Case histories from the sulfuric acid industry

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Supporting acid pipelines

One of the cost-effective methods used by piping designers to support pipelines is to weld a dummy pipe on elbows to provide vertical or horizontal support, as shown in Fig. 1.

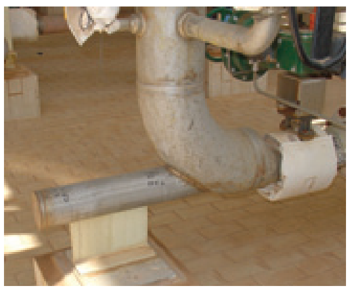

Fig. 1: Dummy pipe support on elbow.

This method was used in a carbon steel acid pipeline to transport 99.2 percent acid to a refinery customer's storage tank located a couple of miles from the acid plant. The pipeline is supported on pipe racks together with other pipelines that run along the roadway. A routine pipeline inspection revealed a leak that was emanating from one of the dummy pipes that was welded to elbows. The pipeline was evacuated to perform a closer inspection and repairs. Removal of the dummy pipe revealed a slit on the elbow, as shown in Fig. 2. The elbow had suffered erosion-corrosion from acid flow, as shown in Fig. 3.

Fig. 2: Slit on elbow. Note the dummy pipe support outline on elbow.

Lesson learned

Never support acid pipelines with dummy pipes on elbows. While this method may be acceptable for non-corrosive/erosive fluids, it is not good practice for acid pipelines. The dummy pipe prevents regular ultrasonic thickness inspections from detecting thinning of the elbows' critical areas.

Consider the effective flow area in elbows when sizing pipelines; acid velocity guideline in open literature is only for straight pipes.

Spitting plant stack

The plant stack normally functions without any trouble in a properly operated and maintained acid plant. It is designed as tall as possible to disperse any residual SO_2, SO_3, acid mist and NO_x to the environment to minimize the impact on nearby communities. Like any acid plant equipment, proper maintenance is necessary for trouble-free operation, such as washing the stack to remove sulfates that may have absorbed moisture during a prolonged turnaround (especially in high humidity regions), checking for holes (especially at the bottom of the stack) that may have formed over years of operation, etc.

Fig. 3: Erosion-corrosion on elbow.

In a particular acid plant in North America, the vent line from decommissioned equipment that was still hooked up to the stack was removed in preparation for demolition of the abandoned equipment. The removal process looked innocuous enough, so a process safety review, as part of the management of change (MOC), was never performed. During the course of plant operation after the vent line removal, sulfate started to appear on roadways in the vicinity of the stack. The stack had been spitting! Investigation revealed that the vent nozzle in the stack for the decommissioned equipment was never blinded off when the vent line was removed. This allowed moisture to draft in, wetting the dry sulfate coating on the stack interior. When enough moisture collects, the sulfate dislodges, gets carried with the gas and spews out of the stack. The sulfate comes back down and lands on nearby equipment, building roofs and automobiles, causing damage to properties.

Fig. 4: Sulfate on asphalt roadway coming from the stack.

Lesson learned

Always perform process safety reviews of equipment changes no matter how innocuous they may appear. Perform regular inspections, especially checking the bottom of the stack for holes that may have resulted from corrosion due to weak acid formation.

SO_2 stripper distributor

SO_2 strippers are used in metallurgical and spent acid regeneration plants to remove dissolved SO_2 in the acid. SO_2 gas laden acid is fed to the top of a packed tower and distributed as uniformly as possible across the tower's cross section using a pipe- or trough-type distributor. Ambient air is fed at the bottom of the packed section and as it flows upward in counter-current flow with the acid, dissolved SO_2 in the acid is stripped. The air plus acid mist coming out of the packed tower is directed to the inlet of the drying tower; so total removal of moisture in the ambient air is not normally done.

The choice of materials for the tower and its internals is critical; improper selection can lead to premature failure. Such is the case for the SO_2 stripper in a metallurgical acid plant. The technology provider chose an alloy material that is resistant to the acid concentration and temperature for the distributor. In less than two years, the distributor failed catastrophically, as shown in Fig. 5. Weak acid that formed on the outside surfaces of the distributor during normal operation and downtimes caused corrosion of the alloy material.

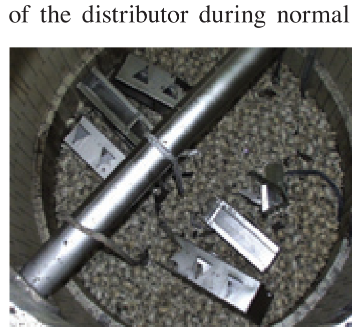

Fig. 5: Corroded SO_2 stripper distributor.

Lesson learned

Always consider the process and all the possible modes of operation for the equipment when choosing materials of construction. Materials that are resistant to the acid concentration and temperature may not necessarily work even for normal operations, let alone upsets or downtime modes.

Water dilution

Water dilution in pump tanks has been and continues to be one of many sources of headaches to many acid plant operators. The corrosion of acid circulation pumps resulting from the failure of the water dilution system has contributed to the reduction of the plant's overall equipment efficiency (OEE). Corroded acid circulation pumps as shown in Figs. 6 and 7 will result in an unplanned plant shutdown due to an increase in stack SO_2/SO_3 emissions. Roof corrosion, as shown in Fig. 8, is also a consequence of the water dilution system failure.

Common methods of adding water to acid in pump tanks are: a) through a dip pipe that is immersed in the acid bath, b) through a sparger in the runback line from the acid tower to the pump tank that is immersed in the acid bath and c) through a sparger in a mixing tee with a dip pipe that is also immersed in the acid bath. Material selection is critical in all these methods for the longevity of the circulation pump and other metallic components of a brick-lined pump tank, and is extremely critical to the longevity of alloy pump tanks.

Fig. 6: Hole in pump discharge pipe. Pump shaft column is also corroded.

Fig. 7: Pump discharge pipe corrosion.

Fig. 8: Stainless steel roof nozzle and pump support beam corrosion.

Technology providers normally specify PTFE encapsulated carbon steel pipe and solid PTFE tube for water dilution dip pipes. Some end-users have used high-alloy dip pipes as replacements only to find out they don't fare as well. This is the case of a metallurgical acid plant where the solid PTFE dip pipe was replaced with a high-alloy dip pipe one failure after the other. The high-alloy dip pipe lasted less than three months due to the frequent shutdown of the acid plant.

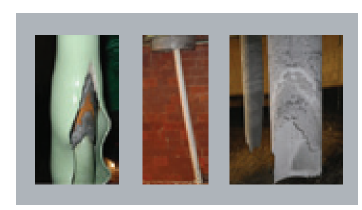

Fig. 9: Common dilution water dip pipes. PTFE encapsulated carbon steel (left), solid PTFE tube (middle), and Alloy (right).

Fig. 9 shows the failures of water dilution dip pipes. Once the dip pipe fails, water will free-fall on the acid bath and the weak acid mist that is created will corrode the roof and other metallic components of the pump tank. The weak acid layer that is also formed due to improper mixing will corrode the pump discharge pipe and shaft column and any other metallic components that are immersed in the acid bath at the operating liquid levels. We redesigned the dip pipe after careful analysis of the failure mode. A prototype has been in service for over eight years now without problems.

Lesson learned

Never change material of construction without having full understanding of the failure mode.

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