Question 39: What are your best practices for transferring FCC catalyst into/from pneumatic trailers and rail cars to ensure personnel safety and catalyst containment?

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These trailers are often referred to as pneumatic, dry bulk, or pressure differential (PD) trailers. On-road trailers and railcars have similar functionality although railcars are not usually rated for vacuum, nor do they usually have a filter system. Both types of transport vessels have multiple hoppers. The multiple hoppers are necessary to make sure that the outlet slope is greater than the angle of repose.

A trailer can be offloaded into either an atmospheric pressure hopper or a hopper under vacuum. A vacuum is not required but can increase the offload rate. Once the trailer arrives at the offloading location, the wheels should be chocked, and the trailer grounded. Proper PPE should be worn. The trailer outlet line is then connected to the refinery piping using a flexible hose. All those connections should be locked. It is best to match the diameter of the trailer discharge piping, hose, and refinery piping. If the refinery piping diameter is larger, additional carrier air may need to be added.

There are 3 air uses in a typical trailer: top air for trailer pressurization, carrier air, and aeration air. The air for trailers is usually provided by the truck blower while air used to offload railcars is provided by the refinery. The refinery storage hopper design pressure and relief valve capacity should be checked against blower design. A filter may be needed on the refinery hopper discharge vent. Some factors that contribute to whether a filter is needed are hopper air velocity, hopper catalyst level, and whether a vacuum system is used on the hopper. A filter is recommended upstream of the refinery vacuum system to minimize erosion in the ejector.

Most trailers and railcars have a design pressure of 15-18 psig. Top air is introduced into the trailer between 8 and 12 psig. Carrier air is introduced into the outlet piping upstream of the trailer hoppers. Setting the carrier air flow is part art and part science. Carrier air velocity is recommended to be 10-20 ft/sec. Measurement of carrier air flow is uncommon; therefore, the flow setting is often set based on experience. Some hoppers also include aeration air which can be used to fluff the catalyst. Once the trailer is suspected to be empty, a visual inspection from the top hatches should be performed. Some trailers have handrails on top for increased safety when accessing the hatches. Proper tie-off is required when on top of the trailer. Trailer pressure should be verified as zero prior to opening hatches.

When loading a trailer, the trailer should first be verified as empty and clean by visual inspection. Trailer loading can be accomplished via gravity flow, pressurization of the refinery hopper, or by pulling a vacuum on the trailer. Gravity flow requires a loading facility where the trailer can be located underneath the hopper. The trailer vent for the displaced air is usually routed to atmosphere due to minimal flow. The second option for loading a trailer is to pressurize the catalyst hopper and add carrier air at the outlet of the hopper. In this scenario, the trailer relief valve capacity needs to be evaluated. Additionally, a filter system is necessary on the trailer vent. This can be a filter system included with the trailer or the vent can be connected to a filter system at the refinery. Another option for trailer loading is to utilize a vacuum system. This option is not readily available for railcars. The vacuum source for the trailer is typically the truck blower pulling suction from the trailer through a filter. For vacuum filling, there are usually multiple fill lines as it is difficult to fill more than two compartments from a single inlet. Most trailers have weight gauges to help prevent overfilling and help determine when to switch hoppers.

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FCC catalyst handling activities constitute an important piece of day-to-day unit operation that can have a tangible impact on operational safety and performance. The health of the circulating catalyst inventory is highly dependent on the success of the routine fresh catalyst transfer process from the delivery vessel to the fresh catalyst hopper – or equivalent recipient.

General Catalyst Transfer Guidelines

From a safety perspective, the key is to identify and actively monitor the mechanical design limits of the lines, fittings and equipment involved throughout each step of the catalyst handling activities. It also becomes critical to properly ground all loading/unloading vessels, equipment and piping/hoses to avoid static electricity hazards. Regardless of the procedural complexity of the material loading/unloading process, a good practice is to at least verify the following items prior to any loading or unloading activities:

1. The shipping truck, or alternative delivery medium, has been properly secured from movement by at least two independent means.

2. Correct lineups of the hose, hopper and corresponding piping. If applicable, any hose connections should be properly secured at each end.

3. Correct valve positions to ensure safe and adequate catalyst routing and flow control. Ensure that the correct material is lined up to the correct storage hopper or recipient.

4. Visual inspection of all equipment and fittings associated with the procedures to ensure that they are in proper working condition.

5. Confirm hopper inventory prior to loading the hopper to prevent overfilling and potential loss of containment.

6. Operators should observe the entire loading process, never leaving the loading process unattended.

All personnel involved in the catalyst handling activities should also adhere to the PPE requirements associated with the local policies and regulations at all times. Permissible exposure levels of the various components in the catalyst are present in the product safety data sheets and should be reviewed with monitoring performed when needed.

Considerations for Catalyst Loading to a Fresh Hopper

Fresh catalyst is typically delivered in railcars or trucks when shipped within North America. The specialized trucks can typically deliver 20 to 25 tons based on multiple factors and regulations, and railcars can carry roughly 80 to 90 tons. The maximum allowable loading limit for individual trucks should always be observed while leaving any necessary clearance within the load compartment for pressurization and depressurization requirements. Apart from potential impacts to transportation safety, overloading of the truck or railcar can also lead to undesired catalyst handling losses that are often costly and may result in employee, public and environmental exposures. All catalyst loading and unloading activities are usually carried out through pressure differentials or gravity feeding. Silo or tank trucks are typically pressurized while the fresh catalyst hopper is placed under a vacuum, using steam ejectors, to establish an adequate driving force for catalyst flow. Prior to pulling a vacuum within a truck, storage hopper, or any other vessel, it is critical to ensure that the corresponding system is rated for the targeted vacuum conditions. Establishing an excessive vacuum within a vessel or delivery medium not rated for this type of service can lead to personal injury, irreversible mechanical damage that can also compromise the catalyst containment efficacy of the system. Railcars are not typically rated for vacuum service. As such, a corresponding lid should be opened, or at least partially cracked, during catalyst transfer activities to prevent the buildup of negative pressure.

Catalyst loading and unloading activities are highly dependent on the mechanical integrity of the piping and fittings connecting the trucks and storage hoppers. Fouled piping or fittings can significantly deter catalyst transfer efficiency while potentially posing a back-pressure hazard to upstream equipment. Therefore, adequate debris screens should be installed and frequently inspected at the bottom of storage hoppers to help prevent plugging hazards. Catalyst manufacturers have quality assurance controls at the manufacturing plants to prevent debris ingress into the delivery medium. The catalyst should be kept dry and free of contamination throughout the catalyst handling activities to ensure proper flow characteristics. Any carrier air or fluffing air supplies should be regulated and maintained adequately dry at all times, particularly in winter service. Steam ejectors for vacuum service can also introduce moisture into the system and lead to catalyst agglomeration issues.

The carrier air rates should be controlled such that the superficial velocity through the catalyst transfer lines is maintained at 10 to 20 ft/s at all times. Excessive line velocities can lead to accelerated wear of the piping and internals based on the high loading and unloading frequency for typical FCC units. Long-radius elbows and cushioned tees help mitigate erosion across any change in piping direction but can still be susceptible to mechanical wear throughout long-term operation. Ceramic, cast basalt, and/or alumina linings can be used for susceptible piping sections to improve mechanical resiliency throughout catalyst transfer cycles.

Considerations for Catalyst Unloading from a Spent Hopper

With respect to catalyst withdrawal from the regenerator and spent catalyst hopper, the same considerations and best practices apply. However, there is also an increased focus on catalyst temperature throughout the catalyst transfer activities. The mechanical design limits for the transfer piping, spent catalyst hopper and truck or railcar containers should be observed at all times. Adequate insulation or PPE requirements should be established to properly protect field personnel from the high temperatures associated with this type of activity. Entrained flue gas from the regenerator should also be accounted for throughout safety assessments and procedure development. Catalyst temperatures can usually be controlled by controlling the rate of spent catalyst withdrawal from the regenerator and storage hopper residence time. The superficial velocity limits for the catalyst transfer lines should still be observed and the higher temperatures should be taken into account.

Considerations for Emissions Control

Engineering controls are the preferred means to control personnel exposure. The use of closed systems for storage, dustless systems for material transfer, ventilation for industrial hygiene and dust collection are all highly recommended. Good housekeeping practices should be employed to reduce airborne material and the accumulation of settled dust. Vacuum systems should be equipped with High Efficiency Particulate Air (HEPA) filters. Dry sweeping is to be avoided as it can result in re-distribution of material. Airborne dust levels must not exceed the permissible exposure limits (PELs) that are found in section 8 of the product MSDS. Be aware that it is very difficult to visually determine airborne concentration of dust.

The actual level within the hopper or storage vessel should be frequently monitored via manual gauging or reliable instrumentation for particulate service. Overfilling of the storage hopper represents a common root cause of excessive catalyst handling losses and emissions throughout catalyst loading and unloading activities

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