

Oil and gas fired power station in Saudi Arabia uses the Pennguard® Block Lining System in six free standing steel chimneys for long term corrosion protection



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with regards to the design and application of the Pennguard® Block Lining System in various markets. In October 2012 Gary joined the Hadek Business Development team where today his focus remains on the development of business within the North American market.



Picture 1 - View of 6 carbon steel flues internally lined with the Pennguard® Block Lining System

In 2011, The Dow Chemical Company and Saudi Aramco formed a joint venture known as the Sadara Chemical Company. This joint venture is currently completing the final stages of the Sadara chemical complex (picture 1).

Once the project is completed in 2016 this fully integrated, highly efficient 26-plant complex will make up the worlds

largest petrochemical facility ever built in a single phase.

Fluor Corporation was awarded the EPC contract for all of the utilities at Sadara, which included a 6 x 80 MW oil and gas fired power station.

In terms of the design and construction of the six boilers and the air quality control system Fluor selected Alstom and Cerrey SA de CV. For this portion of the project Cerrey was tasked with building the boilers while Alstom supplied the Selective Catalytic Reduction (SCR) plants required for NOx emissions reduction as well the Flue Gas Desulphurization (FGD) plants needed for Sox emissions reduction.

For this particular project Alstom had proposed its New Integrated Design (NID) technology, which is a proprietary, semi-dry FGD technology. The treated flue gas at Sadara has an exit temperature of around 80°C and is released into the atmosphere through the use of six separate 76-meter high chimneys.

Because of the design height, the engineering and design team responsible for the chimney portion of the project found that constructing these six chimneys as free standing steel flues would be most efficient. However, in order to protect the steel chimneys against any risk of acid dew point corrosion, the designers chose to internally line the chimneys with a Pennguard® lining system using a 51mm thick Pennguard® Block type 55.

In order to properly execute this portion of the project Fluor once again chose two companies to handle each very specific task. Nasser S. Al-Hajri Corporation (NSH) oversaw the construction of the Generation Units as well as the freestanding steel chimneys. The Pennguard® installation was handled by Refractories & Chimneys Construction Company (Rcc) who worked hand in hand with the Hadek Protective Systems QA Inspection team to ensure a high quality, long lasting application.

Technical advantages

Though each Pennguard® installation is somewhat different in terms of design and construction there are several constants that remain technical advantages for each project.

The Pennguard® Block is made of a closed-cell borosilicate glass which is both lightweight (under 3 lbs / sqft.) and chemically resistant to sulfuric acid over a wide range of temperatures and concentrations. Coupled with the Pennguard® Adhesive Membrane the installed lining system has great insulating properties and acts as an impermeable barrier between the substrate and acidic flue gas, eliminating any risk of corrosion.

For the lining of the Sadara chimneys there were several key needs that the client needed to meet in order to ensure long term success of the units. These include:

- Cost effective solution to the need for corrosion protection
- A Product that minimizes timeline impact for construction
- Long term, proven solution to protect their chimneys for years to come

With that said, the Pennguard® Block Lining System proved a perfect solution for the Sadara Chemical Company's needs.

By installing Pennguard® to the interior surface of the six freestanding steel stacks (picture 2) the owner eliminated the possibility of corrosion by isolating any contact of sulfuric acid or chlorides from the substrate itself.



Picture 2 - Internal view breaching and target wall area after Pennguard® installation

One other major advantage to the system is its ability to act as a thermal insulator. This quality eliminates the need for costly and often problematic exterior insulation.

The major issue with exterior insulation is that it needs to be protected by metallic plating which, through the influence of rain, wind and thermal cycles can become leaky. Once water enters into the insulation and is trapped against the steel substrate a severe corrosion hazard occurs that can ultimately threaten the structural integrity of the steel chimney itself.

Pennguard® lined steel chimneys avoid this risk, using only an external coating system to protect the structure against the elements. A modern, well-applied coating can protect these chimneys over many years, quite possibly for the life of the chimneys themselves.

Installation details:

This portion of the paper will outline the details of the construction and installation as performed by Nasser S. Al-Hajri Corporation (NSH), Refractories & Chimneys Construction Company (Rcc) and also the Hadek Protective Systems QA Inspection team.

As with any major project there is a certain level of “pre-planning” that must be in place in order to make operations run smoothly. The Sadara project was no different. A great deal of time was taken before hand in order to plan for any foreseeable issues that may arise from various controllable circumstances. This includes such things as:

- Climatic conditions
- Staging of materials
- Workflow application stages and milestone planning
- Quality Control reporting

Climatics:

Saudia Arabia, as a whole has a very warm climate. The region of Jubail, located near the Persian Gulf, where the Sadara project was executed is considered to be a particularly hot area within the country. For this reason a great deal of thought was put into how the climatic conditions for the project were to be handled.

For this reason the temperature sensitive applications which include priming and Pennguard® Block application were conducted during the evenings once the sun had set and temperatures became more manageable. Rcc would also make use of an industrial air conditioner throughout the project. By piping cooler air into the applicable areas this helped in minimizing the possibility of any work stoppages due to exceeded temperature limits. Also, along with the use of the previously mentioned industrial cooling units, Rcc blanked off the top of each flue in order to contain the cooler air within the chimney.

The climatic conditions during each stage of the application process were carefully documented using an electronic gauge (Elcometer 319) designated to measure air temperature, substrate temperature, relative humidity and also the dew point. These statistics were placed within the Hadek daily report which outlined any and all pertinent information with regards to the application of the Pennguard® Block Lining System.

Staging of materials:

As with many products it is important to be aware of temperature ranges that are considered acceptable for storage and use. With this in mind the decision was made to store temperature sensitive materials as Pennguard® Block Primer - Parts A & B, Pennguard® Adhesive Membrane - Part A and Urethane Asphalt Hardener - Part B in air-conditioned containers on site. Once materials were required they were then brought to the application area by truck in order to ensure that the product remained unaffected by higher than normal temperatures.

Workflow and milestone planning:

Because of the large size of this project it was essential that careful considerations were made in order to maintain a proper

flow of work and milestones were met in a timely manner.

For each of the six chimneys a set of four protocols were written in order to accept various portions of the lining under the Hadek Warranty. These include:

- Protocol 1: Acceptance of the steel substrate
- Protocol 2: Acceptance of the blasted steel substrate
- Protocol 3: Acceptance of the primed steel substrate
- Protocol 4: Acceptance of the Pennguard® lined steel substrate

Below you will find a more detailed description of the requirements and the process to obtain said requirements during the Sadara Project.

Protocol 1: Acceptance of the steel substrate

Each of the six chimneys constructed for the Sadara project were built on ground level in sections of varying length. All exterior equipment such as ladders, lighting and other appendages were installed at ground level before erection. Once completed the sections were lifted and using a large industrial crane and then welded to their adjoining section (picture 3).



Picture 3 - Erection process of carbon steel flue prior to welding

For this portion of the protocol section Hadek requires that all welds shall be continuous and any weld splatter, slag and anchor welds shall be removed and ground flush with the parent

metal. Gross pinholes, pits, blind holes, porosities, undercutting or similar depressions should not exist in the finished surface of the weld before or after cleaning. Also we required that all plates should be properly aligned so to minimize any offsets which would hinder the lining system from laying flush. Once these requirements were met the next stage of application was then ready to take place.

Protocol 2: Acceptance of the blasted steel substrate:

For this portion of the installation process it was necessary to install a suspended platform or “work deck” in order to have full access to the internal surface of each 76 meter high chimney.

Structural beams were placed at the top of the chimney in order to provide a sound structural base to hang the cables necessary to move the deck vertically up and down through the use of Tirfors. There were a total of 4 manually operated Tirfors installed to each platform, which also included the use of a stop block for added safety. The flooring of the platform consisted of a steel structure with wooden beams and boards to allow for a flat surface to work from.

In order to access the platform a “man cage” was installed which would allowed travel to and from the deck for not only



Picture 4 - Photo of man cage used for transporting men and material during application

the application teams but also for any material necessary for the application process (picture 4).

The man cage was operated using a winch system located on the exterior of the chimney. A steel cable ran the height of the chimney and then through the structural beams at the top where it ran directly down the center of the flue. This was controlled using several video monitors, an operator handling the winch motor and then a worker with radio giving verbal commands once the man cage neared the working platform.

Once the platform was installed blasting activities could begin. Once again there are several standards that were necessary to attain before clearance of the protocol would be allowed. With regards to blasting, Hadek requires a near white metal blast of Sa 2.5, ISO 8501-1:2007.

After blasting was completed and accepted by the on site Hadek QA Inspection representative priming would then take place during the evening. The surface must then be clean and dry with a temperature of between 10°C - 32°C (50°F - 90°F). Also, it is necessary that the steel surface was kept 3°C (5°F) above the moisture dew point.

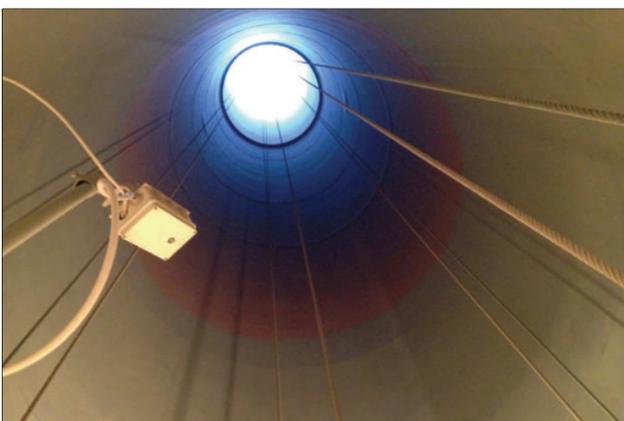
Protocol 3: Acceptance of the primed steel substrate

In order to prohibit the formation of rust bloom prior to the application of the Pennguard® Block Lining it was necessary to apply the Pennguard® Block Primer to the freshly blasted steel substrate (picture 5).

This was accomplished through the use of rollers and brushes. Once the substrate was free of any debris or foreign matter the Pennguard® Block Primer Parts A & B were mixed and placed within buckets where they would be applied using brushes and rollers. The desired thickness of the primer was as follows:

- Wet Film Thickness (WFT): 5 mils – 10 mils
- Dry Film Thickness (DFT): .6 mils – 1.1 mils

A thorough inspection of the previously primed areas would be conducted at the start of each shift prior to blasting commencing on a new area. Once accepted the next stage of activities would then commence.



Picture 5 - Comparative view of blasted SA 2.5 carbon steel and previously blasted/primed carbon steel

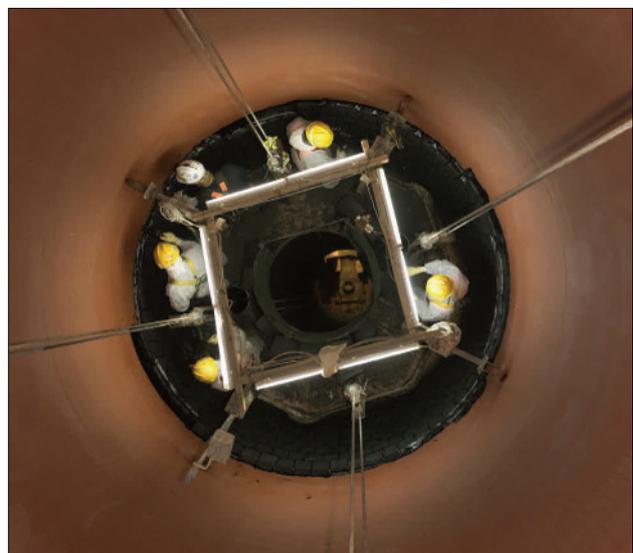
Protocol 4: Acceptance of the Pennguard® lined steel substrate

The final step of the lining process is the installation of the Pennguard® Blocks with the use of the Pennguard® Adhesive Membrane. For this portion of the lining process, Pennguard® Blocks were staged on the working platform in order for the applicators to have proper access and stock for optimum productivity. In each chimney a team of four applicators and one helper made sure there was a steady supply of material while continually keeping clean the work area.

The Pennguard® Adhesive Membrane was mixed by hand at the base of the chimney using a heavy-duty drill with a Jiffler DC312 mixing blade.

A sample was then taken from each mix and placed on a verification card in order to assess the cure. These cards were placed in a designated area and then inspected during the following shift to ensure that all mixes had cured properly.

During the installation process, the four experienced applicators worked in teams of two, with one applicator spreading the mastic onto the steel substrate and then placing the Pennguard® Blocks his partner had “buttered” into place. The Pennguard® Block was then slid into position to remove air from behind the block and to promote a proper bond to the substrate and any adjoining blocks. Once the Pennguard® Block is in place the joints are struck smooth in order to leave a flat surface (picture 6).



Picture 6 - Top view of application team on working platform during Pennguard® installation

Hadek QA Inspectors remain on the platform during application in order to ensure proper joint thickness, to make sure that all standards in regards to application, including a double buttering technique, are being met. Once again these points are noted and provided in the daily report for each given shift (picture 7).



Picture 7 - Hadek Technical Services inspector documenting climatic conditions during application

Once the application has been completed to the top elevation the final step in the application process is for Hadek personnel to perform the final inspection. This will ensure the following:

- Verification that all Pennguard® Adhesive Membrane has cured
- Verify that all joints are without voids or craters
- Final verification that there are no mechanical damages to the lining

Once all points have been verified Protocol 4 will be accepted and the lining is complete.

QA Inspections and reporting

During all phases of surface preparation, primer application and lining installation, experienced Hadek QA Inspectors were active on the Sadara site to technically support NSH and Rcc, and to ultimately verify that work was done in accordance with technical requirements (picture 8).

The work of Hadek's QA Inspectors began before the actual start of the work, as the contractor was setting up his equipment and training his teams. By understanding the requirements and using Hadek's practical experience gathered over many years, the contractor was able to ensure that his teams would be efficient and effective. During most phases of the chimney lining project, two Hadek QA Inspectors were present on site.

The Inspectors would personally check each area that was grit blasted, prior to primer application, and check the area once again when the primer had been applied. The Inspectors were present virtually full time as the Pennguard lining itself was being installed, monitoring installation technique as well as the joint widths within the installed lining.

Once the lining had been completed, Hadek QA Inspectors performed one further inspection, the "Final Inspection" and with this completed, the work platform could be carefully removed from each of the lined chimneys.

All of the QA Inspector's observations and measurements, as well as the various Acceptance Protocols, were included in the



Picture 8 - Verification of joint thickness during final inspection of Pennguard® lining

so-called Manufacturing Report, a document that confirms to the Owner and the Contractor that the Pennguard lining has been installed in accordance with all requirements and is ready for many years of service.

The Contractor planned his work on the Sadara chimneys carefully and by being very efficient, he was able to reduce the number of QA Inspector man days on the project from 294, as initially estimated, to 178.

Conclusion

The installation of Pennguard linings in six free standing steel chimneys at Sadara was a commercial and technical success.

The Pennguard Block Lining System, which was in this case used at a thickness of 54 mm, will offer a service life exceeding 30 years. Due to the strong insulating properties of Pennguard linings, these chimneys could be built without any external insulation system, eliminating a significant vulnerability from these chimneys, and likely eliminating future maintenance and repair. The Pennguard linings were installed under the supervision of Hadek's QA Inspectors to ensure that this specific installation would have a very high quality level and will live up to the full potential of the lining technology. The contractor planned his work methods, manpower and equipment carefully and was able to perform all works efficiently, on time and within budget.



Picture 9 - Exterior view of free-standing steel flues near end of project