

Operating performance of Pennguard® lined steel flues in FGD Wet Stacks in the United States and Canada



Ruud van Noort

Rudy joined Hadek Protective Systems in 1992 and has been involved in numerous Pennguard Block Lining System installations worldwide as QA/QC supervisor, project manager and currently holds the position of Quality Assurance manager / Manager Technical Team in the Hadek Protective Systems, Inc. office, in Pittsburgh, PA. His background / education is in coating and lining technology. Before joining Hadek, he held laboratory positions with Hercules BV (scope of work; water soluble polymers in coatings) and Sigma Coatings BV (scope of work; 2-component flow coatings and coal tar epoxies) in The Netherlands.

Introduction

The use of Wet Flue Gas Desulfurization (WFGD) plants has become common for both new and existing coal, oil and lignite fired power stations in North America. The great majority of power plants using WFGD operate their chimney as an “FGD Wet Stack”, carrying desulfurized, unreheated, water saturated flue gas.

The operating environment within an FGD Wet Stack is aggressive. Due to the saturation of the flue gas with water, there is a constant formation of condensate on the chimney (flue) walls. Due to the presence of residual sulfur trioxide in the flue gas (SO₃), this condensate is comparable to a dilute sulfuric acid, with a pH value of around 1.

The Pennguard Block Lining System is based on blocks of closed celled, cellular borosilicate glass (“Pennguard Blocks”) that are applied to a substrate using a flexible, acid resistant adhesive (“Pennguard Adhesive Membrane”). From the earliest days of WFGD retrofits in North America, Pennguard linings have been used successfully within the WFGD outlet ducts running between WFGD absorbers and chimneys.

Based on their proven success in water saturated flue gas downstream of WFGD, as well as on their favorable properties related to condensate reentrainment, a number of newly built FGD Wet Stacks in the United States and Canada have been equipped with Pennguard lined steel flues.

This paper will describe the operating performance of Pennguard lined steel flues in FGD Wet Stacks of selected power stations in the United States and Canada. In each case, Hadek

technicians visited the subject power stations and interviewed plant personnel, performed inspections if possible and reviewed documents if available.

The case studies are related to the following power stations:

1. Cole-son Cove, St. John, NB, Can-ada,
2. Spur-lock Power Sta-tion, Mays-ville, KY,
3. Mayo Power Sta-tion, Rox-boro, NC,
4. Power Plant in Texas.

Case 1: Coleson Cove Generating Station, St John, NB-Canada

The Coleson Cove Generating Sta-tion (picture 1) is owned and operated by New Brunswick Power and consists of 3 units of 350 MW each. In conjunction with the retrofit of a WFGD plant in 2004, a new chim-ney with 2 steel flues was constructed and a 2" thick Pennguard Block Lining System was installed to protect the steel chimney flues. The lining system was installed in phases between March and Septem-ber 2004.



Picture 1 - Coleson Cove Generating Station, Canada

The Pennguard lining in both flues starts at EL. 196'-9" and terminates at EL. 584', a total of approximately 56,000 ft² steel surface is protected by the Pennguard Block Lining System (see figure 1).

At several locations throughout both flues, Liquid Collection systems have been installed to trap the condensate and move it out of the chimney flue. The outside of both flues is not insulated as the Pennguard lining system is not only a corrosion barrier, but also a strong thermal insulator. The chimney flue gas temperature within both flues is between approximately 130°F, the flue gas velocity is approximately 60 ft/sec.

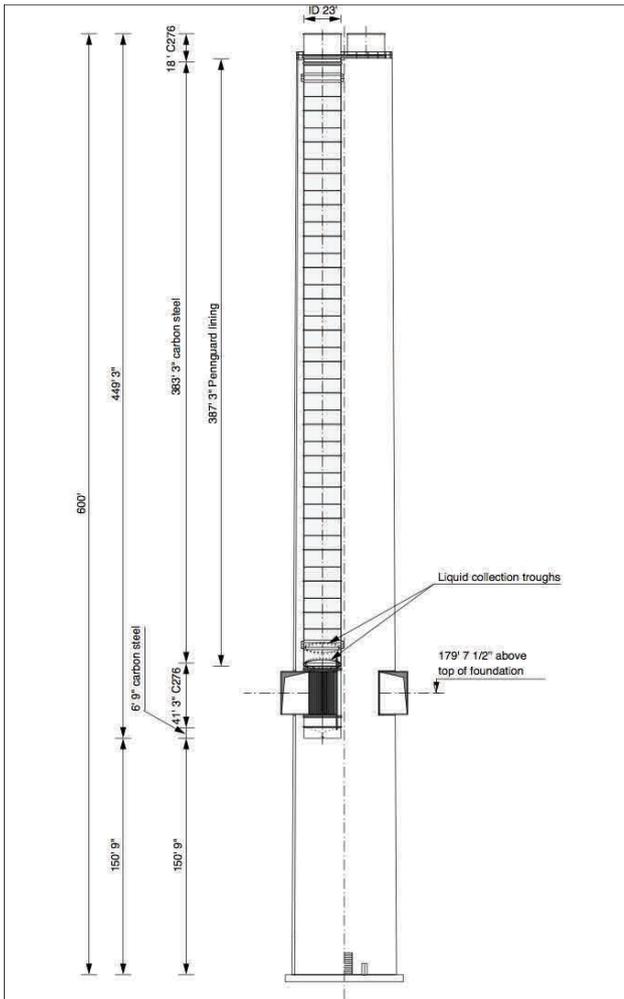


Figure 1 - Chimney layout

Over the years, several visual inspections were carried out to monitor the performance of the Pennguard Block Lining System. The inspections showed that the Pennguard lining system fully protected the steel flues from corrosion, while acidic condensate was running down the insides of the flues continuously.

The Coleson Cove plant has to deal with some severe weather conditions during winter but both units have not had any repairs over the last ten years. Plant personnel is very happy with the maintenance free performance of the lining.

Pictures 2 – 4 detail the performance of the Pennguard Block Lining System after being in service for about 10 years.

The Pennguard lining technology offers the possibility of another, unique inspection method for steel flues that is applied during power plant operation. This inspection method is based on Thermal Imaging technology and it makes use of the fact that any significant defect to a Pennguard lining in a chimney would show up as a warm spot on the outside of a chimney flue during plant operation. Even though the temperature difference between such a warm spot and the surrounding flue surface would be small and it would not be



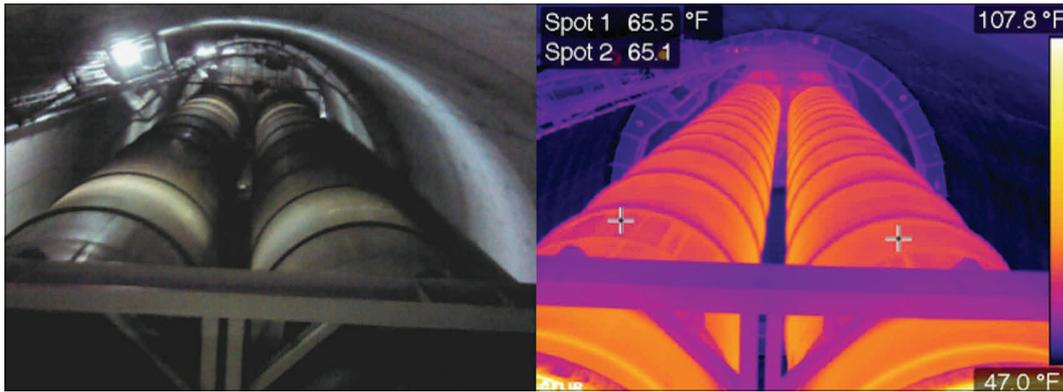
**Picture 2 - Coleson Cove Power Station:
top view of the Pennguard lining system in one of the
2 flues after being in service for 10 years**



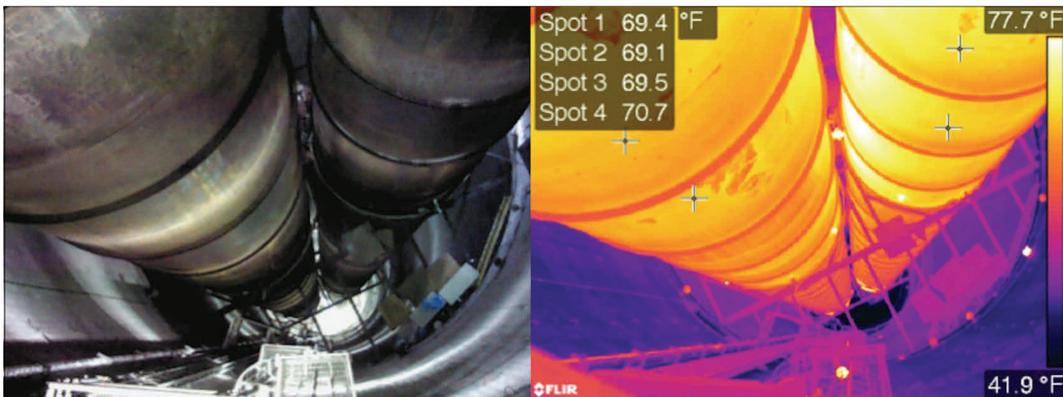
**Picture 3 - Coleson Cove Power Station:
Condition of the Pennguard lining system in detail**



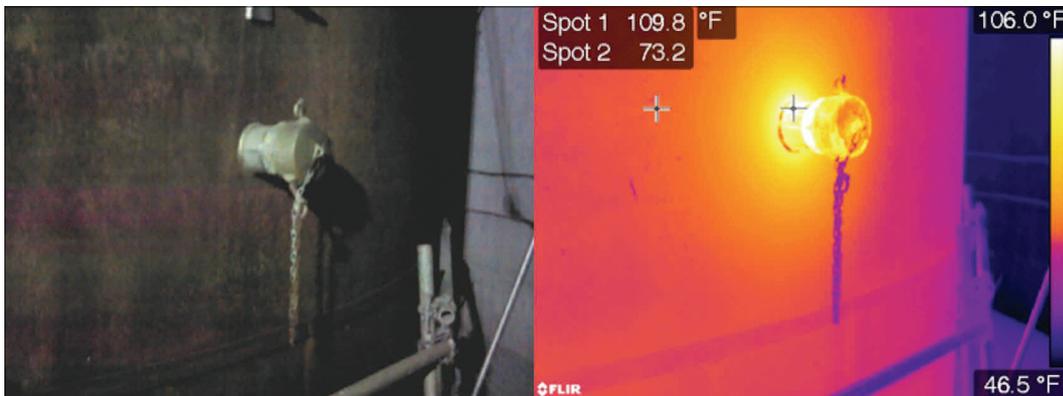
**Picture 4 - Coleson Cove Power Station:
This picture is showing the Pennguard lining system as
well as a liquid collection gutter detail
after 10 years of operation**



Picture 5 - Coleson Cove Power Station: Overview of the 2 steel chimney flues



Picture 6 - Coleson Cove Power Station: Even heat distribution looking downwards



Picture 7 - Coleson Cove Power Station: Heat distribution around one of the CEMS ports

possible to find it by a normal visual inspection, modern Thermal Imaging technology will readily show any such area. Pictures 5 – 7 were taken in the Coleson Cove chimney and clearly show how well the lining system performs. Please note that these units have been in service well over 10 years.

**Case 2:
Spurlock Power Station, Maysville, KY**

Spurlock Power Station is the largest plant owned by Winchester-based East Kentucky Power Cooperative (EKPC). Two FGD systems were retrofitted to the 325 MW Unit #1 and

the 525 MW Unit #2 in 2008 and 2009. Both Units #1 and #2 are conventional coal fired units, using coal with a sulfur content of 3.5 - 4.2%.

EKPC and their consulting engineers initially looked at the possibility to reline the existing Unit #2 chimney but it was found that the fast construction and commissioning schedule for the FGD retrofit project would not allow a sufficiently long outage to achieve this.

Two new 650' concrete chimneys, each with a single steel flue were built, and lined with a 1.5" thick Pennguard Lining. Unit

#1 had a diameter of 21 ft, Unit #2 had a diameter of 27 ft. A total of approximately 87,511 ft² of steel flue surface was lined with the Pennguard Block Lining System, which was installed in phases between January and November 2008.

The Spurlock chimneys are FGD Wet Stacks carrying desulfurized, water saturated gas streams. The flue gas temperature in the chimney flues is between 125 and 130 °F. The flue gas velocity is less than 50 f/s.



Picture 8 - Spurlock Power Station, Kentucky

Since 2009, regular inspections have been carried out to inspect the performance of the Pennguard lining and except for some mechanical damages found around some of the drains and Liquid Collecting system, no repairs have been needed; the Pennguard lining is in excellent condition. It is apparent, when looking at the pictures 9-12, that both Units are operated very efficiently as there are no deposits to be seen on the flue walls.



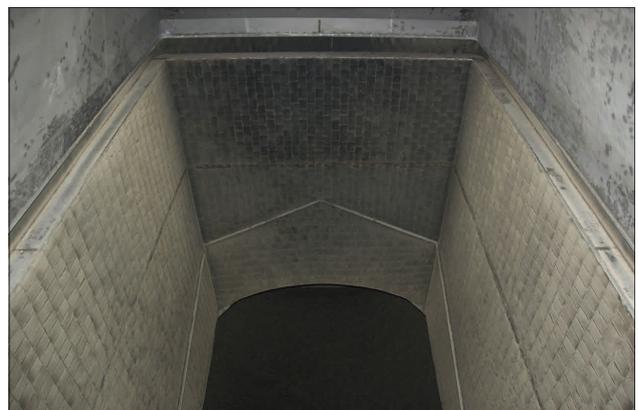
Picture 9 - Spurlock PP: Unit #1: View upwards, excellent performance of the Pennguard Block Lining System

**Case 3:
Mayo Power Station, Roxboro, NC**

The Mayo Plant (picture 15) is a single unit, 727 MW coal-fired power plant, located near Roxboro, NC. It began commercial



Picture 10 - Spurlock Power Station Unit#1: View towards chimney target wall area



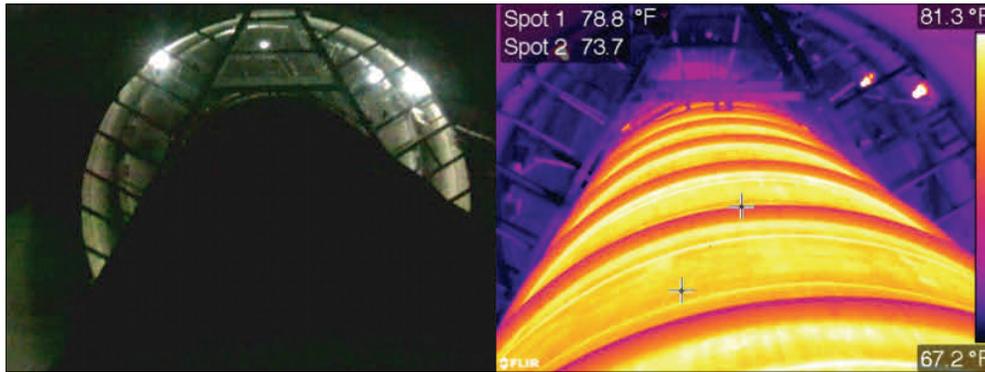
Picture 11 - Spurlock PP: Unit #2: View towards top of inlet (note the Liquid Collection gutters)



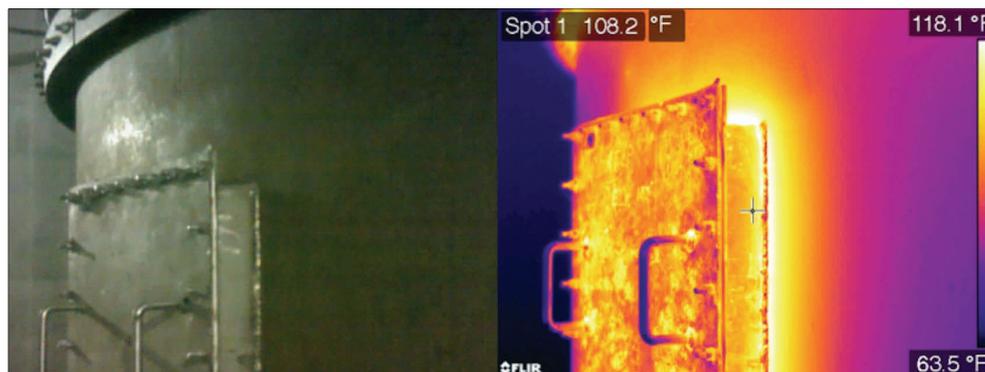
Picture 12 - Spurlock PP: Unit #2: Impression of the Pennguard Block Lining System around several Liquid Collector systems

operation in 1983. In 2008, as part of a project to retrofit WFGD, the plant constructed a new chimney with a single steel flue.

The height of the concrete column is 360' (above foundation), the carbon steel flue has a total height of 255' and spans from the 125' level to the 380' level. The diameter of the steel flue is 30'-9" (constant). The breeching duct leading to the scrubber is 17' x 42'.



Picture 13 - Spurlock PP: Unit #1: Even heat distribution



Picture 14 - Spurlock PP: Unit #1: Heat distribution around one of the inspection hatches

Between June 2008 and September 2008, 25,192 ft² of a 1.5" thick Pennguard lining were installed in the chimney and an additional 6,967 ft² of the same 1.5" thick Pennguard lining were installed in the breeching duct.

The chimney operates at 125°F and has seen 38,520 hours of operation after commissioning of the WFGD plant. The unit ran/runs at full load during 50% of its total operating hours. Approximately 25 starts and stops were recorded since the WFGD plant was commissioned. The FGD flue gas velocity is between approximately 51 ft/sec and 54 ft/sec at 100% design load.

In September 2014, the plant awarded an independent consulting company a contract to perform a visual inspection of the entire chimney and its appurtenances. Part of the contract was to inspect the Pennguard lining.

It was found that after 6 years of operation with WFGD, the Pennguard lining was still in excellent condition. Apart from a small area (approximately 4' x 4') at a higher elevation where some blocks showed some scattered cracks, the Pennguard Lining did not require any repairs whatsoever. In the Spring of 2016, Hadek Protective Systems will have an opportunity to investigate the cause of these cracked blocks and replace them.



Picture 15 - Mayo Power Station, Roxboro



Picture 16 - Chimney of Mayo Power Station

Based on the elevation where these cracked blocks were found we suspect that the flue liner may have moved in high winds during construction and may have touched the landing in the annular space. The surface of Pennguard lining shows a very thin layer of deposits but overall no issues were found and it is expected that the Pennguard lining system will protect the flue for many years to come.

The pictures 17 and 18 provide an impression of the performance of the Pennguard lining seen during the September 2014 inspection (courtesy of Bednash Consulting, Inc.).

In February 2015, Hadek had the opportunity to enter the chimney annular space and examine the thermal insulating properties of the Pennguard lining using Thermal Imaging technology. It was found that the Pennguard lining kept the exterior steel temperature low compared to the wet flue gas temperature inside. No flaws in the insulating properties of the Pennguard Lining could be detected (pictures 19 – 20). As quoted by one of the engineers responsible for the chimney, "we love this stuff!!!"

Case 4: Power Plant in Texas

This power plant is located in Texas and consists of two (2) 800MW lignite fired units. The power plant was equipped with WFGD plants during its initial construction to reduce the sulfur dioxide (SO2) emissions.

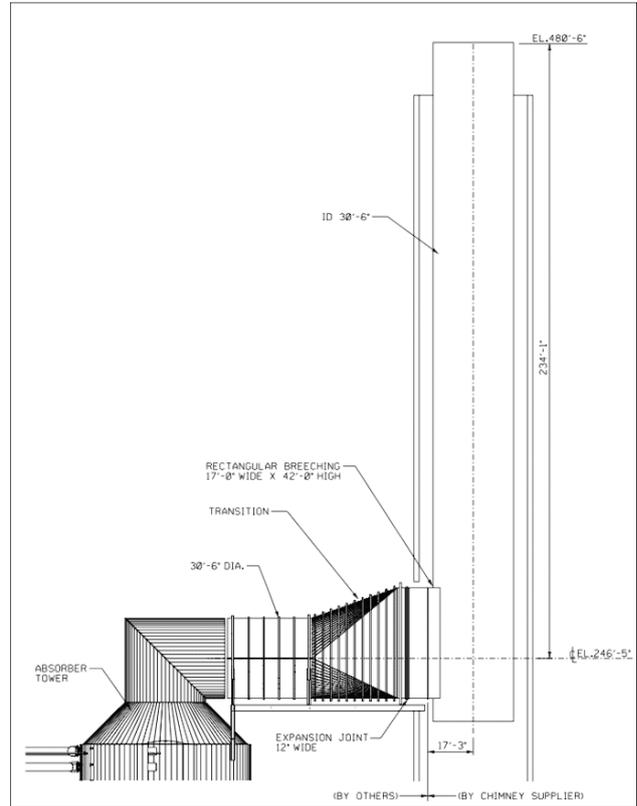


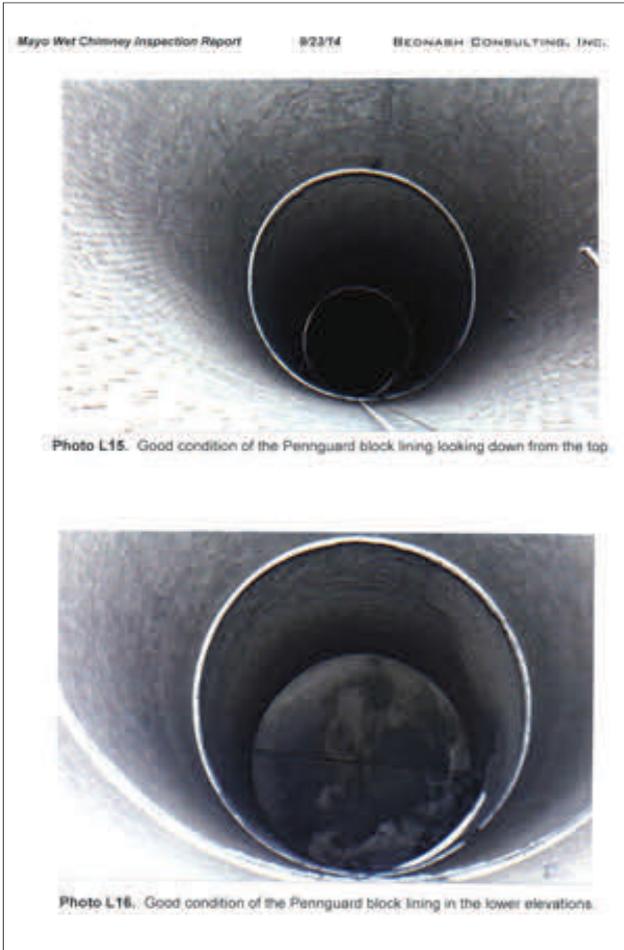
Figure 2 - Chimney Design layout of Mayo Power Station

Each 800 MW unit has an identical concrete chimney with a single steel flue. These chimneys are 450' high and each has a 32'-10" diameter internal flue. Between October 2008 and May 2009, both flues were lined with the Pennguard Block Lining System, using 1.5" thick Pennguard Block 55. A total steel surface area of approximately 66,000 ft2 was protected with the Pennguard Block Lining System.

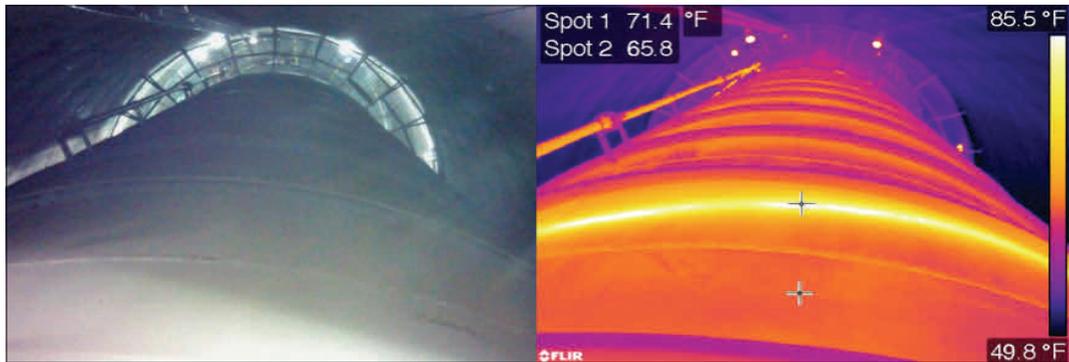
A C-276 Liquid Collection system was installed to trap liquid and discharge it through a drain system to the outside of the chimney flue. The operating temperatures are around 125 °F, the flue gas velocity, as confirmed by plant personnel, is 59.6 ft/sec.

Between 2010 and 2015, as part of our 10 year warranty with the customer, several inspections were carried out in order to investigate the condition of the Pennguard Block Lining System and in each case the lining the lining was found to be in a very good condition; the Pennguard Block Lining System protected both chimneys very well against the aggressive flue gas and condensate. According to plant personnel, both units run almost full time with few starts and stops. Pictures 22 and 23 are taken during the most recent inspection in March 2015, showing the good condition of the lining.

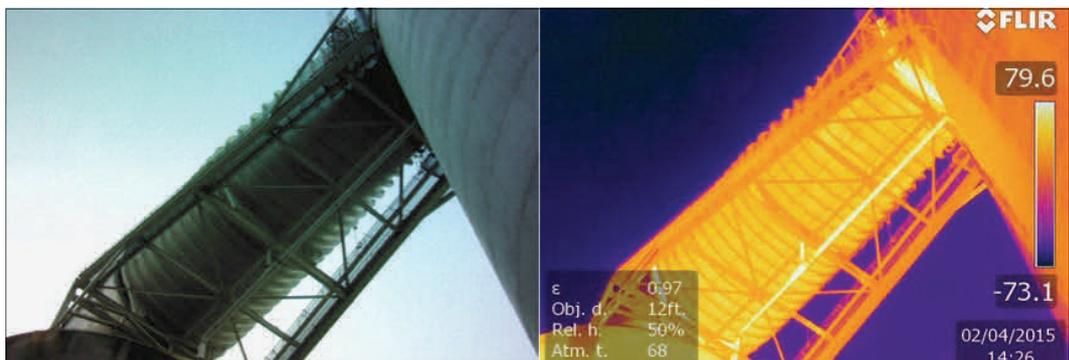
As in other projects, we have used Thermal Imaging technology (pictures 24 - 26) to monitor the thermal insulating capabilities of the installed Pennguard lining. I must



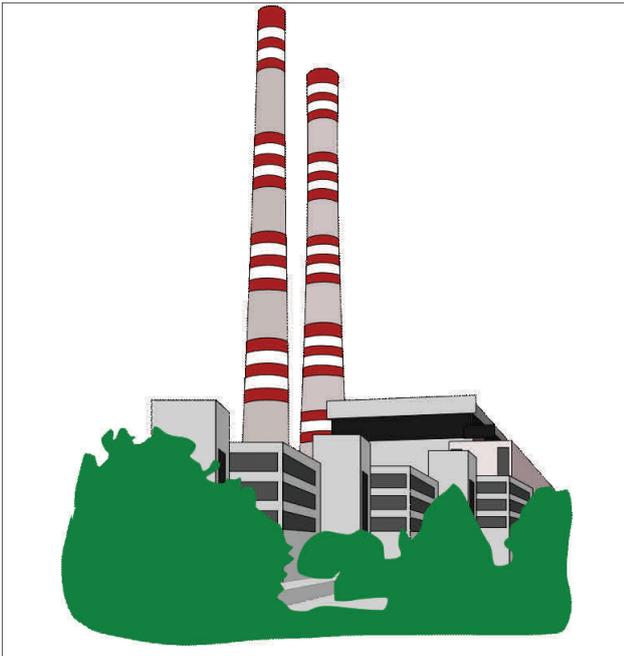
Pictures 17 and 18 - Mayo PP: Pictures showing the condition of the Pennguard chimney lining



Picture 19 - Mayo PP: Even heat distribution looking upwards



Picture 20 - Mayo PP: Even heat distribution inlet duct



Picture 21 -
Design drawing lignite firing power plant in Texas



Picture 22 - Good condition of the Pennguard lining at 800 MW lignite firing power plant in Texas

emphasize that the thermal images below were taken while one of the units was in start up mode and consequently they may not provide a 100% correct image. In this case these images are for illustration purposes only.

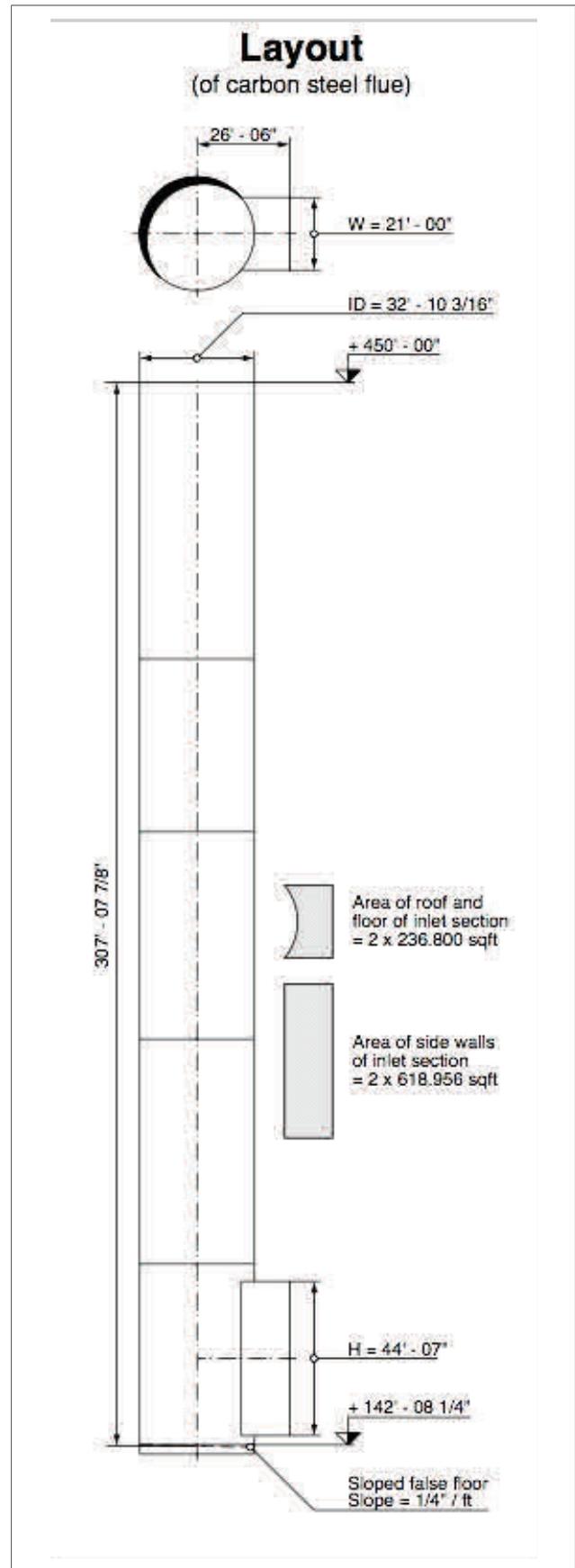


Figure 3 -
Chimney layout lignite firing power station in Texas

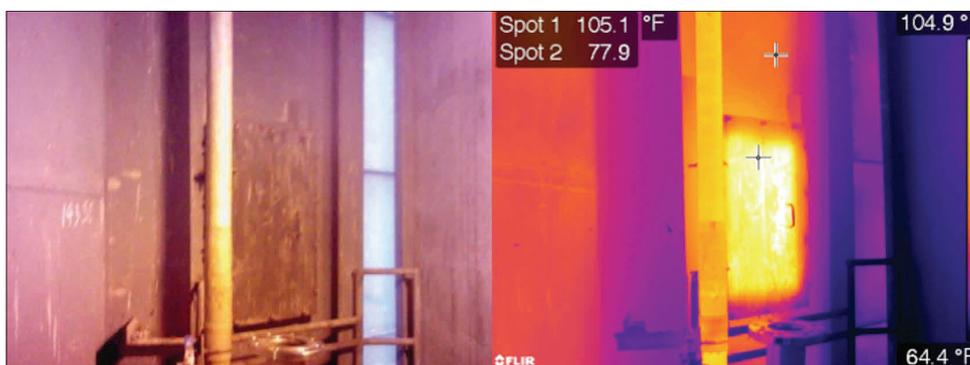
Summary and Conclusion

This paper reports on the operating experience gathered with Pennguard lined steel chimney flues within FGD Wet Stacks in the United States and Canada. Hadek representatives visited four power stations using Pennguard linings installed between 2004 and 2009. In each of the four cases, it was found that the Pennguard lining system protected the steel flues very well and no significant problems with the Pennguard linings, the steel flues or the chimneys as a whole were reported by plant personnel.

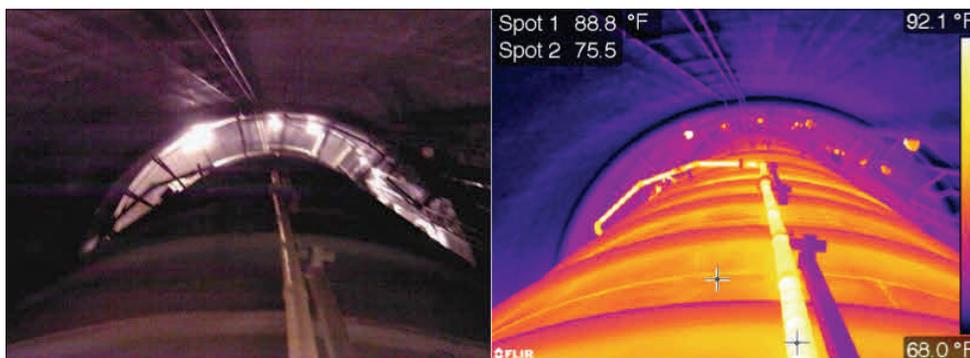
Based on these findings, it can be reconfirmed that the Pennguard lining technology offers a reliable and durable solution for corrosion in FGD wet stacks. Provided that the lining system is well installed and used within its technical limits, it offers power plant owners an excellent option for these types of chimneys.



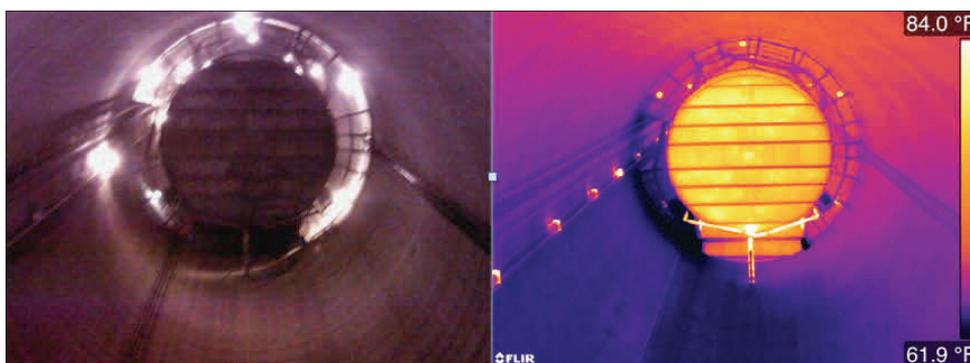
Picture 23 - This picture is showing the perfect condition of the Pennguard lining around nozzles at lignite firing power station in Texas.



Picture 24 - Power Plant in Texas: Pennguard lined steel flue showing an even heat distribution



Picture 25 - Power Plant in Texas: Even heat distribution from bottom to top



Picture 26 - Power Plant in Texas: Bottom of the Pennguard lined steel flue with an even heat distribution as well