

INSTALLATION OF A PCM LINER FOR GROUND SUPPORT ENHANCEMENT IN THE COTE BLANCHE MINE PRODUCTION SHAFT

*PCM – Polymeric Composite Membrane

COMPASS MINERALS



- Company history dates back to 1844
- The largest salt producer in North America and the U.K.
- A leading supplier of highway deicing products
 - Keeping roadways safe in the U.S., Canada and the U.K.
- A key producer of high-quality salt for consumers and industry throughout North America
 - Food salt, water care products, packaged deicing, minerals for animal nutrition, and other salt and mineral products
- The leading sulfate of potash specialty fertilizer producer in the western hemisphere
 - Helps produce nutritious fruits, vegetables, tree nuts and other important crops
- A growing micronutrient business with the acquisition of Wolf Trax and Produquímica
- Provider of secure records management services in the U.K.



COTE BLANCHE MINE #3 SHAFT



- The #3 shaft is an ore shaft and uses a single drum double skip friction hoist
- Shaft is nominally 16 feet in diameter
- Shaft is concrete lined to -750 feet elevation to stabilize the strata overlying the salt dome and to prevent water intrusion into the salt mine
- The shaft walls are exposed salt from -750 to -1550 feet
- Intake (downcast) ventilation shaft using an ALPHAIR ventilation fan rated at 650,000 CFM



PROBLEM STATEMENT

- The salt mines in the southern United States, predominantly in Louisiana, are all within domal formations (diapirs)
- Scales in the vertical shafts in the Cote Blanche salt mine present hazards to personnel and hoisting equipment
- Scale formation: The combination of exposed natural salt, salt squeeze and subsidence, result in the formation of scales in the shafts at this domal salt mine
- Seasonal Moisture Variations: Seasonal variations in the moisture content of the intake air contributes to scale formation
- Salt Dust: Salt dust from hoisting operations adheres to the shaft wall masking scales
 - Dust build-up also results in the formation of sizable salt crystals hazardous to people and equipment
- Scale Removal: Scales must be mechanically removed by specially trained shaft workers working from the top of the skips wearing full body harnesses and fall protection gear



SOLUTION IDENTIFICATION



- The installation of a full concrete liner to the -1,550 level was deemed very costly and infeasible
- Other more conventional shaft liner technologies were deemed to be infeasible for various reasons
- Compass Minerals became aware of ongoing work by 3M in collaboration with the Canadian Mining Industry Research Organization (CAMIRO) to adapt a synthetic material with unique properties to use for mine ground control applications (ultimately reverted back to Hanson as original formulator)



SOLUTION IDENTIFICATION

- The Polymeric Composite Membrane (PCM) material was identified as a potential scale control solution due to the following properties:
 - The material can be sprayed directly onto natural salt without the need for a primer
 - Salt cannot degrade the PCM
 - PCM is impervious to water
 - Appropriate physical / chemical properties
- Physical/chemical properties established:
 - Tensile strength
 - Elongation
 - Various toughness and tear criteria
 - Various adhesions criteria
 - Fire exposure
 - Water immersion stability

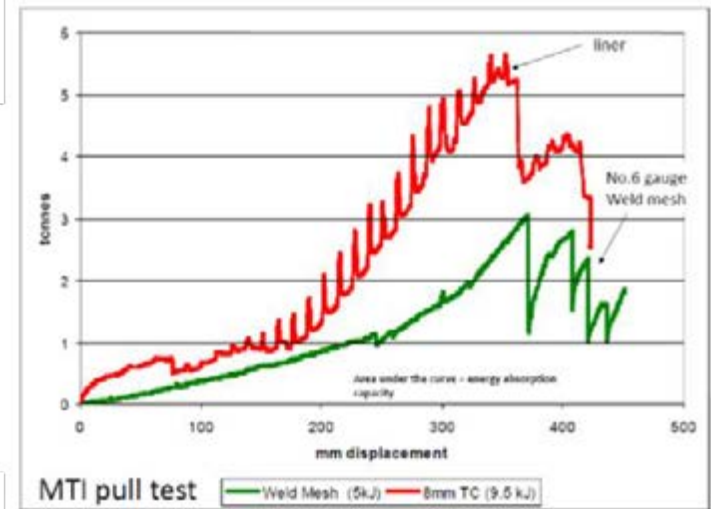
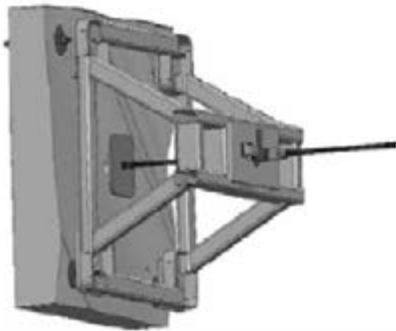


TESTING

- Lab testing was originally done at the 3M lab in Canada
- Lab testing confirmed adequate adhesion and performance
- Full scale testing was then done in an underground shop area confirming adhesion and performance
- Significant areas of study:
 - Industrial hygiene
 - PPE
 - Mine air quality
- Successful testing results



ELONGATION TESTING OF PCM



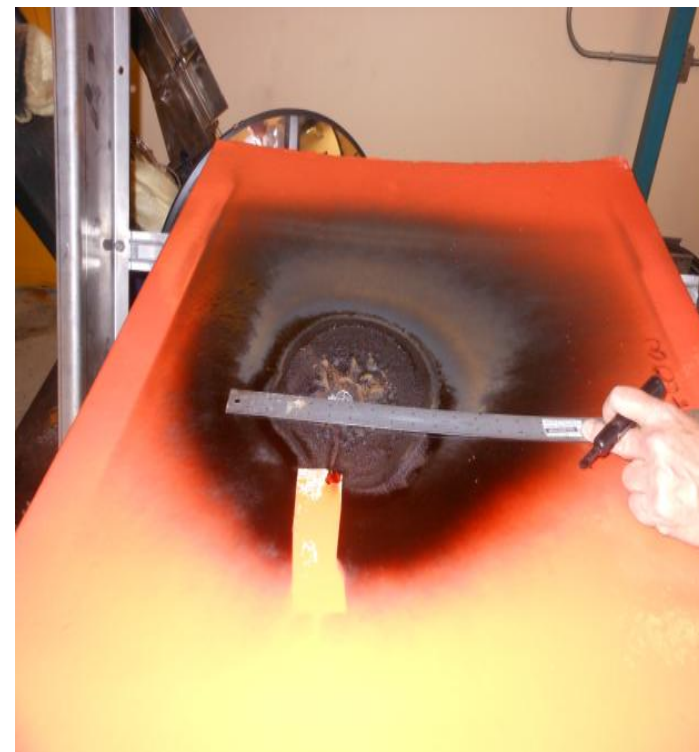
Extreme Elongation
Demonstrated



FIRE TESTING DATA DIRECT FLAME IMPINGEMENT (ASTM E162)



Test 1



Test 2



LAB TESTING ON COTE BLANCHE BLOCKS



UNDERGROUND TESTING



BENEFITS & RISKS OF INSTALLATION OF PCM LINER



- Benefits:
 - Enhanced ground control by encapsulating exposed salt on shaft walls with a high tensile strength elastic material compatible with salt
 - Reduced personnel risk associated with frequent manual scaling
 - Reduced shaft wall scaling maintenance costs
 - Reduced shaft equipment damage from falling scales
- Risks:
 - Lost production during scheduled mine idling to prepare shaft wall and install liner
 - Project cost over-runs due to unknowns associated with this pioneering project
 - Potential for personnel exposure to chemical hazards during PCM liner application



PROJECT PLANNING RISK MANAGEMENT



- Extensive upfront analysis and planning was conducted to ensure the project would be successful
- Three primary risk categories risk addressed:
 - Contractor selection
 - Engineering design and fabrication
 - Personnel safety



CONTRACTOR SELECTION PROCESS

- Objective: Mitigate project risk by selecting the right contractor(s)
- Select up to three contractors with various skills and expertise:
 - Experienced Part 48 trained personnel that have installed specialized equipment
 - Engineering firm with the capabilities to design shaft infrastructure
 - Fabricator with the ability to build specialized shaft infrastructure

OR

- Select a full turnkey contractor capable of overseeing design and fabrication of equipment and with enough qualified personnel to install the specialized equipment and apply the PCM lining in the shaft
- Decision:
 - Cementation USA selected as a full turnkey contractor based on their diverse project management, engineering, and mine operational capabilities and solid track record of delivering for clients



ENGINEERING CHALLENGES

- Equipment and utilities to support PCM liner application
- Secondary means of egress from shaft in case of an emergency
- Design and fabricate work platforms large enough to accommodate personnel and to hold equipment and supplies needed to safely and efficiently work in shaft
- Initial discussions considered removing the two counter-balanced ore skips from the hoisting system and replacing them with custom work decks
- The solution selected involved fabricating and installing work decks on top of each skip that met all of the above criteria

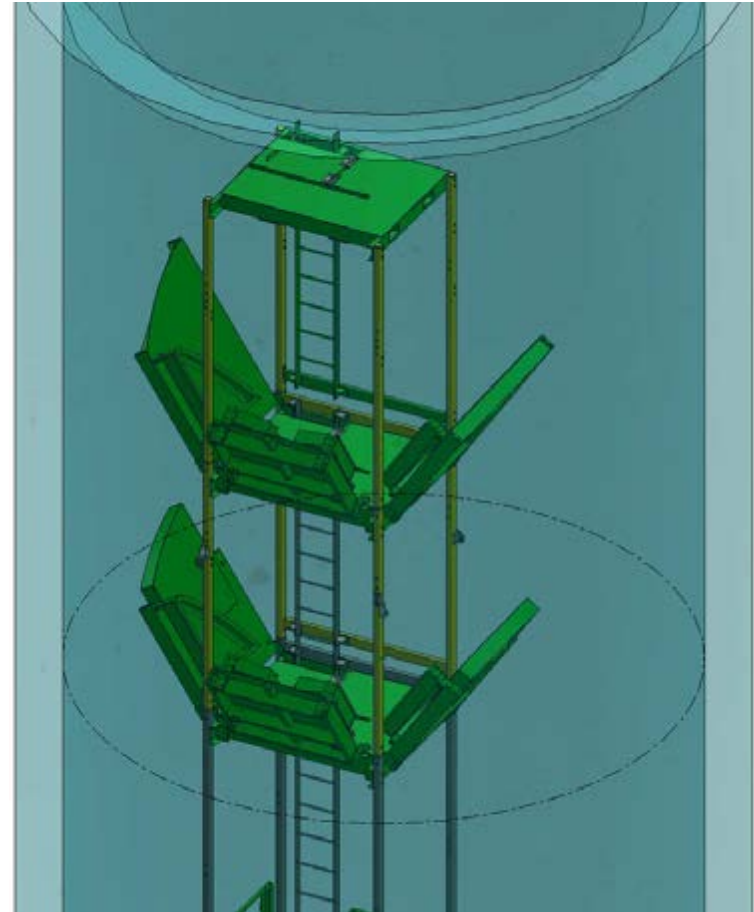
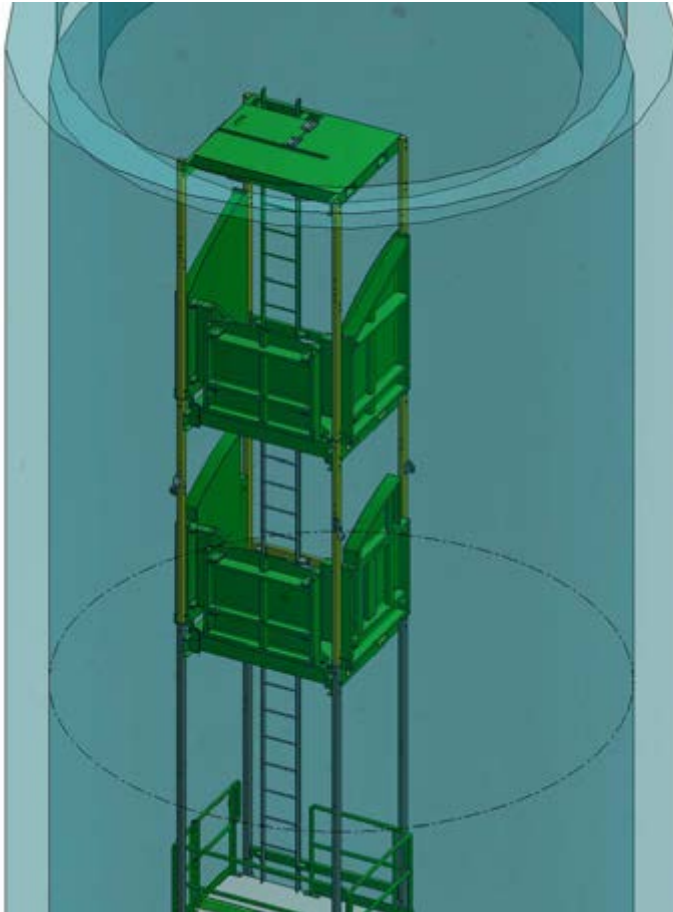


WORK DECK CRITICAL TO PROJECT SUCCESS

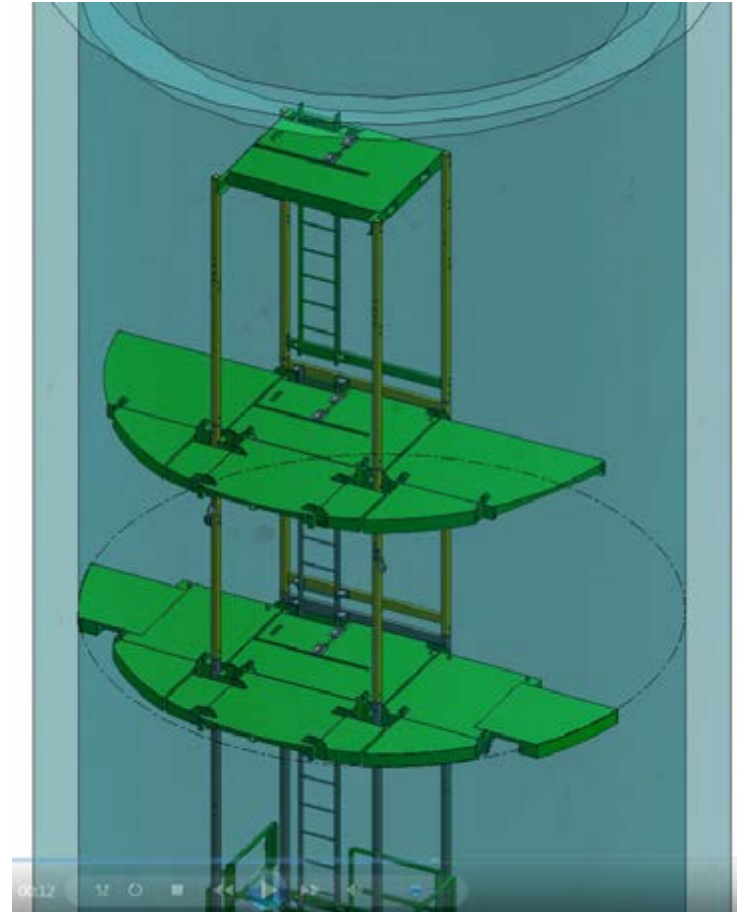
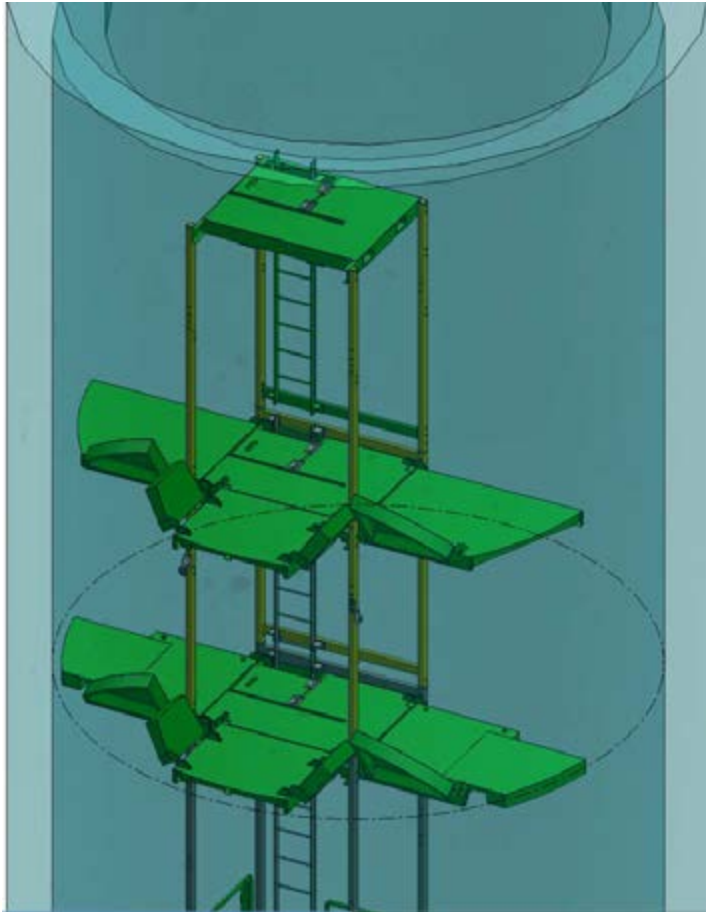
- Recognized early that a work deck capable of traveling from the surface to the bottom of the shaft capable of carrying personnel, equipment and supplies safely was critical to safety and success
- The working footprint of the work deck needed to be large to allow personnel close access to the exposed salt walls and minimize fall risk exposure while working in the shaft
- The chemical spraying equipment and hoses, as well as chemical drums, needed to travel with the work crews
- A multi level deck was designed and fabricated
- RESULT: The work deck was a huge success and facilitated the very satisfactory outcome of this project



GRAPHIC OF WORKDECK DEPLOYMENT IN SHAFT (STEPS 1)



GRAPHIC OF WORKDECK DEPLOYMENT IN SHAFT (STEPS 2)



PERSONNEL SAFETY & HEALTH



- Fall prevention and overhead protection
 - The work deck integrated hand rails and rated anchor points
 - Personnel used full-body harnesses with SRLs
 - The work deck provided full overhead protection to the personnel
- Preventing chemical exposure
 - An industrial hygiene program to mitigate PCM related exposures was developed and executed
- Heat stress risk assessed
 - Heat strain prevented via in-line vortex air coolers lowered the breathing air temperature
- Results: There were no recordable injuries and no chemical exposures above OELs during any work in the shafts throughout three scheduled outages to install the PCM liner



PROJECT EXECUTION

- Greater than 90 days of active work spread across 18 months and three spray phases, the installation of a spray-on shaft liner at the Cote Blanche Mine was completed in March 2017
- Based on feedback from employees and supervisors at the mine, the significant investment of time, expertise and resources in the mine represented by the liner has brought about the desired results – a safer work environment



TRANSITION FROM THE PCM LINER TO THE EXPOSED SALT DURING INSTALLATION



PCM LINER AVERAGED 4 TO 6 MIL THICK



CURRENT STATE - CLEANING

With the new liner in place, cleaning the shaft walls to remove hazards is more effective and lends a higher degree of confidence prior to shaft work



Shaft wall before cleaning



Same wall section cleaned using only low-pressure water through extended blowpipe nozzle



PROJECT OUTCOME



- The PCM liner was installed to the brow of the loading pocket in the shaft
- Learning Curve
- Planning was Key
- Safety
 - 0 (zero) reportable accidents and 0 (zero) chemical exposures
- Next Steps
 - Record the performance of the liner over time and build learning from the project, as well as experience gained from working with the liner, into the next application



CURRENT STATE & TESTIMONIALS



- Historically, salt buildup from dust and humidity on rough and irregular bare salt created hazards that were very difficult to identify and mitigate in the shaft. With the new liner in place, identification and removal of hazards are much more definitive and effective.
 - “We approached the manufacturer with an idea that had never been done before. We wanted to use their polymeric spray to line the shaft, and they agreed.” – *Engineering Director of Strategic Mine Projects*
 - “Our employees have shared with me that they’ve never seen conditions as good as they are now.” – *Maintenance Foreman*
- This confidence was very noticeable when the crew recently changed the tail (balance) ropes on the hoisting skips – a project that had to be completed from the bottom of the shaft.
 - “The ability to clearly identify clean shaft walls gives a lot of confidence when we’re working in the shaft.” – *Shaftsman*
 - “You can see the comfort level in the men while being surrounded by that shaft.” – *Maintenance Foreman*

