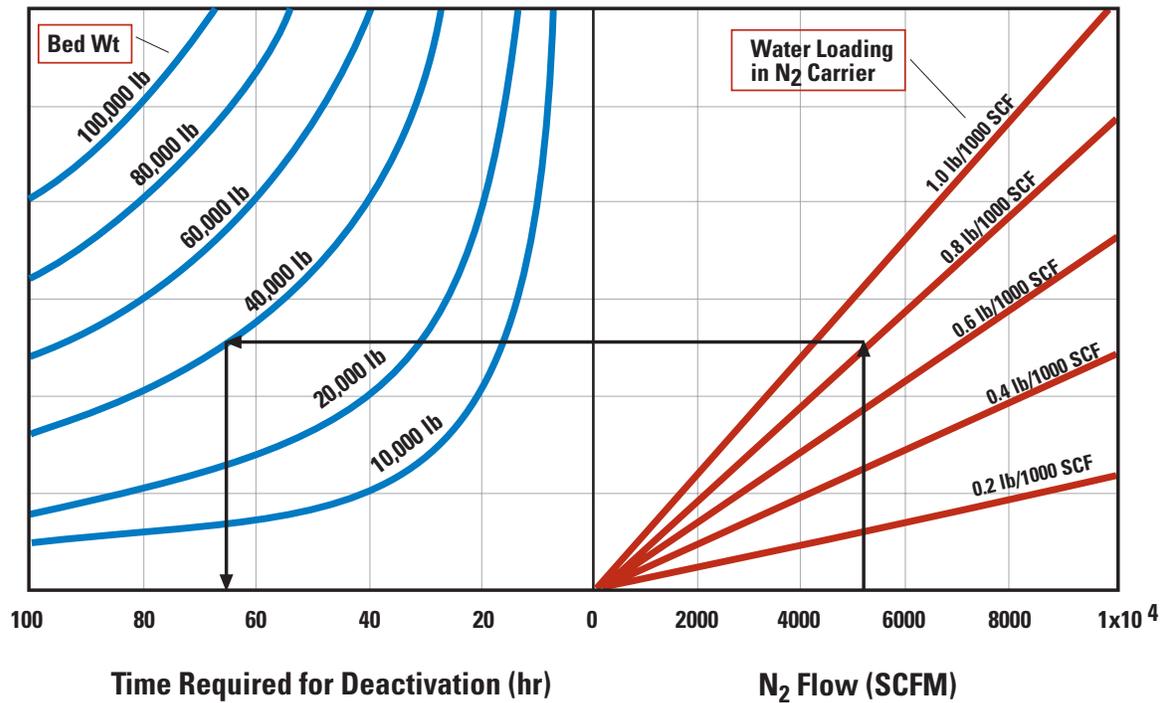
gas, to a temperature above that of the saturated steam. Ensure that the temperature and pressure ratings of the vessels and equipment are adequate for the conditions.

1. Regenerate the bed, but do not cool it. If the gas normally used to regenerate the bed is unavailable or contains toxic components at hazardous levels, use nitrogen or an alternative nontoxic gas. Your UOP activated alumina adsorbent representative will help select an alternate gas and determine the proper flow rate, temperature and pressure.
2. Isolate the vessel and depressurize it. Install blind flanges on all inlet and outlet lines except the flare line. Connect a steam source at the opposite end of the vessel.
3. Steam should be directed downflow through the bed and out the bottom to the flare. Condensate can be drained from the flare knockout drum. Test for contaminants at the bottom of the bed. Maximize the steam flow within the DP limits of the adsorber.

**FIGURE IV-1A**  
**Minimum Flow Required For Good Distribution**



**FIGURE IV-1B**  
**Deactivation Time vs N<sub>2</sub>/Water Flow**



- Each 100 pounds of adsorbent requires a nominal 40 pounds of water for deactivation.
- Each 1,000 SCF (ft<sup>3</sup>) of nitrogen carrier gas will hold one (1) pound of water.

The minimum theoretical amount of steam required for deactivation may be estimated based upon the adsorbent capacity for water (a nominal value of 40 pounds or 18 kg of water per 100 pounds or 45.4 kg of adsorbent).

However, the amount of steam is ultimately determined by the LEL and toxicity monitoring to be done following completion of the steam flood, as described above for the other deactivation methods.

Following confirmation of low levels of contaminants at the exit, continue to steam at least 2 hours more. After this, purge and cool the bed with nitrogen to ~ 50°C (120°F) while continuing to direct the effluent to the flare.

*Note: Gases can concentrate in the pores of the adsorbent. Ambient moisture can desorb these gases allowing them to concentrate in enclosed spaces. The resulting atmosphere could be toxic or depleted in oxygen creating a personnel hazard. Do not allow personnel to enter confined spaces containing spent adsorbent without proper precautions.*

### KEY POINTS FOR DEACTIVATION OF ADSORBENT

1. Regenerate with gas. If the gas you normally use to regenerate the bed is unavailable or contains toxic components at hazardous levels, use nitrogen or an alternative nontoxic gas. Your UOP activated alumina adsorbent representative will help you select an alternate gas and determine the proper flow rate, temperature and pressure.
2. Completely cool the bed with gas, then block-in the vessel and depressurize it to the flare. Install blind flanges on all vessel inlet and outlet lines except the flare line. Install a nitrogen tap at the opposite end of the vessel.
3. Select an appropriate deactivation fluid (in addition to nitrogen) to effectively displace potentially hazardous materials from the internal cavities of the adsorbent bed. Establish a detailed procedure for using this deactivation fluid.

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*Note: The use of both nitrogen and CO<sub>2</sub>, described in the above procedures, present a danger in themselves. Both gases are heavier than air, and both gases can lead to asphyxiation.*

4. Continue the deactivation procedure until the outlet gas from the adsorber vessel contains less than 10% of the lower explosive limit (LEL) and is free of toxic materials.
5. Particular care should be taken in applications where the process streams contain H<sub>2</sub>S, COS, mercaptans and other sulfur-based compounds – even if these compounds are only present in minute quantities.  
**Inhalation or exposure to these products can be fatal.**
6. Contact your UOP representative with any questions you may have regarding these procedures.

## SECTION V

# UNLOADING AND HANDLING OF SPENT ADSORBENT

*Read and understand this document thoroughly before unloading used adsorbent.*

### PREPARATION

Regardless of what technique of adsorbent deactivation and purging is used in preparing the adsorbent for unloading, it is important to maintain a nitrogen blanket on the vessel during unloading. **Always assume that some hazardous and toxic materials remain on the adsorbent. Do not enter the vessel while the 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 appropriate respiratory protection such as respirators or self-contained breathing apparatus.

*Note: UOP recommends that the spent activated alumina adsorbent be deactivated prior to unloading. Spent material that has not been fully deactivated could present a safety hazard in that it may still contain toxic gases despite having been regenerated prior to unloading. Furthermore, it could present a safety hazard in that it has the potential to release a significant amount of heat energy should it be wetted either with hose water, rain or snow.*

### UNLOADING

Contact with used adsorbent should be avoided. Workers involved with unloading the adsorbent should use 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.

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.

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 a 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 to react (as indicated by a large heat release), stop unloading.** Clear 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 the spent material as a result of the heat release or fire, or as a result of dousing the spent material with water.*

Once all the adsorbent has been removed, 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. The air will carry any remaining vapors out of the vessel and away from the workers. Such vapors may be released by adsorbent trapped under the bed support. Extra care should be exercised for internally insulated vessels. Hydrocarbon and toxic vapors may be slow to outgas from the insulation. Leave the air mover on at all times. **Never use a plant air supply to purge the vessel with air – a plant supply could become contaminated or be hooked up to another source by mistake.**

Once the actions have been completed to establish a safe environment for vessel entry, personnel entering the vessel must follow confined space work practices as outlined in **Section II**.

## **DISPOSAL**

Either dispose of spent activated alumina adsorbent immediately or store it in a manner that will not impact the environment until disposal can be arranged. It is recommended that spent activated alumina 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 activated alumina 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 adsorbent 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**

