UNIQUE DISH BOTTOM DESIGN

EXTENDS ACID PUMP TANK LIFE

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INTRODUCTION

Sulfuric acid is by far the most widely produced industrial chemical in the world. It finds extensive use as one of the essential components in the wet process production of phosphoric acid. In fact, most major manufacturers of phosphoric acid have their own on-site sulfuric acid production facilities.

One such major producer is Texasgulf Inc., which utilizes phosphoric acid in the production of phosphate fertilizers, feed products and industrial phosphates. Four sulfuric acid plants, having a total production capacity of over 9000 tons per day, are currently operated at their Aurora, North Carolina manufacturing facility. Due to the highly corrosive nature of sulfuric acid, Texasgulf utilizes acid brick linings to protect the steel shell interiors of their large diameter, recirculation pump tanks. These tanks are used to hold 93% to 98% sulfuric acid while it is being pumped to the top of the absorbing towers. The acid then cascades down through the absorbing tower where it meets counter-current SO_3 gas. The acid, thereby, scrubs the gas before it leaves the plant.

PREVIOUS DESIGN

In two of the plants, a flat bottom brick lining design was used for corrosion protection of the tanks. Specifically, the following lining system was employed at Texasgulf, starting at the steel shell and working inward:

Layer	Description
1	Carbon Steel
2	Asphaltic Mastic Membrane
3	Tar Paper
4	Asphaltic Mastic Membrane
5	5 mil TFE sheet, lapped with Asphaltic Mastic Membrane
6	Asphaltic Mastic Membrane
7	5 mil TFE sheet, lapped with Asphaltic Mastic Membrane
8	Asphaltic Mastic Membrane
9	Course of 3-3/4" thick Acid Brick with Elf Atochem HB® Mortar as bed and side joints
10	Course of 2-1/4" thick Acid Brick with Elf Atochem HB® Mortar as bed and side joints

The brick performs three major functions. First, it serves as insulation to reduce the temperature at the brick/mastic membrane interface to below the maximum allowable temperature of the membrane. Typically, these pump tanks operate at temperatures as high as 250° F, while the softening point of the mastic is about 200° F. Second, while the acid permeates even properly designed and installed acid brick linings, the acid is stagnated at the brick/mastic interface so it does not flow freely and degrade the membrane by allowing fresh acid to come in contact with the membrane. Last, it serves as protection against mechanical abrasion and degradation.

However, the principal problem, when a flat bottom acid brick lining design is utilized, is the heaving or arching of the lining away from the tank bottom. This phenomena can be attributed to the irreversible growth of the brick as it absorbs acid. This linear brick growth, in some instances, can be as high as 0.16% . Over large diameters, the amount of compressive force generated by this outward movement can cause the brickwork or the whole lining system (including the steel) to arch upward. In either case, cracks develop in the brick lining, allowing the acid to penetrate and flow freely over the membrane surface. The fundamental benefit of acid stagnation is lost, and the acid eventually deteriorates the membrane and readily attacks the steel shell.

As a consequence, Texasgulf has had to reline the tank bottoms every 14 months, and replace the steel shell roughly every other relining, causing lengthy production downtime, and large maintenance and repair expenses.

DISH BOTTOM DESIGN

One solution to this problem is to create a dish bottom which will confine the growth of the brick by translating any compressive force outward against the bottom of the tank. This makes it virtually impossible for the brick lining to heave. Initially, these dish bottom designs were quite expensive, as the steel shell had to be specially pre-fabricated into a dish design. However, engineers at Elf Atochem North America's Corrosion Engineering Department developed a method of producing a dish bottom on top of an existing flat steel tank bottom.

The key to this technology is Elf Atochem's TUFCHEM® Silicate Concrete - Foundation Grade(FG); a wholly acid resistant, potassium silicate bonded concrete, which can be cast into a dish shape by utilizing proven installation techniques. Since this method involves building-up the tank bottom with the silicate concrete, the tank capacity will be slightly decreased. Therefore, before any installation begins, capacity calculations should be made to assure that the tank has adequate drainback capacity when the plant is shut down.

DISH BOTTOM INSTALLATION

Currently, Texasgulf has dished the bottoms of both the interpass absorbing tower (IPA) and final absorbing tower (FAT) pump tanks in the two plants with flat bottom pump tanks, by using TUFCHEM® Silicate Concrete - FG. The installation procedure employed was derived from cumulative experience and knowledge gained from the study of similar installations. The following detailed procedure was carried out for one of the IPA pump tanks having an inside tank diameter of 18 feet:

- The old lining system was removed to reveal the steel bottom. The bottom was then sandblasted to a commercial finish.

- Approximately 11-1/4" of sidewall brick and membrane were removed from the bottom up. The remaining sidewall brick was supported with wooden blocks and wedges.

- Asphaltic mastic membrane was trowel applied to the exposed portion of the steel sidewall and onto the tank bottom within one (1) foot of the perimeter.

• A 5 mil TFE sheet was laid on top of the membrane while the membrane was still tacky to form a corner membrane.

• A pre-fabricated, butt fused, 20 mil thick FEP disk having a diameter equal to that of the tank was rolled out on top of asphaltic mastic membrane as it was being applied.

• Another 5 mil TFE sheet was installed on top of the 20 mil disk with asphaltic mastic membrane to form another corner membrane.

• Acid brick was then installed as shown in Figure 1 to create a notched sidewall which the silicate concrete would later fill.

• A pre-cut plywood screed arm was affixed to a central pivot arm. The pivot arm was supported from the top of the tank, allowing the screed arm to hang 2-1/2" above the center point of the tank bottom. The dish radius was calculated using the equation R_{dish} = 5.6 x (Inside Tank Diameter). This determined the curvature of the screed arm, and the thickness of the silicate concrete at the sidewall.

• Elf Atochem's TUFCHEM® Silicate Concrete - FG was mixed continuously in two mixers to give a constant supply.

• The TUFCHEM® Silicate Concrete - FG was lowered into the tank in buckets and then cast into place. The outer diameter was built-up first, allowing the concrete to fill the notched sidewall. Then a pie shaped section was built-up to slightly below the height of the screed arm.

• Another layer of concrete was applied, and then hand screeded with the pivoting arm to obtain the dish profile.

• Subsequent pie sections were produced in succession, until the entire dish bottom was formed with the acid resistant concrete. The dish had a minimum thickness of 2-1/2" at the center and a maximum thickness of approximately 7-1/2" at the sidewall. Since the concrete was continuously lowered into the tank, and no seams were involved, the bottom was essentially a monolithic pour.

• A course of 3-3/4" thick acid brick was laid over the concrete, using Elf Atochem's acid resistant HB® Mortar as bed and side joints. The bricks were laid in quadrants, employing a broken bond pattern. A 2' x 2' x 8" thick splash pad was formed beneath the acid return line by laying the 3-3/4" x 2-1/4" x 8" bricks on end.

CONCLUSION

All four tanks at the Texasgulf facility with the dish bottom design have recently been inspected and were found to be in perfect operating condition. The operating life of tanks that have been relined using this technique has yet to be established, as tanks with proper dish bottom installations dating as far back as 1984 are still in operation.

On a cost comparison basis, additional expenditures incurred with dish bottom design are from the material cost of the TUFCHEM® Silicate Concrete - FG and the labor cost involved in casting the dish bottom. However, the increased operating life of the tanks, by far, outweigh any installation cost increase. Furthermore, production downtime is greatly decreased by not having to replace the lining every 14 months.

According to Kevin Bryan, Texasgulf maintenance engineer, "The technical assistance of Norm Huxley and Charlie MacAdams, of Elf Atochem's Corrosion Engineering Department, was instrumental in developing the plans for the installation. Carl Horecky of Interep Inc. (an Elf Atochem distributor) was hired as a consultant for the dish bottom installations in the first plant. Carl had been involved with previous installations, and together with John Artis of C.E. Thurston, who performed our installation work, we were able to refine the installation techniques."

Mr. Bryan went on to add, "This was the first time that a fused FEP disk was used over the asphaltic mastic membrane. The disk eliminates the potential leak paths which were present with the old lapped edge technique. The dish bottoms have solved a major maintenance problem at Texasgulf.

These four dished bottom installations at Texasgulf's Aurora facility are shining examples of how superior materials technology and innovative engineering by Elf Atochem's Corrosion Engineering Department combine to solve complex corrosion problems in the chemical process industry.

FIGURE 1
Corner Profile for Dish Bottom IPA Pump Tank