

# Project REPORT

## Craiova power station

### Romanian power station modifies concrete chimney using Pennguard® Block Lining System

The Romanian national electricity generation company, Termoelectrica, is currently modernizing its fleet of power stations. When the largest power station in the Southwest of the country, Craiova Isalnita, had to make a list of its priorities, the 656 ft high reinforced concrete chimney was identified as a high risk for the long term availability of the station. The power station then developed a plan for a complete refurbishment of the chimney.

The chimney was a 656 ft high, conical reinforced concrete shell, which was internally protected by a sectional ceramic brick lining. The brick lining was placed on concrete supports, attached directly to the concrete shell. Between the concrete shell and the brick lining, there was a narrow space, filled with a thermal insulation material.

Although the design of the chimney was originally quite conservative, the specific operating conditions of Craiova power station created a very aggressive environment. The chimney carries the flue gas from four coal fired units with a combined capacity

of 400 MW. The coal, which is found locally, near Craiova, contains sulfur. As the four units go through startups, shutdowns and load changes, the chimney is frequently exposed to conditions, where acid condensate is formed.

A 1999 technical survey of the chimney showed, that flue gas could penetrate into the space between the concrete shell and the brick lining and, as a result, the concrete shell and the brick lining supports were under attack from sulfuric acid condensate. Furthermore, thermal cycling had created wide cracks in the concrete windshield. It was concluded, that any further deterioration of the chimney would be an unacceptable risk, especially if the earthquake risk in the area was also considered.

Based on a design by a leading chimney construction company, GIP Grup from Bucharest, the chimney was completely refurbished in 2002. Instead of using ceramic brick once again, the internal concrete surface of 51,130 ft<sup>2</sup> was relined using a lightweight Pennguard® system. ♦



**HADEK**

Duct & Chimney Linings

## Repair of the chimney

1

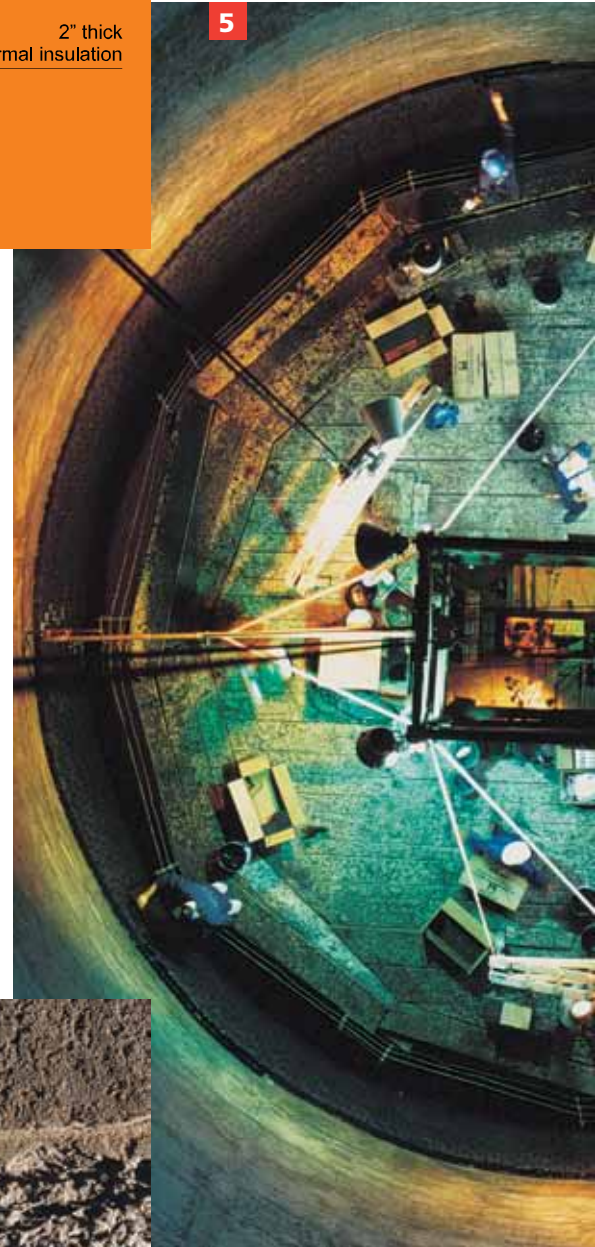
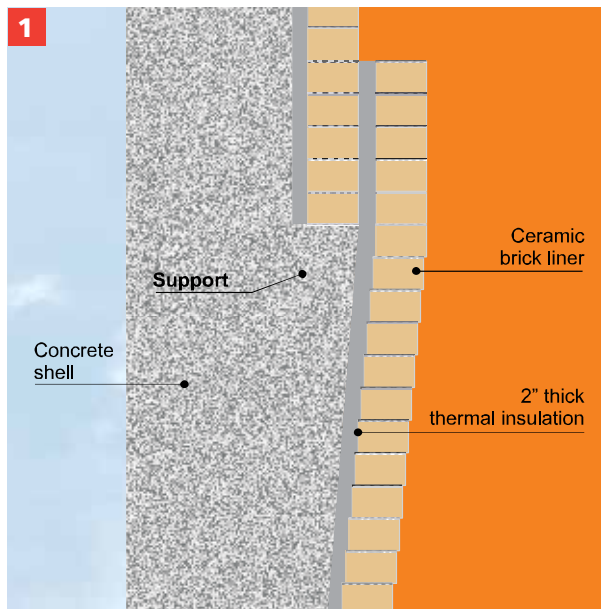
First, GIP Grup removed the ceramic brick liner, its supports and the old thermal insulation from the chimney. The combined weight of these materials was 1,500 metric tons.

2

In order to reduce and control the width of the cracks in the 656 ft concrete windshield, the contractor placed a system of high strength steel bands around the outside of the chimney.

3

Prior to the installation of the Pennguard® Block Lining System, the contractor removed a layer of chemically degraded concrete from the inner surface of the concrete shell. He then installed additional steel reinforcement and applied a smooth layer of sprayable concrete.





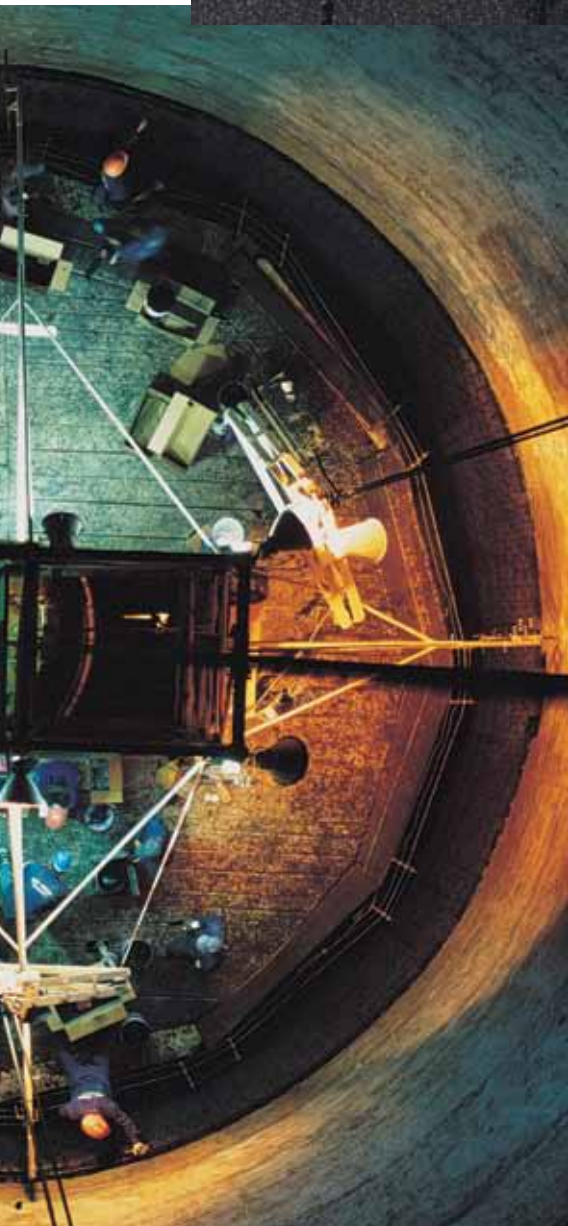
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## Installation of the Pennguard® lining

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Following the repair work on the concrete shell, the contractor installed Pennguard® linings directly onto its internal surface, to protect the concrete from acid condensate as well as from high temperature and thermal shock.



5

The Pennguard® lining was installed from a heavy duty movable platform. The platform had two separate lifts and accommodated up to 8 installers and 10 helpers. The typical speed of installation for this project was 19.40 ft<sup>2</sup> per installer per hour.

6

In order to protect the concrete shell from operating temperatures of up to 329 °F, the chimney uses Pennguard® Blocks in thicknesses of 3.0, 2.5 and 2.0 inches. The total weight of the Pennguard® lining system in the chimney is 95 metric tons.

5



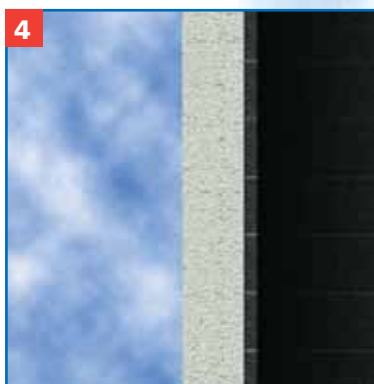
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Height 656 ft

Inside diameter 19'-10"

Pennguard® 55, thickness 2"

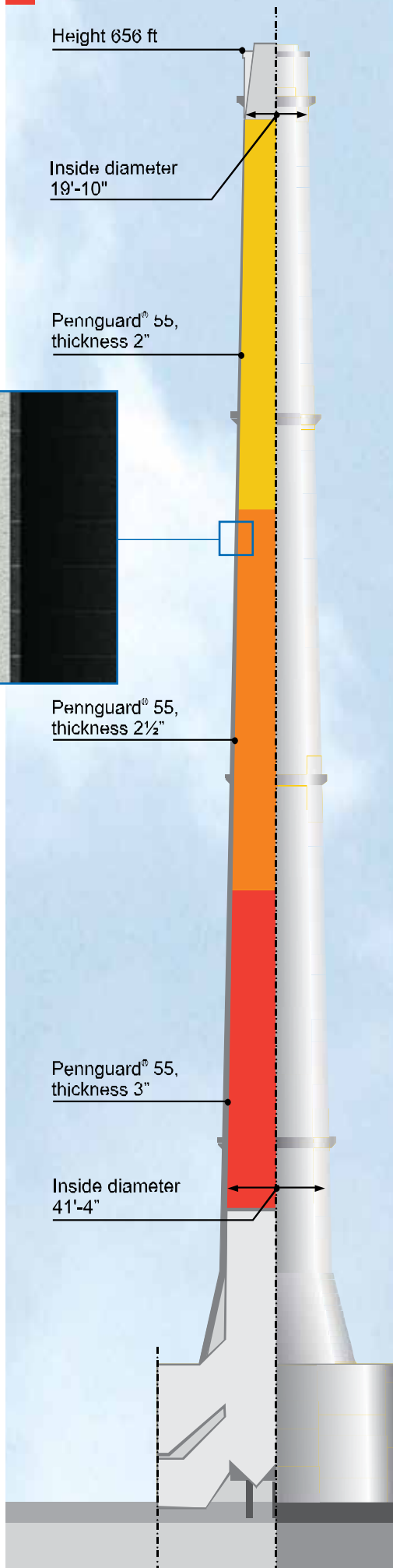
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Pennguard® 55, thickness 2½"

Pennguard® 55, thickness 3"

Inside diameter 41'-4"



## The seismic behaviour of a Pennguard® lining on a concrete chimney - a special study

The new Pennguard® lining on the inside of the Craiova chimney will protect the concrete shell from acid condensate attack. In addition, it will help to increase the earthquake resistance of this 656 ft high chimney. By removing the 1,500 metric tons brick lining and installing, in its place, a 95 ton Pennguard® lining, the forces transmitted to the concrete shell during an earthquake will be strongly reduced.

The use of Pennguard® linings, placed directly on concrete chimney shells also raises a new question: how will the Pennguard® lining itself behave, when the concrete shell is subject to great strain and crack formation during an earthquake? Will the Pennguard® lining also crack and will it be dislodged from the concrete shell?

At Hadek's request, the University of Melbourne, Australia, investigated this question at the specialized test laboratories of its Department of Civil and Environmental Engineering.

The laboratory prepared large slabs of reinforced concrete, with Pennguard® linings attached to them and exposed these to the same forces and move-



*General test set-up*

ments that would be expected for a large chimney during a strong earthquake. The study found, that for tensile strains of up to 1 percent, with formation of 31.5 mils wide cracks, the Pennguard® lining did not sustain any damage, even though the concrete shell itself would require repair after such an event.

During extreme earthquake conditions with up to 3 % tensile strain, (a typical "once in 500+ years" event), the Pennguard® Blocks did crack at the locations of the cracks in the concrete, but the adhesion of the lining to the concrete remained intact.

Dr. John Wilson, who led the study, comments: "The test program demonstrated that the overall performance of the Pennguard® Blocks and adhesive was excellent and superior to that of the reinforced concrete windshield when subject to earthquake ground shaking. In addition, the Pennguard® Blocks, being extremely light, transmit a negligible seismic force to the windshield, which is a significant advantage over more traditional lining systems". ♦

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