<u>SAFETY PRECAUTIONS</u>
<u>AS RELATED TO OPERATING SLURRY SLAKERS</u>

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Slurry slakers produce very high quality lime slurry, however, if not operated properly, have the potential to generate an explosion-like reaction. The most severe type of reaction is due to uncontrolled lime feed (flooding), but they can also result from other causes.

There are several causes for uncontrolled lime feed, or flooding, to the slaker that could result in an explosion or other build-ups of unslaked lime in the slaker that can result in the same. They are:

1. Use of screw or belt-type feeder or any feeder that is not classified as a positive displacement feeder.
2. Use of pebble lime with an excessive amount of powder, or use of pulverized quick lime.
3. Bridging and rat holing in the silo.
4. Fluidizing the lime in the silo.
5. Allowing the level of lime in the silo to drop below the intersection of the silo straight wall and silo cone before loading the silo with new lime and running the system while loading the new lime.
6. Inoperative steam removal system (D&V) due to the lack of preventative maintenance.
7. Failure of the slaker torque control system.
8. Failure of the slaker temperature control system.
9. Lack of routine daily maintenance and cleaning of the build-up within the slaker.
10. Operator error.

Below, I will address each item in detail.

1. Use of Screw or Belt-Type Feeders

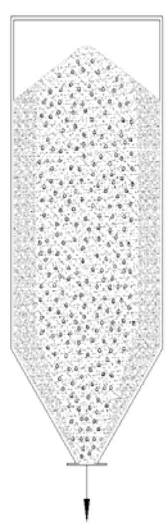
If your lime system is **<u>not</u>** equipped with a positive displacement feeder such as a rotary valve feeder, under certain conditions (which will be described below) the lime can flood uncontrollably through the feeder into the lime slaker. This uncontrolled feed of lime to the slaker will generate a tremendous amount of heat and steam causing an explosion-like reaction, which will spew boiling lime slurry (212°) out of the slaker access doors. This could result in severe burns to anyone present at the time. The only positive way to prevent flooding through the feeder is to retrofit and add a rotary feeder either before or after the existing feeder as dictated by the available space in the existing system. This is probably the most dangerous of all described situations because it can happen with all equipment operating correctly and it only takes seconds to happen. Chemco recommends retrofitting any slaker with this type of feeder to include a rotary feeder.

2 & 3. Use of Pebble Lime with an Excessive Amount of Powder or Pulverized Quick Lime.

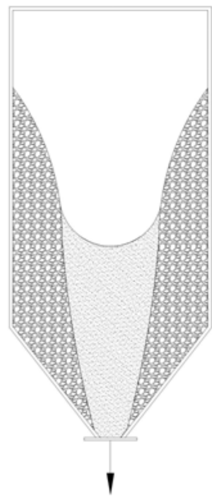
Pebble lime ¾" by ¼" with less than 15% powder will not flood through a screw or belt feeder. It is the powdery lime in the silo that hinders the flow out of the silo and causes bridging and rat holing that could result in flooding through a screw or belt feeder.

The following sketches show what happens in a silo when lime, with a high percentage of powder, is used.

Please note that the effects are exaggerated in these sketches to make this point clear.



As lime is blown into the silo, due to the angle of repose, the material loaded pneumatically into the silo will form a cone shape. The larger particles of lime roll down the sides of the cone and mostly accumulate on the sides with some intermixing in the center of the silo. This action causes segregation of material with coarser material on the perimeter and fine material in the center.



When lime is fed from the silo, first the fine particles from the center will exit the silo. As the height of the fine material in the center is reduced, some coarser material at the perimeter of the silo will collapse into the center of the funnel and trap a large air pocket in the cone of the silo.

The compressed air forces the lime below it and, if there is no positive feed control below the silo, the mixture of fine and coarse lime will be forced through the feeder into the slaker. This sudden introduction of a large volume of lime into the slaker will produce a violent reaction releasing steam that would act as an explosion spraying hot slurry out of the slaker. There is no way to guarantee this accumulation of powder will never occur in any silo.

Bridging can also take place if, during pneumatic loading of the lime into the silo, the pneumatic air is saturated with moisture due to rain or other atmospheric conditions. This moisture will air slake the lime and breakdown the pebbles into a fine powder, thus hindering the flow of the lime. The lime at the interface of the new load and the lime already in the silo will be different in particle size distribution due to air slaking. The lime underneath the new load has a much larger percentage of pebbles and, therefore, will flow readily. The lime above is air-slaked and, therefore, has finer particles and a higher cohesive strength. Therefore, the particles stick to each other forming a bridge. Eventually, this bridge will break, causing the air in the void to get compressed, fluidizing the lime and forcing it through a screw or belt feeder. It is imperative that a positive displacement feed be used at the silo discharge even though a screw feeder or a belt feeder must be used for dosing the lime.

4. Fluidizing the Lime in the silo

If the lime in the silo is powdery and fluidization is used to assist in lime withdraw from the silo, it is imperative that a positive displacement airlock feeder be used below the silo discharge. If the system layout does not allow direct feed of lime from the airlock feeder to the slaker, a screw conveyor can be used to transfer the lime from the airlock feeder to the lime slaker. The dosage control should be via airlock feeder. The conveyor will only transfer the lime from the airlock feeder to the slaker.

In general, if the lime silo is fluidized, dry air must be used to avoid air slaking of the lime. Fluidization is not effective for pebble lime with little powder.

5. Very Low Silo Level Prior to Pneumatic Loading

When the lime level in the silo is below the intersection of the cone and the straight side of the silo, loading the silo pneumatically will pressurize the silo somewhat and, if a screw or belt feeder is used under the silo, the powdery lime can flood through these feeders and flood the slaker with dry lime which will cause an explosion-like reaction spewing hot lime slurry out of the slaker.

To avoid this problem, the silo shall be equipped with three-point level devices or point levels should be derived from a continuous level signal. These are high level, low operating or reorder level, and low low alarm level.

- At high operating, the silo is full and loading must stop.
- At reorder level, the silo is empty enough to receive a full truckload of pebble lime. When this signal is received, lime must be ordered immediately.
- Low low alarm. This level generally must be located near the intersection of the cone and straight side. Operators should not allow the lime level in the silo to go that low.

It is always a good practice to keep the silo as full as possible to minimize the air slaking of the lime in the silo. If the lime level in the silo is at a low low alarm level, it is advisable to stop the lime feeder and shut the knife gate at the silo discharge while unloading the truck. This will prevent the pneumatic air pressure from forcing uncontrolled lime through a screw or belt feeder.

6. Inoperative steam removal system (D&V)

Regardless of what kind of feeder is used at the silo discharge, if the steam removal system fails to remove the steam from the slaker, it could cause a build-up of lime at the inlet of the dry lime feed to the slaker eventually blocking the lime feed to the slaker. This could then cause an accumulation of a quantity of dry lime in the chute between the discharge of the feeder and inlet of lime feed to the slaker. Eventually, this build-up may break loose due to its weight and allow a few cubic feet of lime to enter the slaker suddenly releasing a large volume of steam and spraying hot lime slurry out of the slaker access doors.

It is imperative that the operators check the steam removal system at least once or twice a shift for proper operation of the system. If during these routine check-ups the operator notices a build-up of dry lime in the inlet chute to the slaker (sample box), before attempting to clear the build-up he must wear full body and head protection gear. After protective equipment is worn, the operator can slowly remove the cover to the sample box. If the sample box is full of lime:

1. The operator should shut-down the feeder.
2. Then slowly remove the dry lime from the sample box trying to avoid breaking the blockage, which will allow a large quantity of lime to enter the slaker all at once.
3. Once most of the dry lime is removed, the moist lime that forms the bridge can be slowly forced into the slaker a little at a time while the slaker mixer is running. Since the wet lime is already partially slaked, it will not release a large volume of steam that could cause a violent exothermic reaction.

WARNING:

Do not use water to clear dry lime from the sample box. Adding water could cause a violent reaction that could cause personal injury.

7. Failure of Slaker Torque Control System

Chemco slakers are equipped with a torque control or slurry consistency control system. This control loop is designed to prevent slurry from getting too thick, which hinders proper wetting of dry lime as it is added to the slaker.

If the slurry is too thick, the slaker mixer cannot create enough of a vortex to pull the added dry lime under the slurry for proper hydration. The powdery dry lime will float on the surface of the slurry and eventually form a crust on the surface of the slurry. This crust acts as a barrier and allows the dry lime to accumulate on the crust until the weight of the dry lime reaches a point that the lime crust can no longer support the weight of the accumulated lime. At this point, a large quantity of lime will submerge into the hot slurry. This suddenly generates a large volume of steam, which is created under the surface of the slurry, and acts like an explosion spewing out hot slurry from the slaker access lids.

The torque control system is designed to prevent the lime slurry from getting too thick by adding additional water to the slurry to thin the mixture. The torque system setting is adjusted usually at system start. However, at start up, the motor and gearbox are tight and require more power to drive them. After the system runs for a month or so, the gears will wear in and the mixer will require less power to drive it. So, it is important that the torque system be readjusted after a month of operation. The torque setting must be rechecked once every six (6) months and adjusted as needed. For torque adjustment, refer to the slaker O&M Manual.

8. Lack of Routine Daily Maintenance

Lime slakers are generally maintenance intensive due to the nature of the process. Daily maintenance is necessary not only to keep the system running properly but also to prevent potentially hazardous accidents. The smaller slakers, 250 lb./hour, 500 lb./hour and the 1000 lb./hour units, require more daily attention than the larger slakers.

The atmosphere within the slaker is hot and humid and powdery lime will have a tendency to stick to the sidewalls, mixer shaft and top of the dust and vapor remover pipe. This build-up, if not cleaned regularly by a water hose, could accumulate particularly under the dry lime inlet to the slaker. This accumulation could cause bridging above the slurry and force dry lime to build-up and eventually fall into the slurry and cause a violent reaction as described above.

Dust and vapor removal systems also require routine daily check-ups to make sure the steam is evacuated from the slaker. Major causes of D&V failure are due to either pluggage of the spray nozzle within the slaker or blockage of the D&V canister drain or failure of the D&V draft inducer fan.

9. Operator Error

Operator error can cause accidents, which will result in severe personal injury including third degree burns.

The following are three hypothetical examples of how operator error can result in severe injury.

Hypothetical Example 1

The emergency cooling water solenoid on the slaker's hydraulic panel had been leaking water causing the slaker temperature to vary. The operator, instead of fixing the leak by repairing or replacing the cooling water solenoid, left it in place and shut-off the manual isolation valve ahead of the solenoid. After a month of operating without the emergency cooling water, the operating conditions were just right and, since the torque control system setting had drifted, the slurry became too thick. Slurry got thicker and thicker, and dry lime started to build-up on top of the slurry. Then, the slaker got too hot, but the high temperature water was shut-off and, therefore, the cooling water did not come on.

When the operator came in for routine inspection, he noticed the high temperature alarm was activated. When he opened the slaker injection lid, he saw dry lime build-up on top of the slurry. He immediately got a water hose, opened the slaker lid and started spraying water on the dry lime. The water broke the crust on top of the slurry and dry lime sank into the slurry causing an explosion that poured hot slurry over the entire body of the operator. This caused third degree burns and the operator was hospitalized for months.

In this case, there were two major operator errors. One was that he shut-off the manual valve on the cooling water supply. The second was that when he saw lime build-up on top of the slurry, he took a water hose to it. When the operator saw the lime build-up in the slaker, he should have shut the system down immediately and exited the slaker area to wait for the slaker to cool down to about 100° before opening the slaker and breaking the crust that kept the lime build-up above the slurry top.

Hypothetical Example 2

A system has two slakers, which were retrofitted to an old existing silo. The feeders are belt gravimetric feeders.

The operator entered the lime slaker room and noticed the gravimetric feeder wasn't feeding any lime. He tapped on the chute from the silo to the feeder and it sounded empty. Next, the operator turned on a switch that activated an air impactor on the silo discharge cone.

Suddenly, the lime flooded from the silo through the belt feeder into the slaker. This caused an explosion, which covered the operator with hot lime slurry. The operator suffered third degree burns and was hospitalized for months.

The error in this case was that the operator should have closed the knife gate above the feeder before he actuated the impactors on the silo cone.

Hypothetical Example 3

A system has two large lime slakers with screw feeders. The lime used in this plant is pulverized quick lime. After operating for several months, the control room received a high temperature alarm at the DCS. The control room alerted the operator that there was a high temperature alarm at the slaker and they should go and investigate to see what was happening.

The operator went to the slaker room below the silo and noticed a high temperature of about 200°F on the local panel. He climbed the stairs to the slaker platform and tried to open the slaker access lid to see inside. Just as he was about to open the slaker door, there was an explosion, which opened the slaker lid and spewed hot slurry on the operator, which caused third degree burns over his entire body.

The operator errors were; first, he should not have walked into the slaker room without personal protective equipment when he knew there was a high temperature alarm. Second, he should have shut-down the system from the control room first, then put on personal protection equipment on before entering the slaker area.

WARNING

While considering modifications to the lime system to prevent flooding, the following operational procedures should be used to minimize the danger of uncontrolled flooding and personal injury.

1. Try to limit the percentage of fines in the quicklime by requesting that the lime supplier prescreen the lime during this transitional period.
2. When loading the lime silo, make sure that the operator of the transport truck cuts back the loading pressure to 8-10 PSI to reduce transfer velocity and lime degradation.
3. As soon as the lime level in the silo is low enough so the silo can receive one full truckload of lime, order new lime. Try to keep the silo full. **DO NOT ALLOW THE LIME LEVEL TO DROP BELOW 50% IN THE SILO.**
4. Do not load the silo during rain or at times when the air is saturated with moisture.
5. When entering the silo slaker level for inspection and cleaning, make sure you wear full protection clothing including:
    - Head and face shield mask
    - High temperature (212ºF) rubber gloves
    - Full body safety clothes
    - Safety boots

    All clothing and shields used must be able to protect body from lime slurry with a temperature of 212ºF. Since the lime slurry is highly caustic with a pH of 12-13, all safety protective clothing must be suitable for this purpose.

    Make sure you shut the feeder down before you open the slaker door for inspection and cleaning.

    Please review all safety precautions that are described in the O&M Manual.
6. Due to the hazardous constituents associated with the slaking process, extreme caution should be exercised when working around this system. Protective clothing and eye protection must be worn by personnel when performing maintenance on the system's equipment. Extreme caution must be exercised when working with the grit discharged from the slaker since it still contains reacting lime. Particular caution should be used when unplugging the grit disposal equipment since steam generated inside the plugged equipment creates the potential for the impacted contents to explode when cleaning operations are being implemented.