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Sulfuric Acid TODAY

Developing a Repair Method for Leaking Acid Towers

by Matthias Walschburger, Knight Material Technologies

During the Sulphur conference, in Berlin, in November 2012, Knight Material Technologies (KMT) was approached by Rick Davis, President at Davis & Associates Consulting. Rick wanted to know if KMT had a repair method for a leaking absorption tower that had an uncontrolled energy release (hydrogen explosion) earlier in 2012. The tower had started leaking only weeks after the start-up of the plant. The owner, Noracid, wanted a temporary solution until the installation of a new brick-lined tower could take place, which was planned several months down the road.

KMT met with the original equipment designers during the conference to gain some insight into the lining design. All absorption towers for this acid plant were designed without any type of acid-resistant membranes to protect the steel shell, such as Pecora Mastic, Rhepanol ORG or PYROFLEX® acid-resistant sheet lining. The original designers believed that only a layer of ceramic paper soaked in potassium silicate solution would suffice for this purpose.

In further discussions following the meeting, it was disclosed that leakage of acid in one of the heat exchangers was caused by an uncontrolled energy release. During the start-up of the acid plant, the instruments in the control room never showed a decrease in pH value in the cooling water circuit of the heat exchanger, and therefore, the plant never would have shut off.

KMT explained to the OEM engineers the idea of injecting resin into the interstice between the brick and the steel shell of the intermediate absorption tower that had suffered the damage. At the time, they were not convinced that an injection of resin could be the solution. They were concerned about the level of acid resistance of the resin in that harsh an environment and the uncertainty of how the interaction of the steel shell and brick lining with an intermediate layer of hardened resin would work. KMT's take on the structural implication was that the injection material, once solidified, would create a combined structural system with the brick. As the injection would be executed under ambient temperature, the void between brick and steel would be the maximum and filled with resin, leaving very little or no space between the shell and brick. When heated up under operation, the thermal expansion would create an annular compression load on the brick and a radial load from the brick on the shell, closing any void. This would reduce the possibility of acid flowing in this interstice and cause damage to the shell.

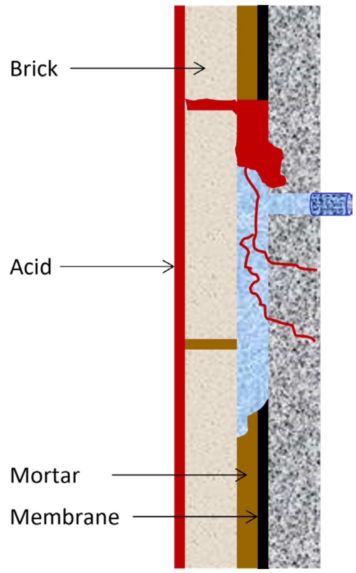
To test the extent of the damage, Noracid performed several plate thickness measurements and detected a reduction in steel thickness in several areas of the steel shell. In the areas where they detected reduced thickness, they welded steel plates over the thinning shell to reduce the possibility of leakage and further structural instability. While the structural stability was less of a concern, the leaks continued, so this solution was viewed as a limited success. Noracid had just finished the construction of the acid plant the year prior and had already performed several repairs to the acid plant to get it running. Now they were under pressure to prove to their shareholders that they could expect production and associated revenue as soon as possible. This meant that Noracid was in dire need of a permanent repair as soon as possible, and finding a solution had to start immediately.

KMT's sulfuric acid specialist, Matthias Walschburger, had previously performed similar injections in Turkey, Colombia, and Mexico. He was confident that with the right resin design, KMT could fill the voids created by the acid flowing in the gap between the brick and steel, stopping the degradation of the steel shell.

Regarding optional repairs to towers, which range from the welding of a steel box to the outside of the shell and filling it up with potassium silicate to an injection with Pecora Mastic through injection ports, several shortcomings for these techniques could be visualized:

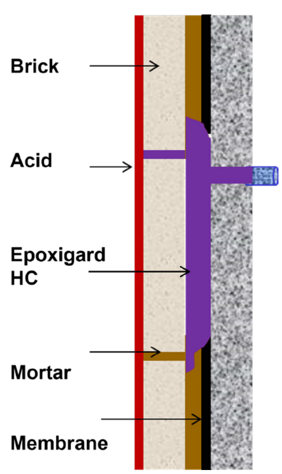
- Trying to stop corrosion/degradation of the steel shell by filling a box weld to the tower's exterior with potassium silicate and hoping that gravity would make the potassium silicate flow into the gap created by corrosion would not work. The silicate would react with the acid, hardening immediately. The problem is the silicate can't reach the inside of the tower. Instead, it creates a patch on the outside, and the acid begins flowing in that space, damaging the steel shell around the corroded hole even more.

Pecora Mastic Injection

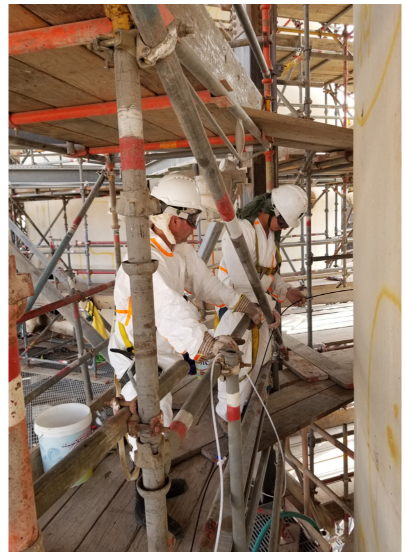


- Another alternative was to inject Pecora Mastic into the void. This needs to be done at a high temperature with solvents present to dilute the Pecora to achieve the required low viscosity to penetrate the narrow space between the steel shell and the brick. The inherent problem of this type of injection is that solvents and flexibilizers - VOCs - evaporate, leaving small evaporation channels inside the resin. This hasn't solved the issue as the acid can flow back to the steel shell, continuing to deteriorate the steel. Therefore, this strategy will work only for a limited period. Furthermore, during wind and seismic activity, if the injected material starts cracking due to the loss of flexibilizers, as is common in Chile, those cracks can contribute to a quicker propagation of the acid attack to the shell.

EPOXIGARD HC Injection



KMT needed to find a type of resin for its injection system which would not result in the shortcomings of previous techniques - the acid hardening injection materials immediately or leaving evaporation channels when fully reacted and hardened. The ideal resin needed to stay fluid when coming into contact with acid, stay elastic, not leave evaporation channels after hardening, and also not crack under load. KMT would use the reaction of the epoxy resin turning red when contacting the acid as an indicator to control the progress of our injection when emanating from aeration holes and continue injecting resin until it emerged clear from this aeration hole. This means the void has been filled in its entirety. Due to the low viscosity, the resin will flow in every direction where it finds a path, and it is nearly impossible to limit the expansion to a predetermined section of the tower. That is why we recommend injecting the whole vessel when using this repair method. The only issue uncovered was after injecting some towers, the resin that got into the tower's interior and into contact with the freshly produced acid would change the color of the acid to a light pink. However, the coloring would not affect the quality of the acid produced and would disappear after several days of operation.



KMT started looking into possible resin formulations available on the market but was unable to find one that could fit our requirements of low viscosity, 100% solids with no VOCs, and sufficient acid resistance. After spending significant R&D time testing various formulations to address each of the issues the customer described, we commenced testing a series of resin mixtures we had already developed for high chemical resistant secondary containments. From there, we modified these to achieve the low viscosity required and developed a proprietary epoxy resin with low viscosity, high chemical and heat resistance, and zero VOC as injection material. This resin would lose little, if any, of its components and would not retract or create new flow channels due to evaporation of VOCs, therefore creating a more durable chemical barrier.

While developing the formulation, KMT also needed to create the technology to deliver this new formulation into the gap between the brick and steel without causing additional damage to the brick lining, as other methods have done in the past. Therefore, we developed a delivery system utilizing a static mixer and an appropriate injection nozzle system to push the resin into the voids inside the tower with high enough pressure to get the material flowing into the void. With the right combination, the formula would permeate into the fractures or cracks of the brick or mortar joints while avoiding a pressure peak that could damage or dislodge the brick lining.

The traditional way of pre-mixing a two-component resin product and injecting it via a pressure pot was a possibility but having to deal with a short resin gel time mixing and injecting could only be done in small batches. This would result in additional material loss during the injection process and extend the shutdown time unnecessarily. The challenge was finding a delivery system that included a two-component injection pump with enough throughput volume to shorten the shutdown time.

KMT started injecting its materials into the towers with great success while continuing to look for ways to improve the injection system. We realized that the mixing ratio utilizing an electric injection pump was inconsistent due to the breakage of actuating springs in the ball-valves, which needed improvement. While keeping in mind the need to adequately control the injection pressure to be less than two (2) bar going into the tower, we started to investigate different injection equipment available on the market. We found a pneumatically driven injection pump that was able to control the injection pressure, deliver an adequate injection volume, and have the advantage of handling the resin to hardener ratios consistently.

KMT's first approach to deliver resin into the void area of the towers used packers – a hollow threaded tube with a rubber hose mantle around a set of washers and screws at each end that, when tightened, compresses the rubber hose forcing it to expand into the bore hole. During subsequent procedures, we concluded this solution was more effective for thicker steel shells. The packer could have an adequate thread count for a sufficient grip in the shell so it would not be ejected during the injection. However, with the thin steel shells where the acid plants were designed, we had to go to a solution with a threaded delivery port.

Noracid was keen to have the material injected into their tower quickly to meet their tight deadlines, so KMT airfreighted the new product into Chile before the end of 2013.

Noracid had already built the scaffold around the tower in looking for other ways to save time. Once on-site, KMT was ready to begin sounding the tower, marking the hollow regions behind the steel shell, and drilling the injection ports. The injection process started from the bottom of the tower, working to the top. In ten days, we had filled the voids previously detected by the sounding, and the plant started up shortly thereafter. With great anticipation, the plant personnel waited to see how the resin would perform and for how long, as the tower had deteriorated so badly.

There will always be some areas the resin will not reach during the initial injection, but newly found hollow spots and/or leaks can be easily repaired during a follow-up visit. Noracid asked KMT four months later to perform some minor touch-up work at a few injection points, which we were able to complete in two days.

To date, we have not injected a tower under running conditions. We determined that it would be too dangerous for the operators to perform an injection as acid could come out at high pressure when drilling the ports into the shell, risking serious harm. Towers working under negative pressure – suction – may be injected. However, due to the associated safety risks, we will not perform this task. With safety being the highest priority, it is always recommended that the towers are idle during injection activities.

News of this new repair method traveled quickly around the acid-producing companies with acid plants in Chile, including Codelco Ventanas, who had contacted KMT the same year requesting an injection repair. The following year, CodelcoAltonorte were among some of the customers asking for similar injections. Other markets noticed the excellent results and development work KMT had performed, and this technology expanded into the pulp and paper industry, the phosphoric acid market, and other mixed acid applications. We have performed this work in multiple countries around the globe, including Chile, Mexico, Korea, the Philippines, Australia, Peru, Brazil, and the USA, to name a few.

Three years ago, we were asked by the Chilean paper mill CMPC to inject their two bleaching towers. This application required a different resin-based system - a Vinyl Ester for which KMT had been completing research and development work for implementation. We were requested to inject two bleaching towers, 7.3 m in diameter by 60 m in height. Due to the short turnaround time given, we set up an injection schedule using four injection pumps working in parallel. Due to the high volume to be injected, this job had been divided into two separate injections executed over two planned turnarounds.

In conclusion, a theoretical short-term repair to get a client a few months of serviceability for a tower that experienced a significant event (uncontrolled energy release) has now been in operation for over eight (8) years. In fact, the tower is still in operation, being monitored yearly, and shows no sign of deterioration that would warrant tower replacement.

During the Sulfur Conference 2019 in Houston, we met with Noracid plant manager, Cristian Roempler, and one of the owners. During this conversation, they confirmed KMT's solution has been more than what they had expected in the beginning and has saved them the installation of a new tower. We sent a questionnaire to Noracid to gain additional insight into the performance of our injection solution.

KMT asked the Noracid team the following questions:

- ***Had Noracid considered an alternative repair method before contacting Knight Material Technologies?***
  - Noracid: "We evaluated a partial exchange of the brick lining and the steel shell. We welded several patches on the outside of the tower, which in this case was not a problem as the acid protection installed was a ceramic paper soaked in potassium silicate. These we tried to backfill with mastic.

    During the CRU Sulfur Conference in Berlin, we found out about this concept or idea of doing a resin injection into the tower and got excited about this alternative. Further down the road, we implemented it during the upcoming main outage at the beginning of the year 2014.

    In the beginning, we were not sure about the outcome as there was not much of an experience using the injection method, but under the alternative to replace the tower or giving it some additional months of service before deciding to exchange the tower, we went with this strategy.

    The injection was performed with no setback, and we were able to start up our plant.

    KMT always were following up on our requests and delivered a well-prepared service which over time and with every injection cycle, became more effective in dealing with new leaking points.

    The tower is still in service after 8 years without any major inconveniences and we have done steel shell thickness measurements over this period and have not detected any loss in thickness so far.

    We never expected this repair to be a definitive solution to our problem, but it turned out to be a definitive repair in our case. We had expected this to be a short interim solution for us to build a new tower. Over the years, Knight Material Technologies KMT has become more efficient in implementing improvements to the technology, and we would like to recommend to them to find a more definitive solution to the final sealing of the injection holes."

- ***Have there been any major earthquakes in the Mejillones area which may have affected the performance of the tower?***
  - There have been several earthquakes, but without major repercussions related to the tower operation. We have not had any major earthquakes so far and no adverse effects either.

Seeing the success and the need for enforcing tower strength, KMT has been developing more sophisticated injection ports and final sealing methods to provide continuous improvement to the tower injection process and performance. For more information, contact Matthias Walschburger at matthias.walschburger@knightmaterials.com. For information on Knight products and solutions, visit www.knightmaterials.com