

CASE STUDY

Extreme Engineering: Executing a Critical Autoclave Reline in a Challenging Environment

Situation: A Race Run in Extreme Conditions

Gold mining has undergone a radical transformation driven by advanced technologies in Pressure Oxidation (POX) that extract precious metals from what was once considered “waste rock.” Conventional extraction techniques failed when applied to this lower-grade, complex ore, so it was discarded, or “wasted” ore. Every day, Pressure Oxidation operations process thousands of tons of ore, which often contain gold in microscopic quantities of just 1% or less per kilogram of material, distributed as fine particles within the ore body.

The POX process subjects equipment to extreme conditions: temperatures approaching 240°C, highly acidic slurries, and significant pressure fluctuations. These conditions create a perfect storm of corrosive elements that constantly attack the autoclave lining.

The mine’s remote tropical location added further complications—sweltering ambient temperatures regularly exceeding 35°C with extreme humidity made working conditions challenging even before entering the confined autoclave space. In 2021, after twelve years of punishing service conditions, the autoclave lining at a mine operating in this remote area had reached a critical point of degradation, with each day of continued operation increasing the risk of catastrophic failure.

This operation required continuous production with minimal downtime, requiring the autoclave to operate in excess of 12 months or more between service interventions. The stakes were enormous—each day of interrupted production translated to millions of dollars in lost revenue.

The remote worksite compounded these challenges, requiring materials to travel through three different ports and navigate complex customs procedures before arriving at the operation. Knight Material Technologies (KMT) faced a daunting timeline: complete the entire reline within a 45-day window or risk significant production losses for their client.



The Challenge: A Perfect Storm of Technical and Logistical Hurdles

After more than a decade of continuous operation, the autoclave lining at the remote mining operation had deteriorated, necessitating immediate remedial action. Inspection revealed wear patterns anticipated in the equipment given the constant, prolonged exposure to aggressive, corrosive chemicals, high temperatures, environmental and other operational issues.

The stakes were enormous. Each day of unplanned shutdown in a gold mining operation can cost millions in lost production. A catastrophic lining failure during operation could imperil personnel and cause extensive damage to the autoclave vessel itself—a multi-million-dollar investment. The extremely remote location compounded these technical challenges with logistical constraints:

- **Materials needed to travel through three separate ports before reaching the site.**
- **The nearest major industrial center was hundreds of miles or kilometers away.**
- **Limitations in local infrastructure required coordinated, exact scheduling for both equipment deliveries and personnel.**
- **Extreme climate conditions, limited working hours and complicated material storage.**

The Solution: Engineering Excellence in Extreme Environments

Knight Material Technologies (KMT) leveraged decades of experience designing, installing, and maintaining durable linings to develop a comprehensive approach tailored to these exceptional circumstances. Rather than addressing individual challenges in isolation, KMT implemented a holistic solution that simultaneously tackled technical, logistical, and labor force challenges using five integrated tactics:

1. Vendor and client collaboration: Collaborative, flexible, high-quality

KMT assembled a collaborative framework of specialized partners to tackle the unique issues presented by the mine's extreme operating conditions. Working in confined spaces with temperatures exceeding 40 °C inside the vessel, KMT coordinated with various vendors such as mechanical, pumping and agitation, to orchestrate a precisely sequenced workplan. This approach enabled the team to navigate complex technical challenges while maintaining its commitment to safety and quality in a punishing environment.

2. Extensive pre-planning: Engineering precision in project management

KMT initiated planning 18 months before the shutdown, deploying a dedicated six-person engineering team to develop contingency plans for every conceivable complication. The team created an exhaustive Gantt chart mapping over 1,200 distinct tasks, each with identified failure modes and mitigation strategies. Daily progress meetings enabled real-time tracking and immediate problem resolution, with video conferencing bridging multiple time zones as the international team collaborated. This meticulous approach compressed the traditional project timeline by 15%, creating crucial buffer time for unexpected challenges.

Solution (continued)

3. Logistical excellence: Supply chain as a strategic weapon

Logistics management evolved from a support function to a critical strategic capability.

The operation involves:

- Tracking thousands of specialized components.
- Managing extensive personal protective equipment inventories.
- Navigating complex port storage systems.
- Developing robust material shipping, storage, and tracking mechanisms.
- Marshalling materials once on site to be available throughout the shutdown.

4. Global talent mobilization: Redefining workforce capabilities

Due to their often-remote operating locations and the sheer volume of work involved, autoclave relining projects require a specialized team of hundreds of trained workers to work in back-to-back shifts. KMT assembles its crew from multi-national teams by bringing together specialized technicians from close to ten countries to work on Autoclave projects under KMT.

Professional translators ensure seamless communication, while diverse skill sets bring unique solutions to these complex engineering challenges.

5. Advanced worker support: Human factors in extreme environments

Recognizing that human performance and a healthy, well-protected, comfortably outfitted labor force are central to technical success drives KMT's approach to worker support. High temperatures, extreme humidity, and confined spaces often characterize the environments in which the company operates.

KMT implements best practice HSE (health, safety and environment) controls to maintain worker safety and provide optimal safety gear and living conditions to contribute to continued high productivity.

The support strategies adopted include:

- Battery-powered respirators with fresh air systems.
- Advanced interior environmental conditioning.
- Comprehensive hydration and rest protocols.
- Multi-layered personal protective equipment (PPE).

Striking Gold with the KMT Methodology

A project's crisp execution demonstrates KMT's capability to deliver exceptional results in challenging environments. The situation discussed in the case study experienced the following:

A complete re-lining solution that delivered substantial operational improvements via enhanced maintenance efficiencies, such as:

- Reduction in inspection and repair times by 50% annually.
- Minimized emergency repair requirements between scheduled maintenance periods.
- Additional annual revenue of \$8-\$10 million generated due to reduced downtime (calculated at a base minimum of \$1 million per day).
- Ability to forecast future maintenance needs for predictive scheduling, which enhances repair effectiveness and extends service lifespan.
- Demolition completed 4 days ahead of schedule despite discovering 30% more degradation than initially estimated.
- Construction finished 6 days early, returning the autoclave to production faster than planned.
- Zero lost time to any recorded injuries, despite completing over 42,000 labor hours in extreme conditions.
- Client production targets exceeded by 8% in the first month after relining completion due to improved autoclave performance.

The methodology developed for autoclave relines represents a transferable framework applicable to complex industrial shutdowns across various sectors. KMT's approach, combining global talent mobilization, advanced logistical planning and technologically advanced materials and planning, can be adapted to challenging environments in industries ranging from mining to heavy manufacturing.

Unyielding Performance: The Lining Built to Withstand Extreme conditions

KMT organized and engineered a technical solution specially designed to withstand the punishing combination of high temperature, extreme pressure fluctuations and aggressive chemical exposure. The team developed a sophisticated, multi-layered lining system that incorporated lessons learned from 12 years of operational data collected at this site.

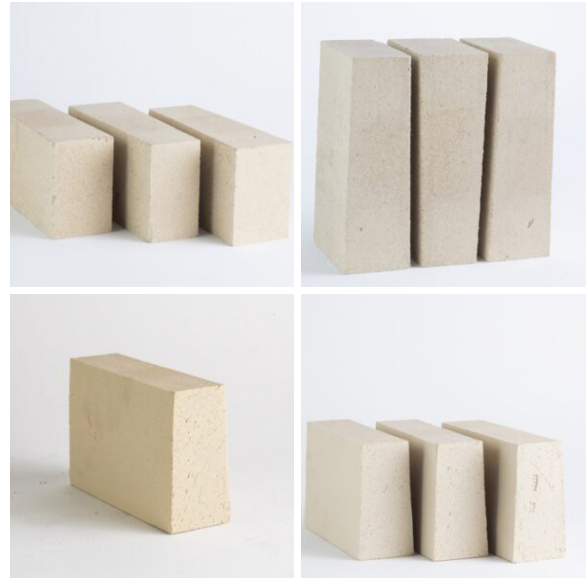
Key performance characteristics include:

- Elimination of traditional acid-based curing processes.
- Reduced overall curing time by 30%.
- Superior protection against thermal cycling.
- Customized brick sizing for optimal performance.

The solution centered on two key KMT products:

[KNIGHT-WARE® PV33P acid-resistant brick](#): Engineered to withstand extreme temperatures and chemical exposure in the POX process. Knight acid-resistant brick is:

- Available in standard and custom shapes and sizes
- Corrosion-resistant in high-temperature environments
- Conforming to ASTM 279 specifications



[Acid-resistant mortar](#): Endures acid corrosion and slurry erosion at high operation temperature and pressure. It eases the installation of acid-resistant bricks and provides additional protection for the membrane. KMT offers a line of proprietary mortars of diverse types and formulations to service the needs of process environments, engineered to maintain structural integrity between 200° C/392° F and ambient temperatures.



This project highlights KMT's ability to deliver reliable solutions for the most challenging industrial applications while supporting customers through complex technological transitions. The complex logistic efforts to secure and support an extensive labor force, in addition to the advanced materials, engineering expertise and dedicated technical support, position KMT as a leader in providing critical protective linings and systems for modern industrial processing systems.