FGI Webinar: Lithium Solar Evaporation Pond Geomembrane Durability

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Date: April 9, 2026

Overview and Purpose

This webinar presents a detailed technical investigation into the durability and performance of PVC geomembrane panels used in lithium solar evaporation ponds in the Atacama Desert of northern Chile. The study was prompted by an unusual real-world scenario: a large shipment of factory-fabricated PVC geomembrane panels was left exposed and uninstalled in one of the world's harshest environments for approximately five years due to installation delays. The central question of the presentation is whether those panels — after five years of UV exposure, extreme heat, and persistent high winds — still met the applicable FGI material specifications. The findings carry significant implications for procurement, storage, quality assurance, and installation best practices in the geosynthetics industry, particularly for large-scale mining and evaporation pond applications.

The Lithium Triangle and the Salar de Atacama

The so-called "Lithium Triangle" encompasses northern Chile, southern Bolivia, and eastern Argentina, and represents one of the world's most significant concentrations of lithium resources. The presentation focuses specifically on the Salar de Atacama in northern Chile, the largest salt flat in the country. The Salar hosts two major lithium production operations, with the northern facility being the primary subject of this study. The nearest logistics hub is the port city of Antofagasta, through which geomembrane samples were shipped back to the United States for laboratory testing. The nearest town to the facility is San Pedro de Atacama, located approximately 7,900 feet above sea level on a high Andean plateau, about 90 minutes by road from the Salar. The presenter visited the site in July 2022, during the tail end of global COVID-19 restrictions, and described both the logistical and environmental challenges of fieldwork at this remote, high-altitude desert location.

The Lithium Extraction Process and Role of Geomembranes

Lithium extraction at the Salar de Atacama relies on a solar evaporation process that is both massive in scale and dependent on geomembrane integrity. Brine rich in lithium, potassium, and boric acid is pumped from subsurface wells into a series of 15 sequential evaporation ponds. Over a period of approximately 18 months, the liquid brine progresses through all 15 ponds, gradually evaporating under the intense desert sun and afternoon winds until it yields a solid salt product approximately three feet deep. This salt contains lithium carbonate and other valuable minerals that are then excavated and processed.

Each pond is roughly three feet deep, approximately one mile long, and about a quarter mile wide. The ponds are lined with PVC geomembrane to prevent brine loss into the subsurface, which would directly translate to lost revenue and reduced lithium yield. The geomembrane is therefore a mission-critical containment component. Any failure or breach results in economic loss and potential environmental impact. The Salar de Atacama environment is exceptionally demanding: daytime temperatures exceed 100°F, UV radiation is intense at altitude, and strong winds occur every afternoon without exception. These conditions make geomembrane durability and proper installation practices especially critical.

Panel Specifications and Factory Fabrication

The geomembrane panels specified for this project are 30 mil thick PVC, selected for their flexibility, weldability, and track record in similar applications. Factory fabrication was employed to produce large panels that minimize the amount of field seaming required, reducing worker exposure time in the harsh Salar environment. Each panel consists of five individual rolls, each 2.16 meters wide, seamed together in the factory with four longitudinal welds to produce a final panel width of 10.8 meters.

Two shipments were involved in this study. The first comprised 224 panels, each 260 meters long, yielding a panel area of approximately 2,800 square meters. The second shipment consisted of 186 panels, each 320 meters long, with a panel area of approximately 3,400 square meters. Combined, the two shipments totaled 410 panels covering approximately 1.3 million square meters, or roughly 13.7 million square feet of geomembrane — a scale that underscores the enormous material demands of this type of operation. Panels were seamed using dual-track wedge welding, which produces an inner and outer weld track with an air channel between them, enabling non-destructive pressure testing of the seam integrity. Panel weights were approximately 3 tons (6,000 lbs) each, and panels were rolled and stored at the Salar site.

Typical panel sizing is governed by allowable shipping weights. The FGI website provides a panel weight calculator that allows engineers to input geomembrane polymer type and allowable shipping weight to determine optimal panel dimensions — a useful practical tool highlighted during the presentation.

Environmental Exposure and Storage Conditions

A critical aspect of this study is that the 410 panels were never installed. Following procurement and delivery, installation was delayed for approximately five years, during which time the rolled panels sat exposed in the Salar de Atacama. Some panels had protective plastic wrapping; others did not, or had wrapping that was torn or damaged. Exposed rolls showed visible weathering and windblown salt accumulation on their surfaces.

Perhaps most significantly, the intense desert heat caused the tightly wound panel layers to partially fuse or stick together over the five-year period, making it extremely difficult to separate individual layers during sampling. This thermal bonding effect had direct implications for measured thickness values, as compressed and fused layers produced slightly thinner readings than factory specifications. The harsh storage conditions — UV radiation, temperatures exceeding 100°F, constant wind, and zero precipitation — represent an extreme upper bound for geomembrane exposure, making the durability findings particularly noteworthy.

Sampling Strategy and Quality Acceptance Criteria

The project acceptance specification required that no more than 10% of the shipment could fail to meet the FGI 1115 (January 1, 2015) PVC geomembrane standard. This contractual framework meant that only one panel needed to pass testing for the entire shipment of 410 panels to be accepted. To test 10% of the shipment by area, 45 panels needed to be sampled and tested (10% of 1.3 million square meters divided by the minimum panel area of 2,800 square meters equals approximately 45 panels).

The initial sampling plan involved unrolling each panel in the field and cutting specimens. This approach was quickly abandoned after one attempt, when afternoon winds made it impossible to control the unrolled geomembrane — the entire field crew was forced to lie down on the membrane to prevent it from blowing away. Plan B was adopted: removing the outermost layers of each rolled panel and sampling from the sixth layer down, on the premise that deeper layers would have been better protected from UV and thermal degradation during storage. There was no ASTM protocol dictating the six-layer depth; it was a pragmatic on-site engineering judgment based on roll geometry and layer thickness.

Sampling was conducted using custom-made templates to ensure consistent specimen sizing. From each panel, three sample pieces were collected: a central piece capturing the middle roll and its two adjacent seams (approximately 2.4 m wide by 1 m long), and two outer seam strips (approximately 0.45 m wide by 6 m long each). All samples were rolled into tubes, labeled, sealed, and shipped to JP Klein at Geotechnics in Pittsburgh for laboratory testing. The two-person field team that conducted all cutting and sampling was described by the presenter as exceptional, given the physically demanding and time-consuming nature of the work.

Laboratory Test Results: Parent Material

Testing followed the FGI 1115 specification across five primary material properties. Results for each are summarized below.

Thickness (ASTM D5199)

The specification requires 30 mil ± 1.5 mil, or a range of 28.5 to 31.5 mil. Many of the 45 panels fell within this range, with some falling below 28.5 mil — attributed to layer compression and thermal bonding during five years of storage in extreme heat. Since the acceptance criterion required only one panel to pass, and multiple panels did, the shipment met the thickness specification.

Dimensional Stability (ASTM Standard)

The specification allows a maximum dimensional change of ± 3% after oven heating. In the machine direction, 15 of 45 panels met this criterion. In the cross-machine direction, all 45 of 45 panels met the requirement. The shipment passed dimensional stability testing in both directions, with notably superior stability in the cross-machine direction.

Tear Strength (ASTM D1004)

The minimum requirement is 8 pounds. All 45 panels exceeded 8 pounds in both the machine direction and the cross-machine direction — a clean pass with no borderline results.

Tensile Strength (ASTM D882)

The minimum requirement for 30 mil PVC under FGI 1115 is 73 pounds per inch. In the machine direction, 43 of 45 panels met the requirement. In the cross-machine direction, only 3 of 45 panels exceeded 73 lbs/in, with the remaining 42 falling just below — in the range of approximately 70 lbs/in. However, since even one panel meeting the requirement satisfies the acceptance criterion, the shipment passed in both directions.

Tensile Elongation at Break (ASTM D882)

The minimum requirement is 380% elongation. In the machine direction, 15 panels met or exceeded 380%. In the cross-machine direction, 13 panels met the requirement. The shipment passed in both directions.

Tensile Modulus at 100% Elongation (ASTM D882)

The minimum requirement is 32 pounds per inch. All 45 panels exceeded this threshold in both the machine direction and the cross-machine direction — another clean pass with strong margins.

Laboratory Test Results: Seam Performance

Seam quality was evaluated for both peel strength and shear strength, testing both the inner and outer tracks of the dual-track wedge welds. With four seams per panel and 45 panels tested, 180 seams were evaluated in total.

Peel Strength

The minimum peel strength requirement is 15 lbs/in. For the inner track, 179 of 180 seams met the specification; one seam recorded 14.3 lbs/in, just below the threshold. For the outer track, all 180 of 180 seams met the requirement. Overall, peel strength performance was excellent and the shipment clearly met specification. The presenter noted that peel strength is the more structurally relevant seam property for these shallow ponds, given that the ponds are only approximately one meter deep with relatively low hydraulic forces on the liner seams.

Shear Strength (Seam Strength)

The minimum shear strength requirement for 30 mil PVC under FGI 1115 is 58.4 lbs/in. Only 18 of 180 seams (approximately 10%) met this threshold. However, 176 of the 180 seams recorded values above 51.3 lbs/in, indicating a tight clustering just below specification — not a catastrophic failure but a measurable degradation. Two seams recorded values below 50 lbs/in (approximately 45 and 49 lbs/in respectively).

The presenter offered a significant explanatory context for the shear strength shortfalls: ASTM D3045 data on heat aging of plastics without load suggests that seam peel and shear strength can degrade by 30 to 35% in elevated temperature environments over extended periods. Five years of storage at temperatures exceeding 100°F in the Salar de Atacama is consistent with this degradation mechanism. Despite the lower shear values, the acceptance criterion was still met because at least one seam per panel exceeded 58.4 lbs/in. The presenter emphasized that shear strength is a less critical parameter for these specific applications than peel strength, given the shallow pond geometry and the parallel orientation of seams relative to the embankment slopes.

Installation Recommendations and Cross-Section Design

The FGI has published a dedicated guideline for desert installation of fabricated geomembrane panels, available on the FGI website, which the presenter strongly recommended for any projects in similar environments.

The recommended pond liner cross-section consists of a compacted subgrade (ideally with a clay or fine-grained soil cap), overlain by the 30 mil PVC geomembrane, covered by approximately 0.3 meters (one foot) of protective salt, above which brine accumulates to approximately one meter depth. The geomembrane should extend up and across the full width of the embankment crest — not terminate at the brine waterline — because afternoon winds generate wave action that can overtop embankments. Since embankments are constructed from dried salt, wave overtopping and dissolution could compromise structural integrity.

For the liner system itself, the presenter recommended nonwoven geotextile cushion layers both above and below the geomembrane where the subgrade or cover material is angular or coarse (e.g., salt). If a fine-grained clay subgrade cap is used, the bottom cushion may be omitted. If reinforced geomembranes are used, cushion geotextiles may not be required at all. Light-colored (white or gray) geomembranes are preferred to reduce solar heat absorption in this high-UV environment.

A practical protective measure recommended for the salt excavation phase is placing a brightly colored warning tarp or geomembrane sheet directly on top of the protective salt cover layer. Front-end loader operators working at height have difficulty seeing the geomembrane below, and a visible color indicator prevents inadvertent excavation damage to the liner.

Leak location surveys should be conducted after the protective salt cover is placed but before ponding begins, ensuring that any liner defects are identified and repaired under accessible, dry conditions.

Key Findings and Conclusions

The central finding of this study is that 30 mil PVC geomembrane panels, after five years of unprotected exposure in one of the world's most demanding environments, still met the FGI 1115 acceptance specification across all tested parameters. This is a remarkable demonstration of PVC geomembrane durability and resilience. However, the data also shows measurable degradation — particularly in seam shear strength and, to a lesser extent, tensile properties and thickness — relative to factory test values. The results confirm that five years of harsh exposure does inflict cumulative damage, even if that damage does not cross specification thresholds under the applicable acceptance criteria.

The presenter draws a clear and unambiguous practical conclusion: geomembranes and geosynthetics should be installed as soon as possible following delivery. Prolonged outdoor storage — particularly in high-UV, high-temperature, high-wind environments — introduces avoidable risk of material degradation, installation difficulty (due to layer fusion), and potential long-term performance reduction. The fact that this shipment passed despite five years of extreme exposure should not be interpreted as license to delay installation; rather, it should be understood as evidence of the material's robustness under conditions that should never be deliberately replicated.

Q&A Highlights for Expert Review

Several questions from the live audience surfaced technically important points that complement the formal presentation:

Oxidative stress from brine: The presenter noted no documented concern about oxidative degradation of the geomembrane from brine contact, given that the liner is buffered by a 0.3-meter protective salt cover layer. These liners have been in service in the Salar since the 1960s with a strong track record.

Subgrade preparation: The angular, highly irregular native salt surface of the Salar is unsuitable as a direct subgrade. A prepared subgrade with a clay or fine-grained cap is required. Cushion geotextiles are used where fine subgrade cannot be guaranteed.

Field seaming: The 410 panels in this study were never installed, so no field seam data was generated. On other installed ponds, field seams are used but the intent is always to minimize their number through large factory panel sizes.

Labor requirements: Installation of panels of this scale and complexity would require specialized geomembrane installation labor, not general construction labor.

Fold and crease deterioration: No visible crease damage was observed at fold lines when panels were unrolled for sampling, despite five years of storage in a compressed folded state.

Non-uniform roll diameter: The visible irregular (bumpy) profile of the stored rolls is due to seam overlap zones creating locally thicker sections within the rolled panel — a normal result of factory fabrication geometry, not a defect.

Comparison to factory test data: Field test results were generally consistent with factory pre-shipment data, with some slightly lower values for seam strength and thickness, consistent with the thermal compression and aging mechanisms described above.

Stress crack resistance: Not evaluated for PVC geomembranes, which are substantially more flexible than HDPE and therefore not subject to the same stress cracking failure modes.

References and Resources

- FGI 1115 (January 1, 2015): FGI PVC Geomembrane Standard — the governing specification for this project
- ASTM D5199: Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
- ASTM D1004: Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
- ASTM D882: Standard Test Method for Tensile Properties of Thin Plastic Sheeting
- ASTM D3045: Standard Practice for Heat Aging of Plastics Without Load
- FGI Desert Installation Guideline for Fabricated Geomembrane Panels — available at FGI website
- FGI Panel Weight Calculator — available at FGI website
- Geosynthetics Magazine (2007): "Massive Mining Evaporation Ponds Constructed in the Chilean Desert" — co-authored by Tim Stark
- Next FGI Webinar: Geomembrane Baffle Curtains to Enhance Water and Wastewater Treatment — Brian Frasier and Justin Gothro, Layfield Geosynthetics, May 5th, noon Central Time
- FGI Associate Membership: $350/year — includes all webinars, PDH credits, technical topics, and online learning center access