FGI Webinar: April 9, 2026

Lithium Solar Evaporation Ponds: Geomembrane Durability

Presented by:

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Outline

- Lithium Triangle
- COVID
- San Pedro De Atacama
- Drive to Salar De Atacama
- Factory Fabricated PVC GM
- Testing Requirements
- Sampling
- Test Results
- Installation
- Summary

Location

- **Lithium triangle**

Salar de Atacama, Chile

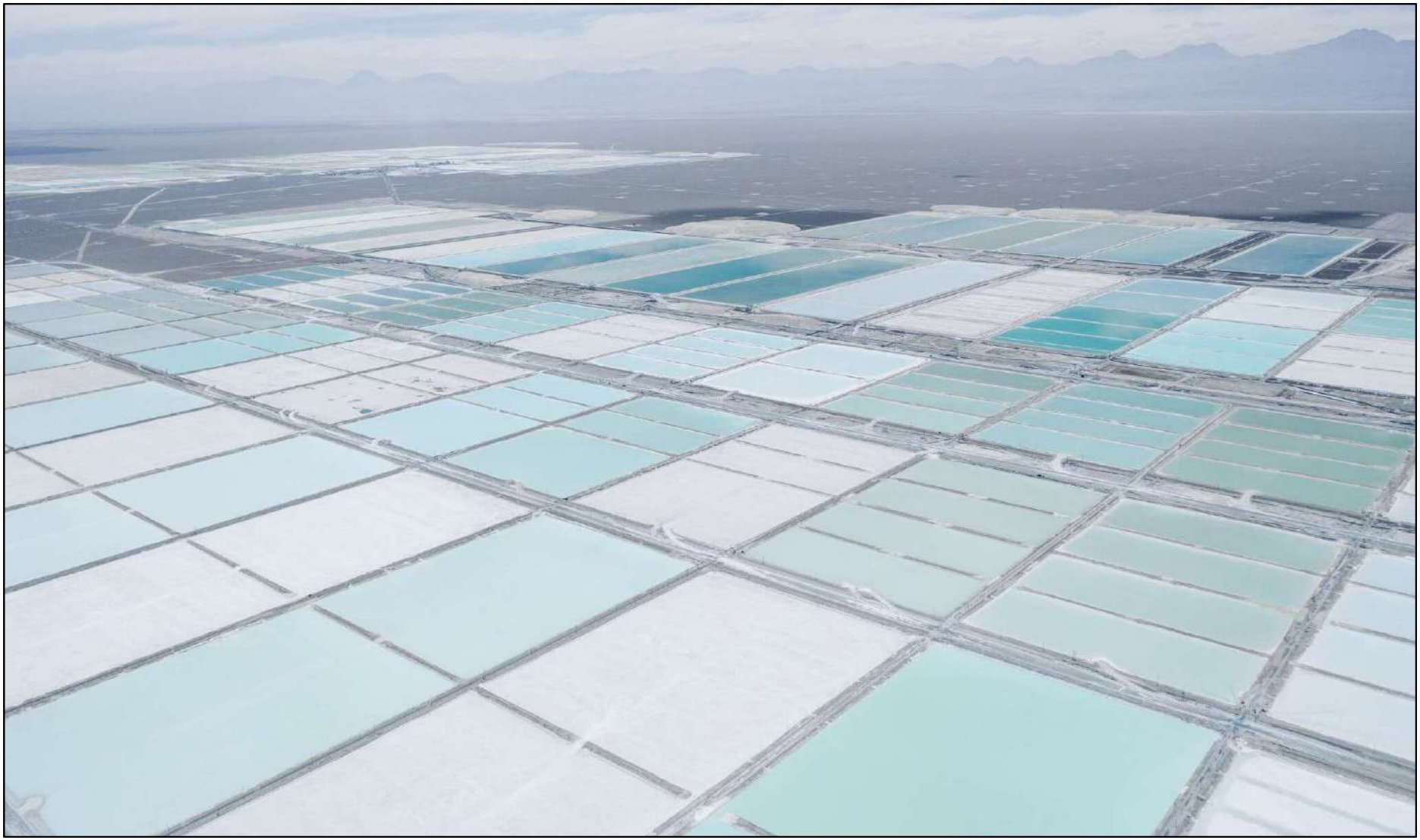
- **Largest salt flat in Chile**

Salar de Atacama, Chile

- **Two big producers**

Salar de Atacama

- ~15 ponds per system
- 18 months to complete system



Subsurface Brine

- **Well brine**
- **Lithium carbonate**

Pond Operations

- Lined ponds hold pumped brine
- Ponds ~ 3 ft deep, 1 mile x ¼ mile (6000 ft x 2000 ft)
- 20 to 30 mil thick PVC geomembrane panels
- Panel size = 2000 ft x 50 ft to reduce field seaming
- Panels weigh ~3 tons (~6,000 lbs)
- Panels seamed using wedge-welders & solvents
- Seams are tested destructively and/or non-destructively
- Entire pond checked by leak location techniques
- PVC placed on compacted clay subgrade
- PVC protected with finely crushed salt layer

Pond Operations

- Wells drilled to pump brine into ponds
- Water evaporates from brine leaving mineral rich salt
- Salt is excavated from ponds and salts separated
  - Potassium (fertilizer)
  - Lithium (batteries – largest source)
  - Boric Acid
- Geomembrane must function otherwise brine/$ is lost!!
- One-year of evaporation yields 3 feet of salt

Brine

Brine

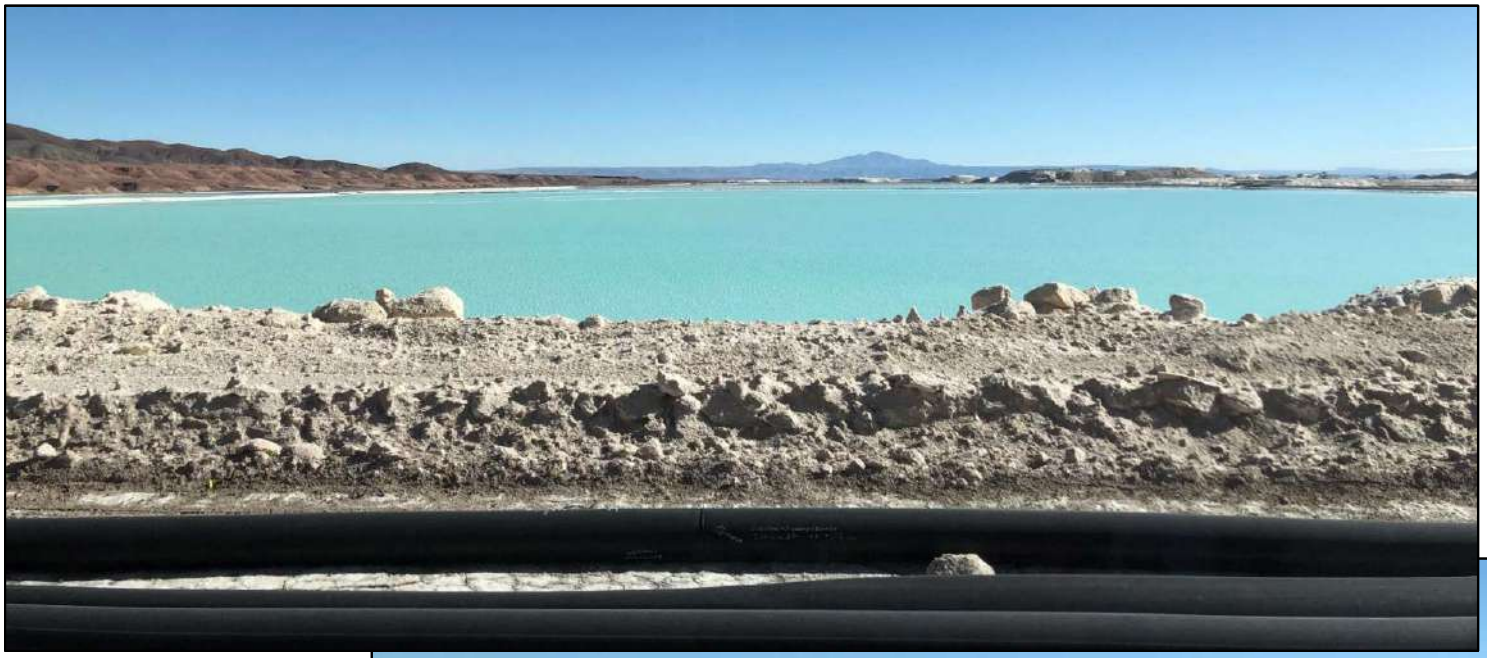
Salar de Atacama, Chile

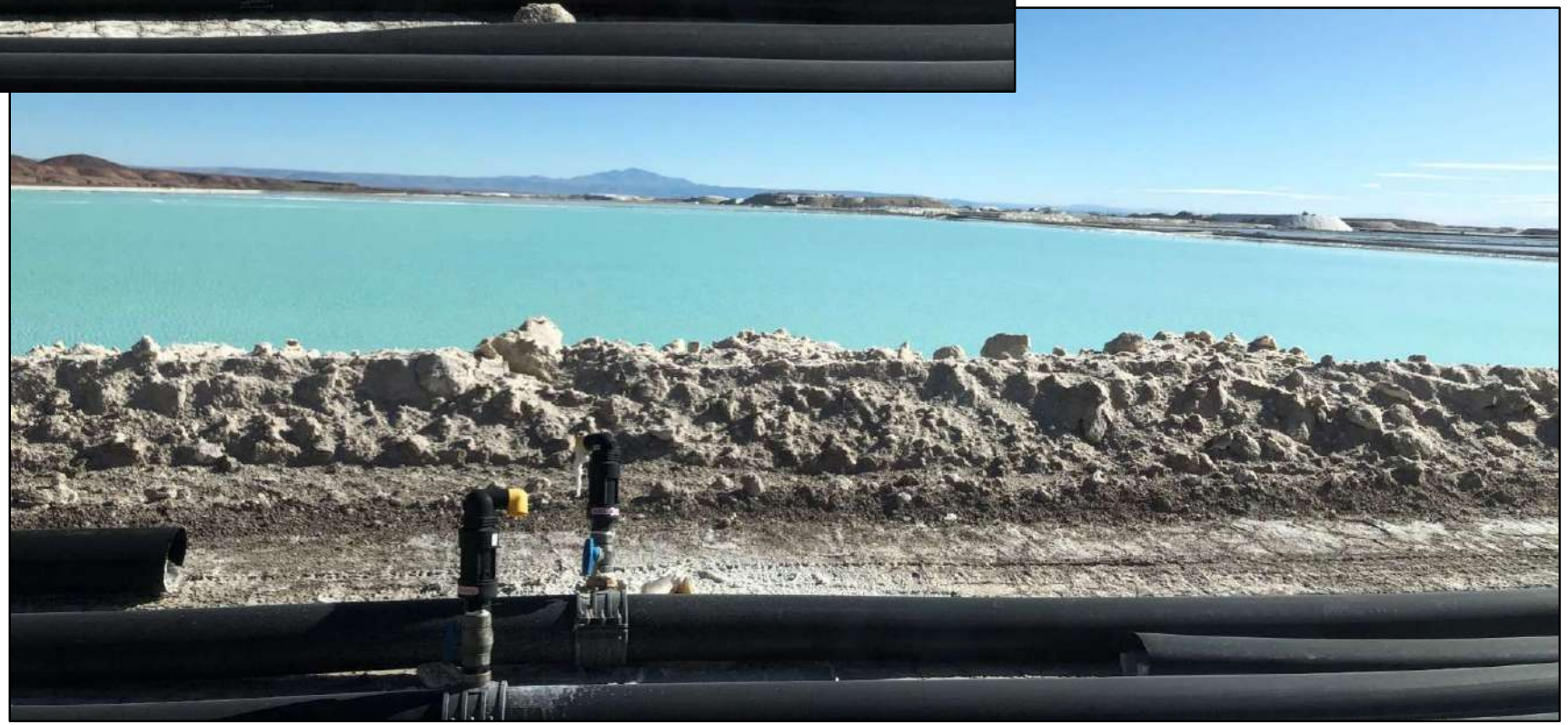
Salt Flat

Solar Pond Best Practices

Fuente Bolsa de comercio de Rosario Photos

Solar Pond Best Practices





Brine

Salar de Atacama, Chile

- **Sunshine and afternoon winds**

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COVID

COVID

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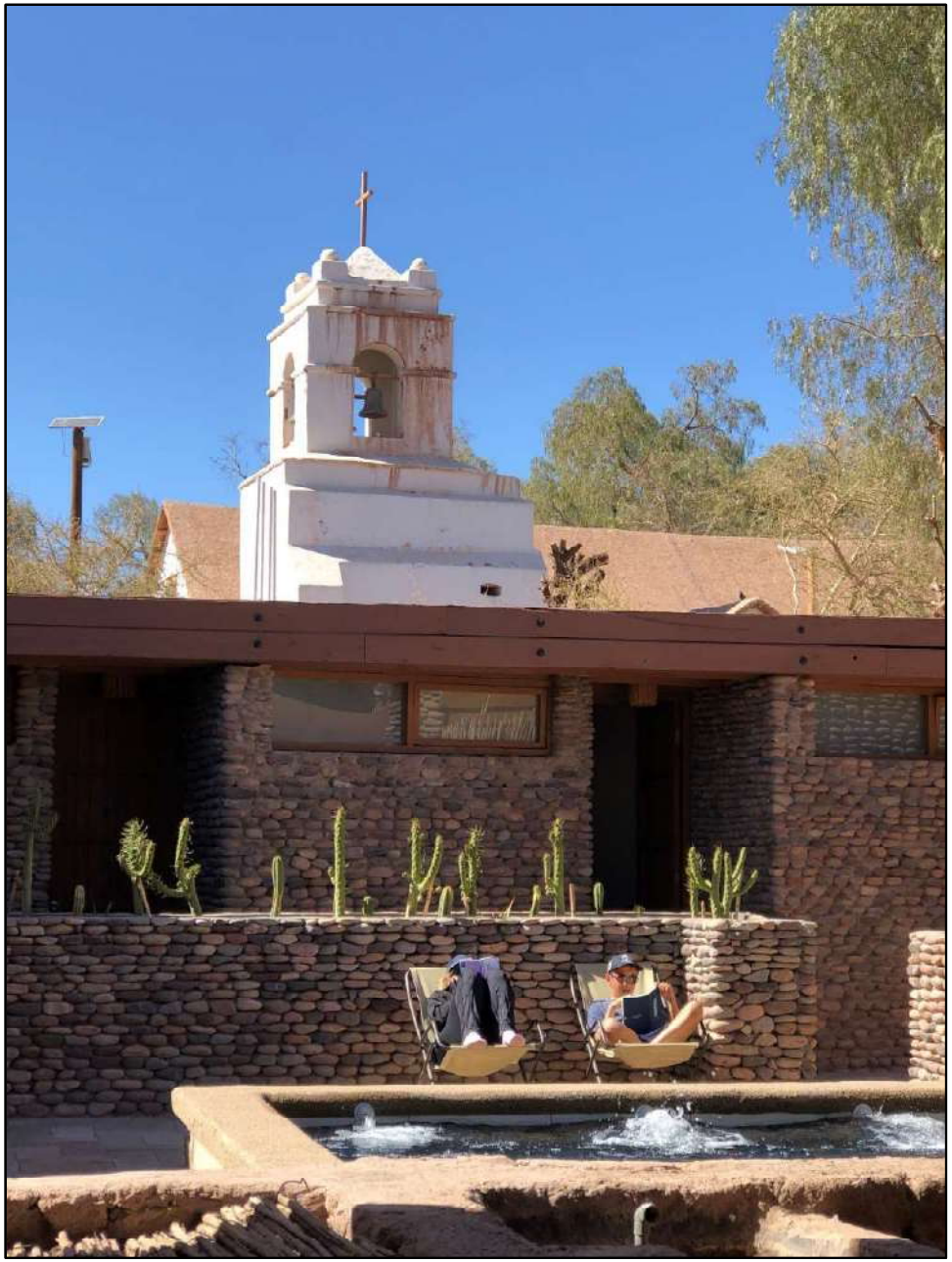
San Pedro De Atacama

- 5 days
- El. +7,900 ft
- 2012 Population ~ 11,000
- Arid high plateau in Andes Mountains
- Steaming geysers
- Hot springs
- Volcanic peaks
- Sandstone canyons
- Desert and salt flats

San Pedro De Atacama

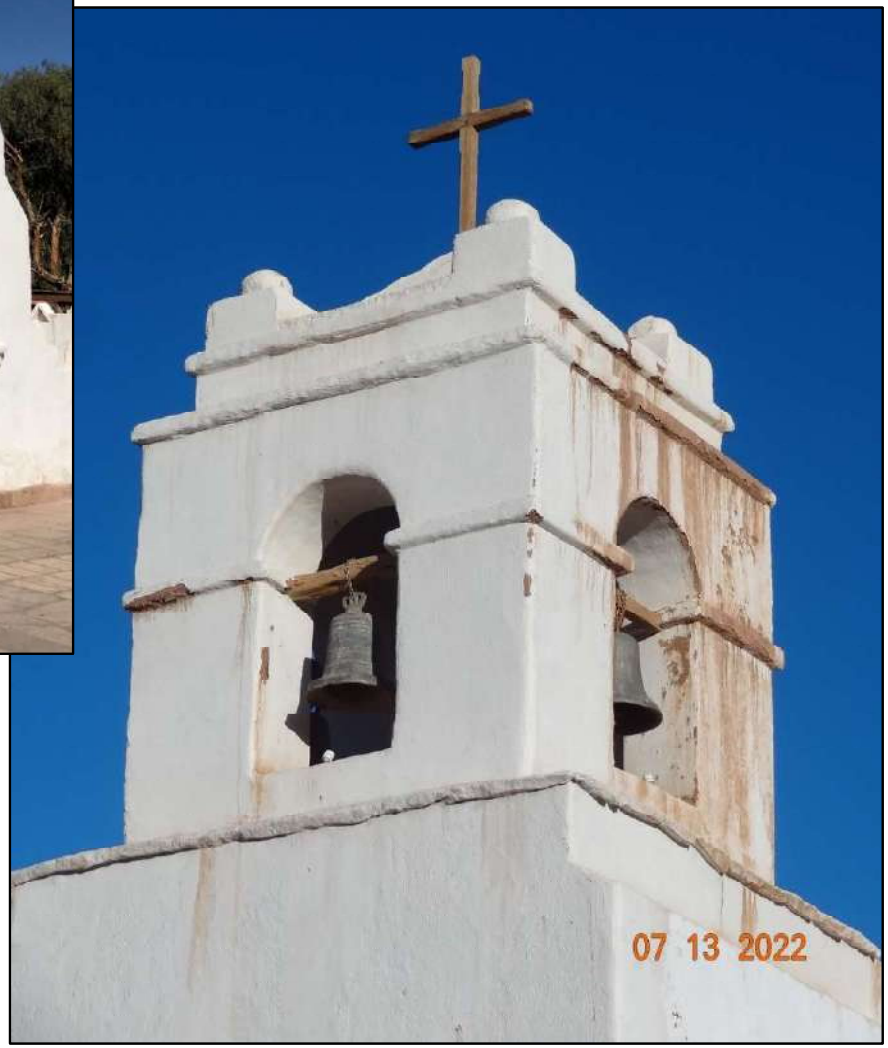
San Pedro De Atacama

San Pedro De Atacama to Salar



San Pedro De Atacama

San Pedro De Atacama



San Pedro De Atacama

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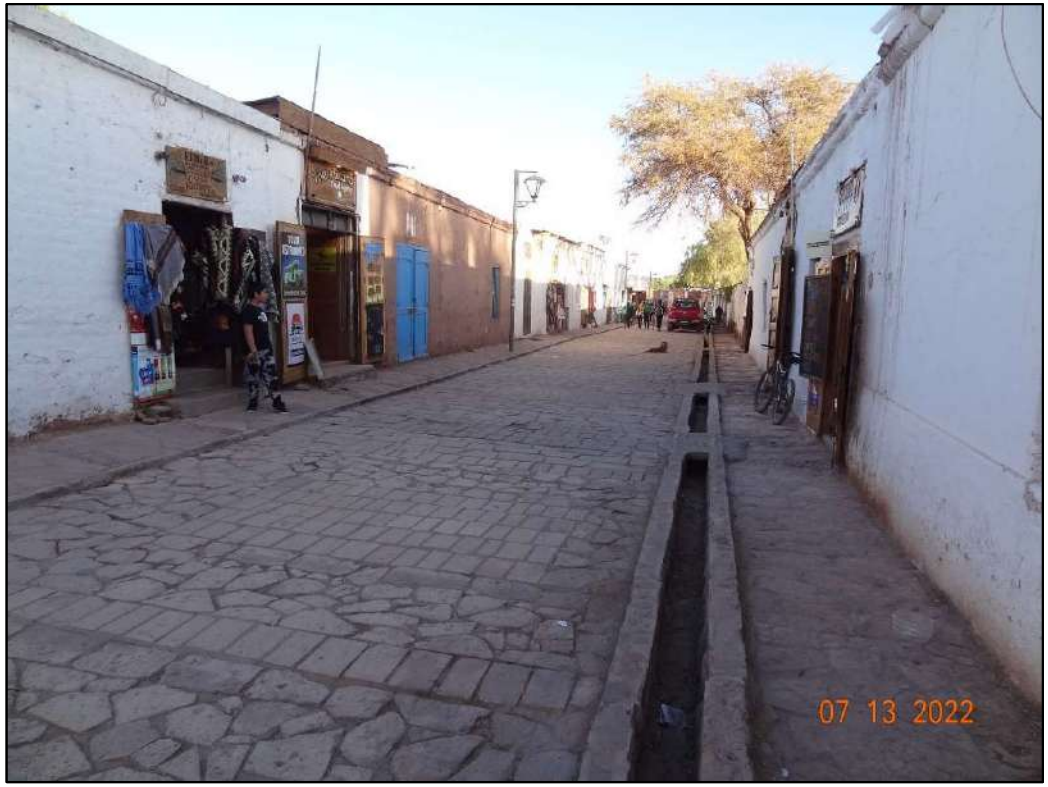

San Pedro De Atacama

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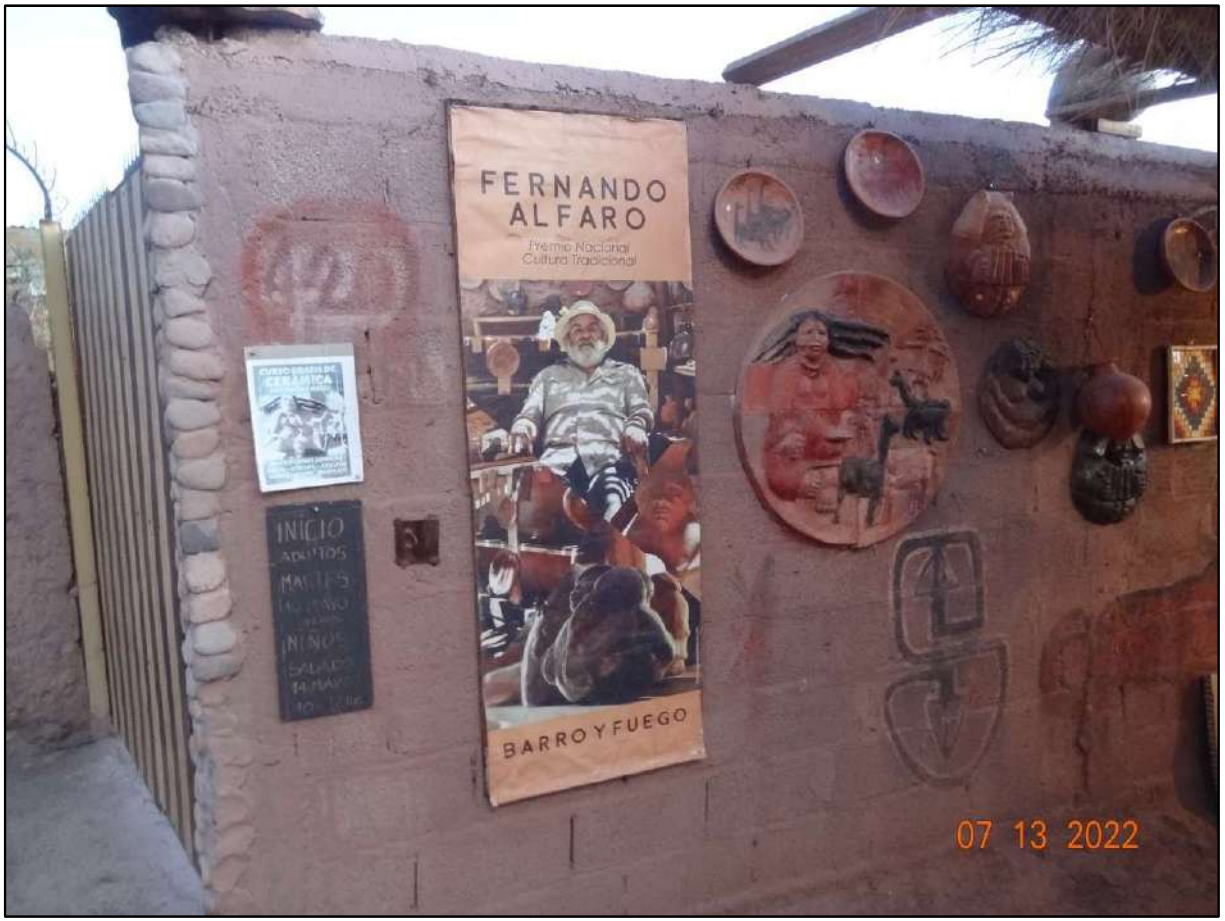

San Pedro De Atacama

San Pedro De Atacama

Volcanes

Volcanic Features

Astronomy

Puritama River Canyon

Geysers

Little Valley

Rainbow Valley

Lake Cejar-Salt

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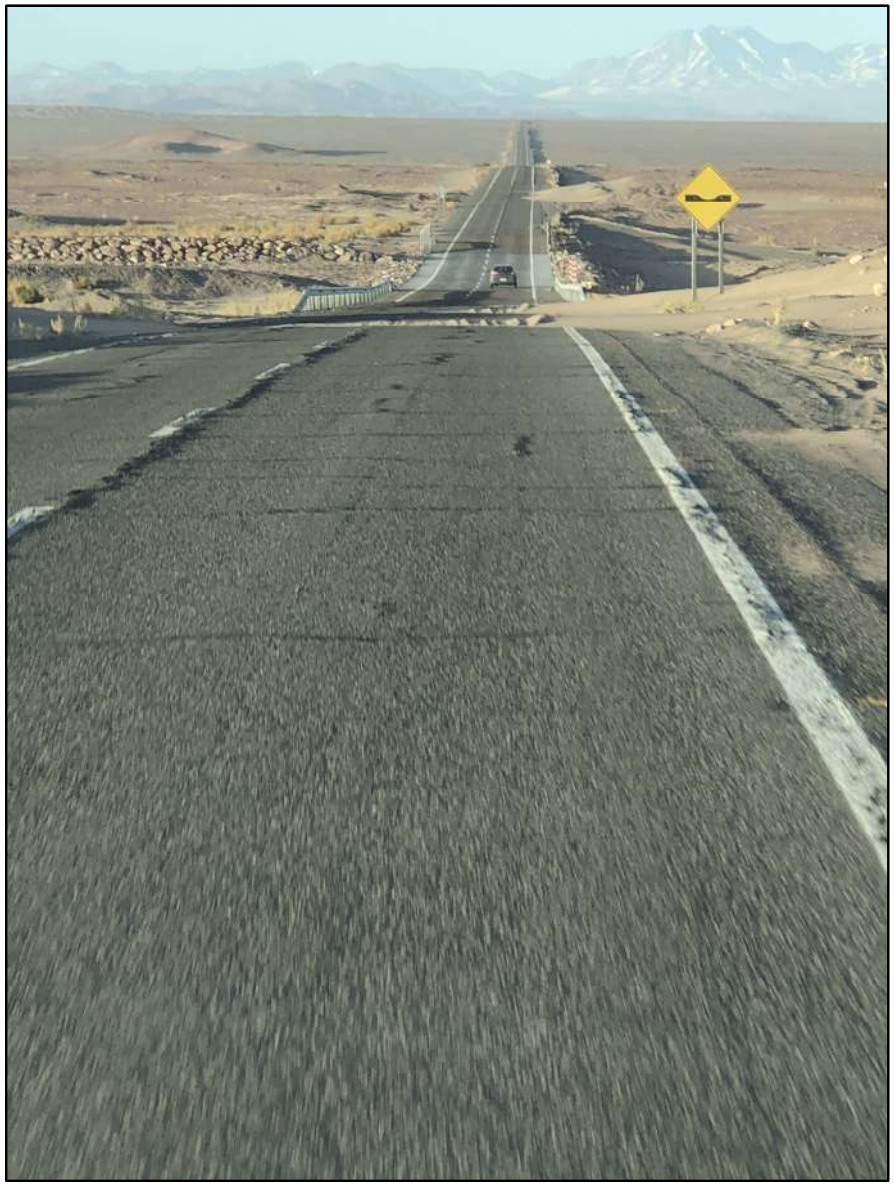
San Pedro De Atacama to Salar

- ~1.5 hours drive each way



San Pedro De Atacama to Salar

San Pedro De Atacama to Salar

- Most southerly latitude at which the sun can appear directly overhead at noon

Atacama Large Millimeter Array

https://www.almaobservatory.org/en/home/

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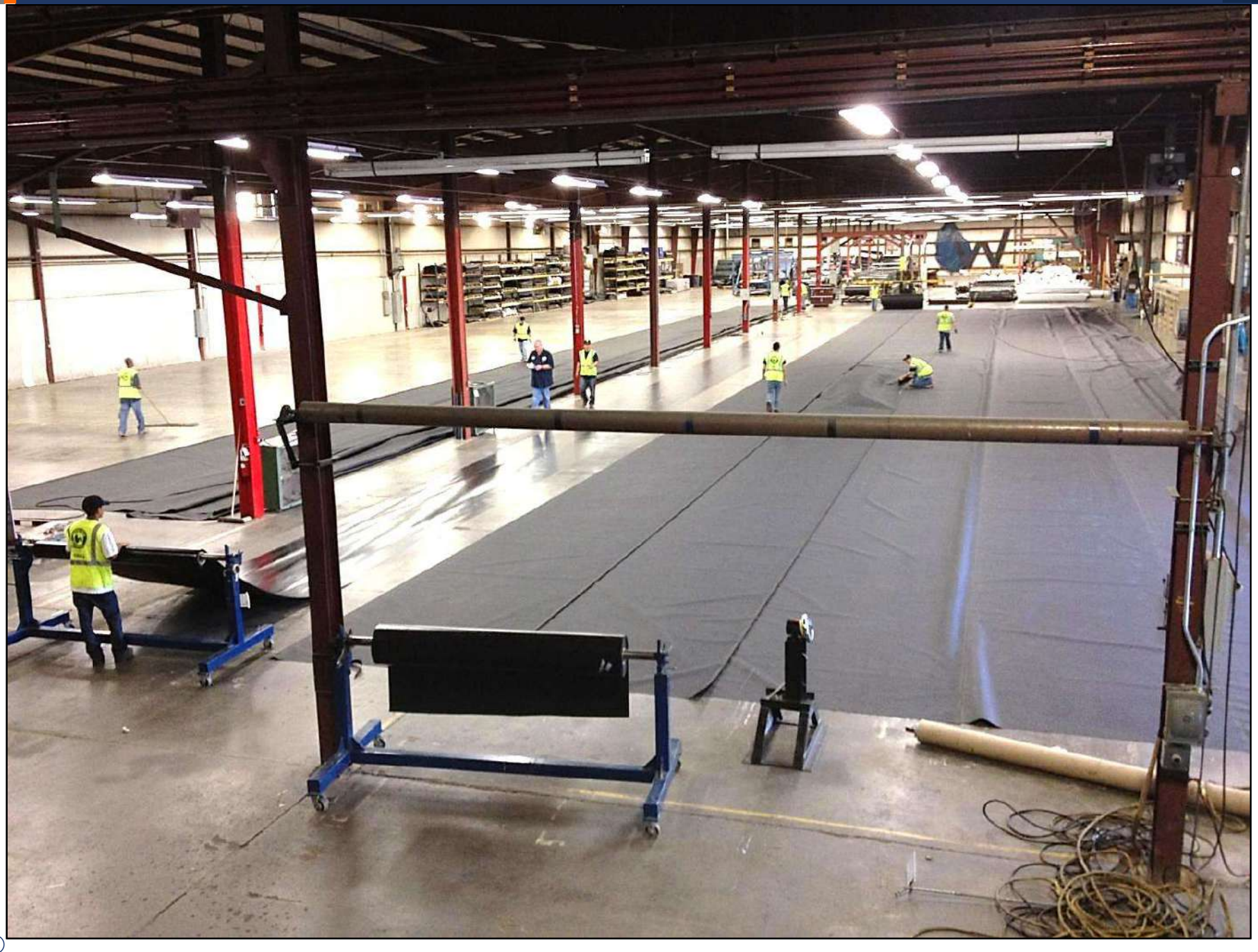
Solar Evaporation Pond Liner

Factory Fabrication



Deploying Large Panels

Salar de Atacama

Typical Factory Panel Sizes

Geomembrane and Thickness	Weight per Area (lbs/ft^2)	Typical Panel Area (ft^2)	Typical Panel Dimensions (ft)
40 mil LLDPE	**0.195**	30,770	150 ft*205 ft
30 mil PVC	**0.189**	31,745	150 ft*210 ft
30 mil Ethylene Interpolymer Alloy (EIA)	**0.22**	27,270	150 ft*180 ft
36 mil Reinforced Polypropylene	**0.165**	36,360	180 ft*200 ft

- **FGI panel weight calculator**
- **Used 850 to 1,050 ft x 35 ft wide (30,185 to 37,150 ft^2 or 2,808 to 3,456 m^2) to reduce field seaming**

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6 Geomembrane Shipments

- **30 mil PVC Geomembranes**
- **Three pools**

# of Panels	Panel Length	Panel Width	Panel Area	Total Area
224	260 m	10.8 m	2,808 m^2	628,922 m^2
186	320 m	10.8 m	3,456 m^2	642,826 m^2
Totals				
410 panels				**1,271,808 m^2** **13,689,627 ft^2**

- **Each panel = 5 rolls each 2.16 m wide welded together = 10.8 m**
- **4 welds/panel**

Testing Requirement

- Shipment accepted if less than 10% do not meet specifications
- FGI 1115
- Test 10%, if one roll passes, shipment passes
- 410 panels = shipment

FGI 1115

Fabricated Geomembrane Institute

FGI 1115-PVC Specification[1]

Effective January 1, 2018

Certified Properties[2]	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Thickness	D-5199	10 ±0.5 mil 0.25±.013mm	20 ±1 mil 0.51 ±.03 mm	30 ±1.5 mil 0.76 ±.04 mm	40 ±2 mil 1.02 ±.05 mm	50 ±2.5 mil 1.27 ±.06 mm	60 ±3 mil 1.52 ±.08 mm
Tensile Properties[3]	D-882[4] Min (MD & TD)						
Strength at Break		24 lbs/in 4.2 kN/m	48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		250%	360%	380%	430%	430%	450%
Modulus at 100%		10 lbs/in 1.8 kN/m	21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	D-1004[4] (MD & TD) Min	2.5 lbs 11 N	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	D-1204[4] Max Chg (MD & TD)	4%	4%	3%	3%	3%	3%
Low Temperature Impact	D-1790[4,6,8] Pass	-10°F -23°C	-15°F -26°C	-20°F -29°C	-20°F -29°C	-20°F -29°C	-20°F -29°C
Index Properties[5]	**ASTM**	**PVC 10**	**PVC 20**	**PVC 30**	**PVC 40**	**PVC 50**	**PVC 60**
Specific Gravity	D-792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction Percent Loss (max)	D-1239[4] Max Loss	0.15%	0.15%	0.15%	0.20%	0.20%	0.20%
Average Plasticizer Molecular Weight	D-2124[4,5,7]	400	400	400	400	400	400
Volatile Loss Percent Loss (max)	D-1203[4] Max Loss	1.5%	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial	G160[4] Max Chg						
Break Strength		5%	5%	5%	5%	5%	5%
Elongation		20%	20%	20%	20%	20%	20%
Modulus at 100%		20%	20%	20%	20%	20%	20%
Hydrostatic Resistance	D-751[4] Min	42 psi 290 kPa	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa
Seam Strengths	**ASTM**	**PVC 10**	**PVC 20**	**PVC 30**	**PVC 40**	**PVC 50**	**PVC 60**
Adhesive Shear Strength[3,11]	D-0882[4] Min	20 lbs/in 3.47 kN/m	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20kN/m
Adhesive Peel Strength[3,11]	D-0882[4] Min	10 lbs/in 1.8 kN/m	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m
Thermal Shear Strength[3]	D-6392 Min	20 lbs/in 3.47 kN/m	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20kN/m
Thermal Peel Strength[3]	D-6392 Min	10 lbs/in 1.8 kN/m	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

Notes: 1. FGI 1115 replaces PGI 1104 Specification effective 1/1/15.

Testing Requirement

- Shipment = 1,271,808 m^2 (13.7M ft^2)
- 10% = 127,180 m^2 (1.37M ft^2)
- Minimum panel area = 2,808 m^2
- Test 45 panels (127,180 m^2/2,808 m^2=45.3 panels)

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Sampling

Sampling

Sampling

- Exposed for five years
- Harsh environment

Sampling

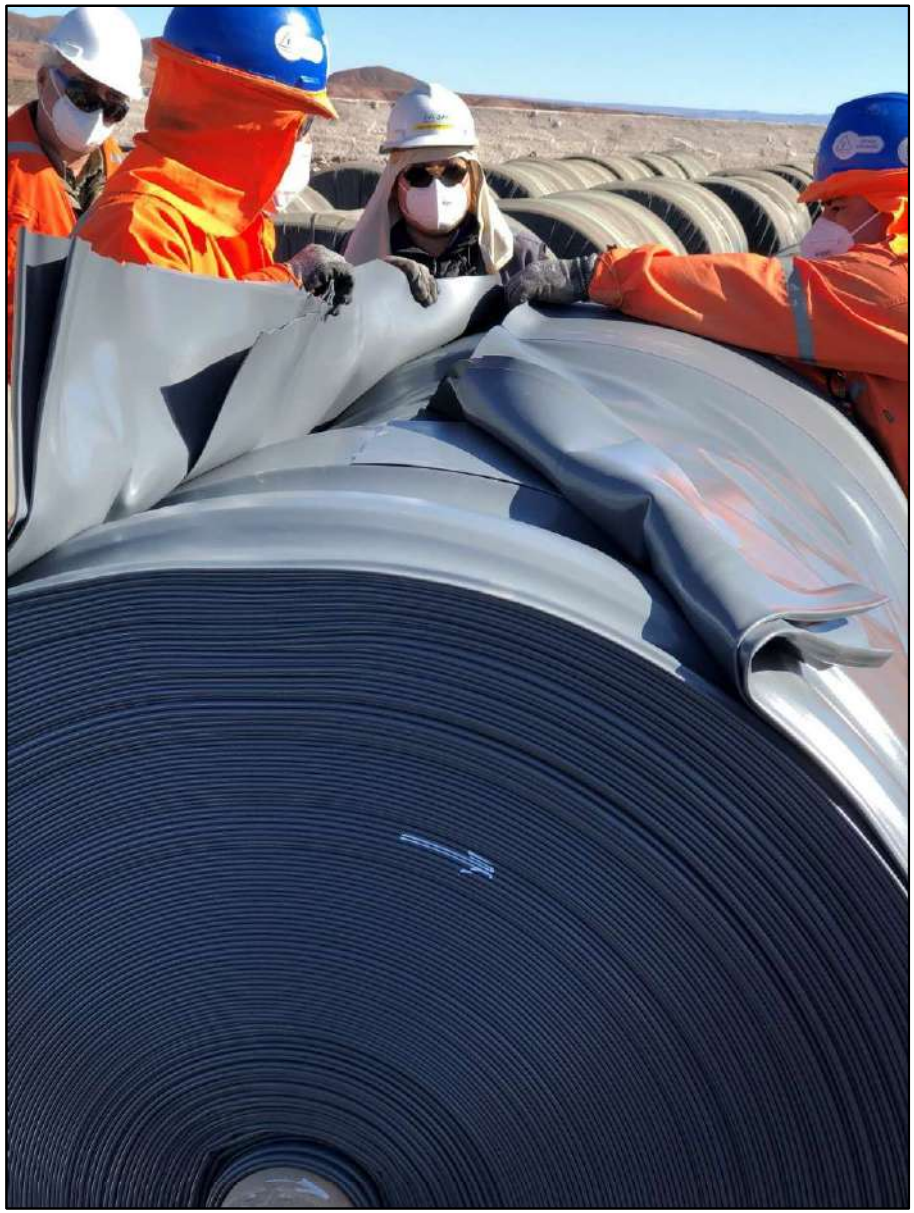
Sampling

Sampling

Sampling

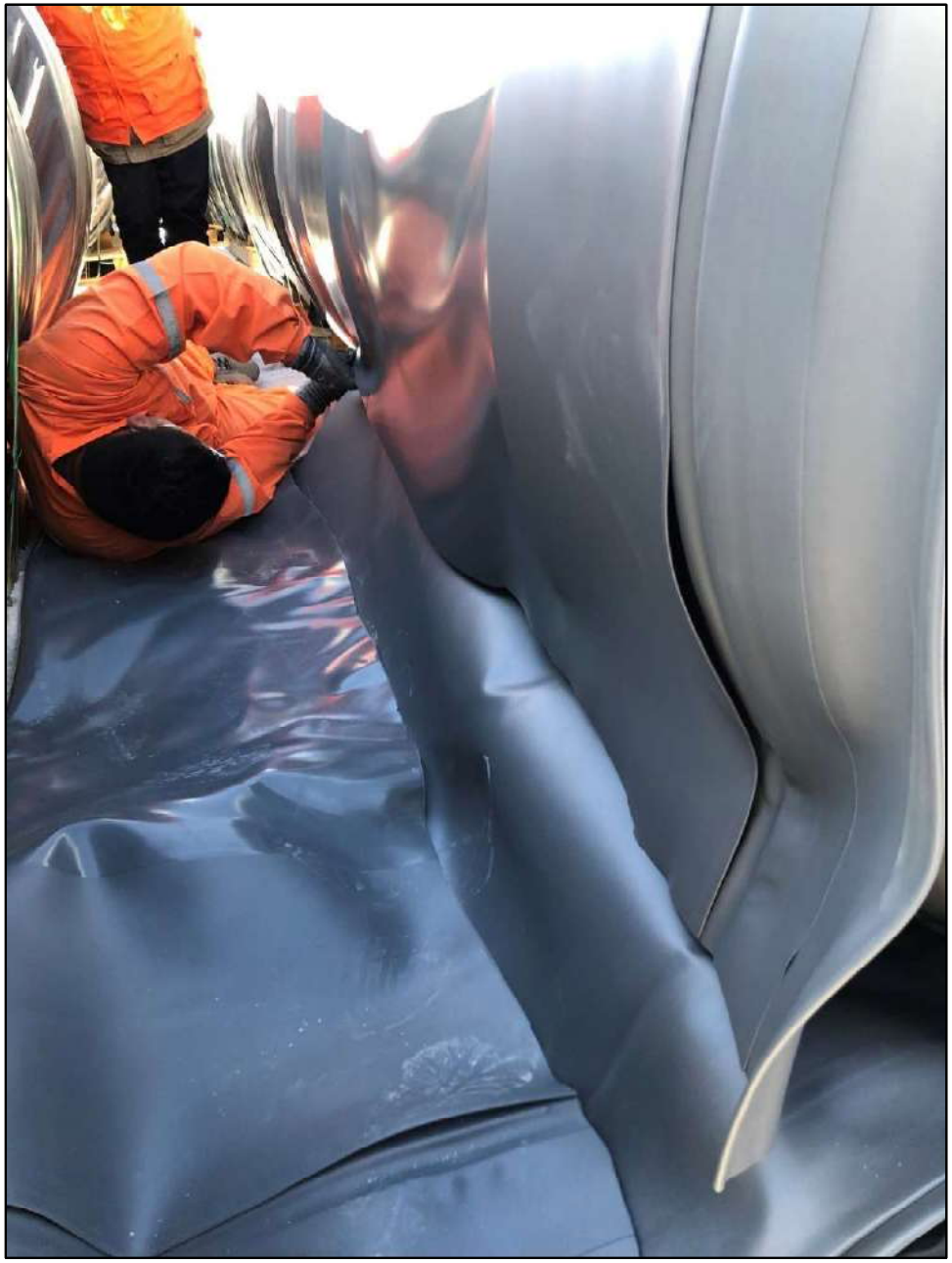
- Video

Sampling



- Cut off outer six layers

Sampling



Sampling

Sampling

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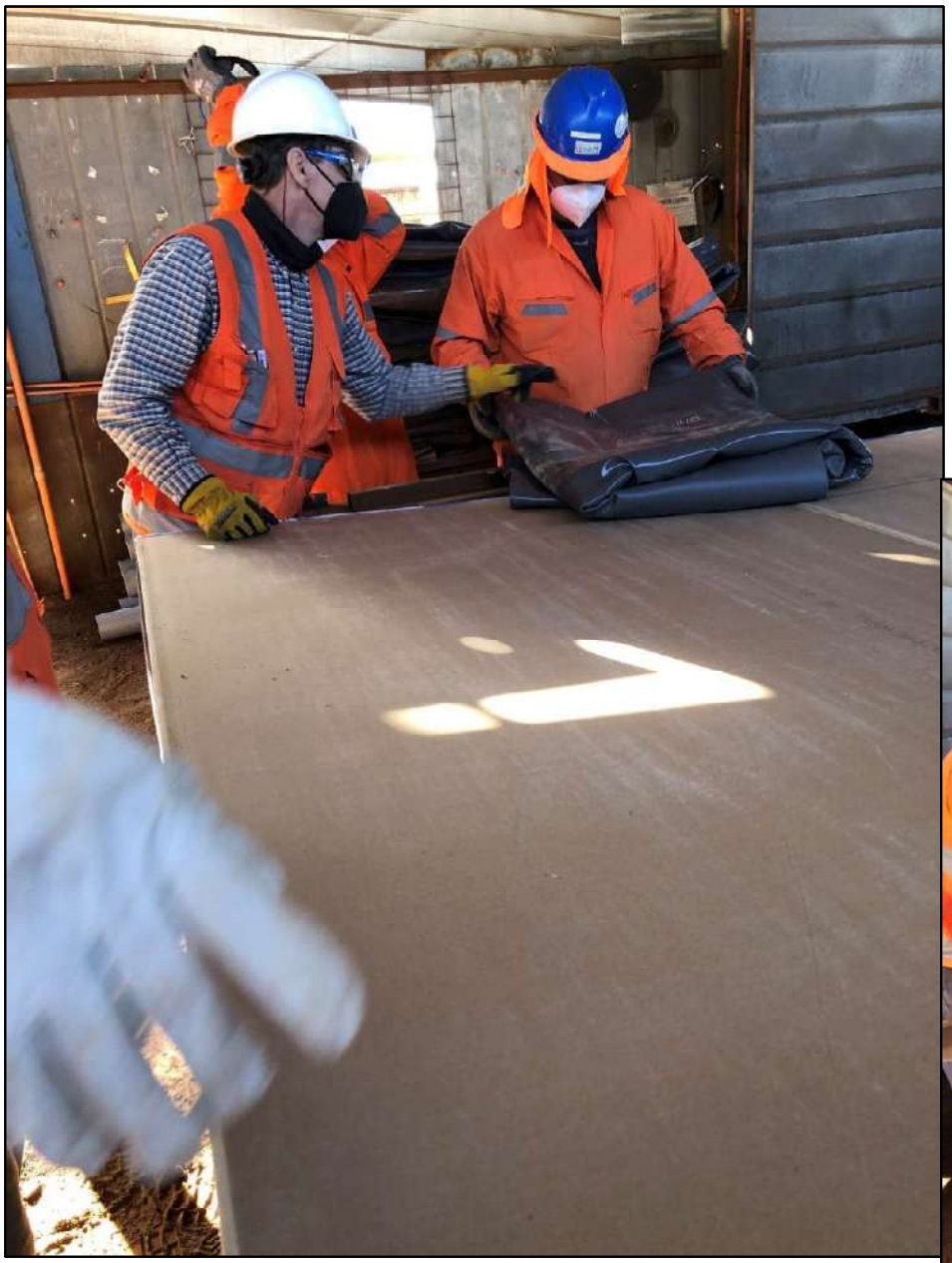

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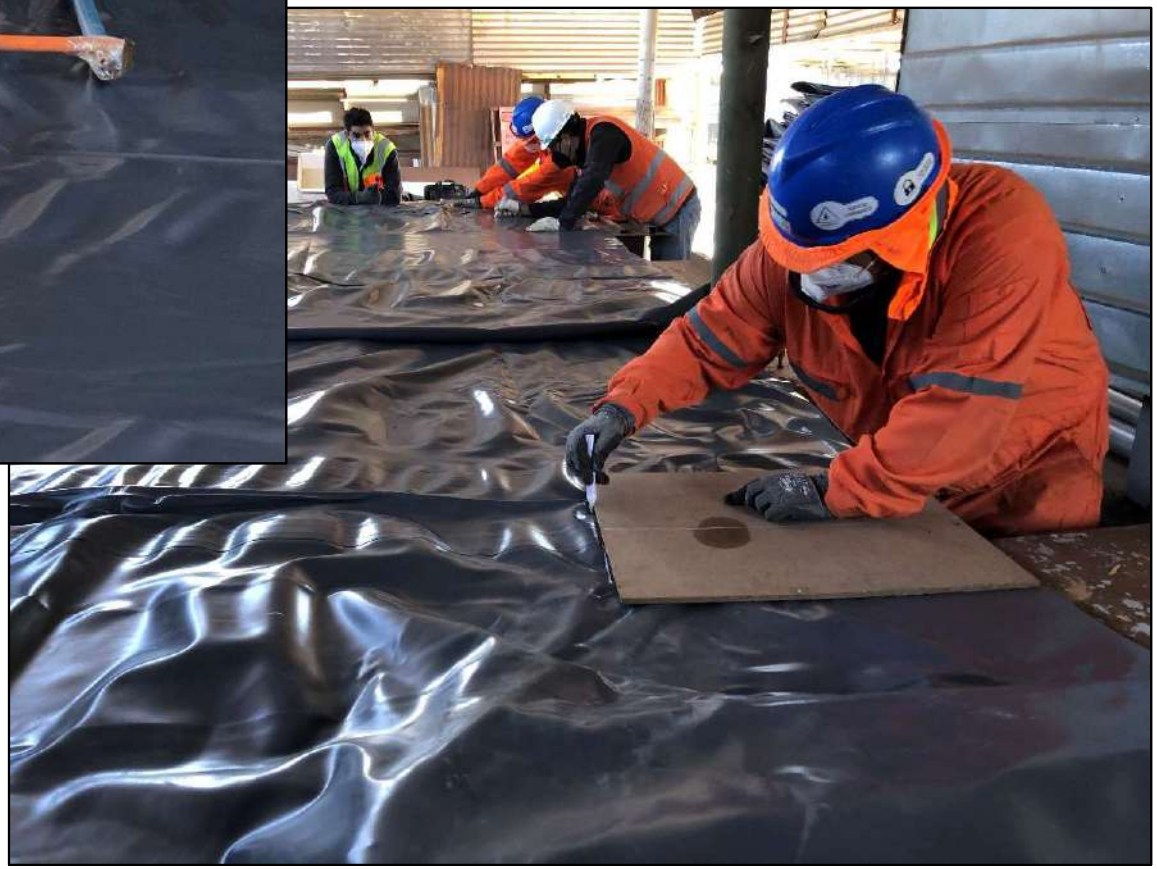
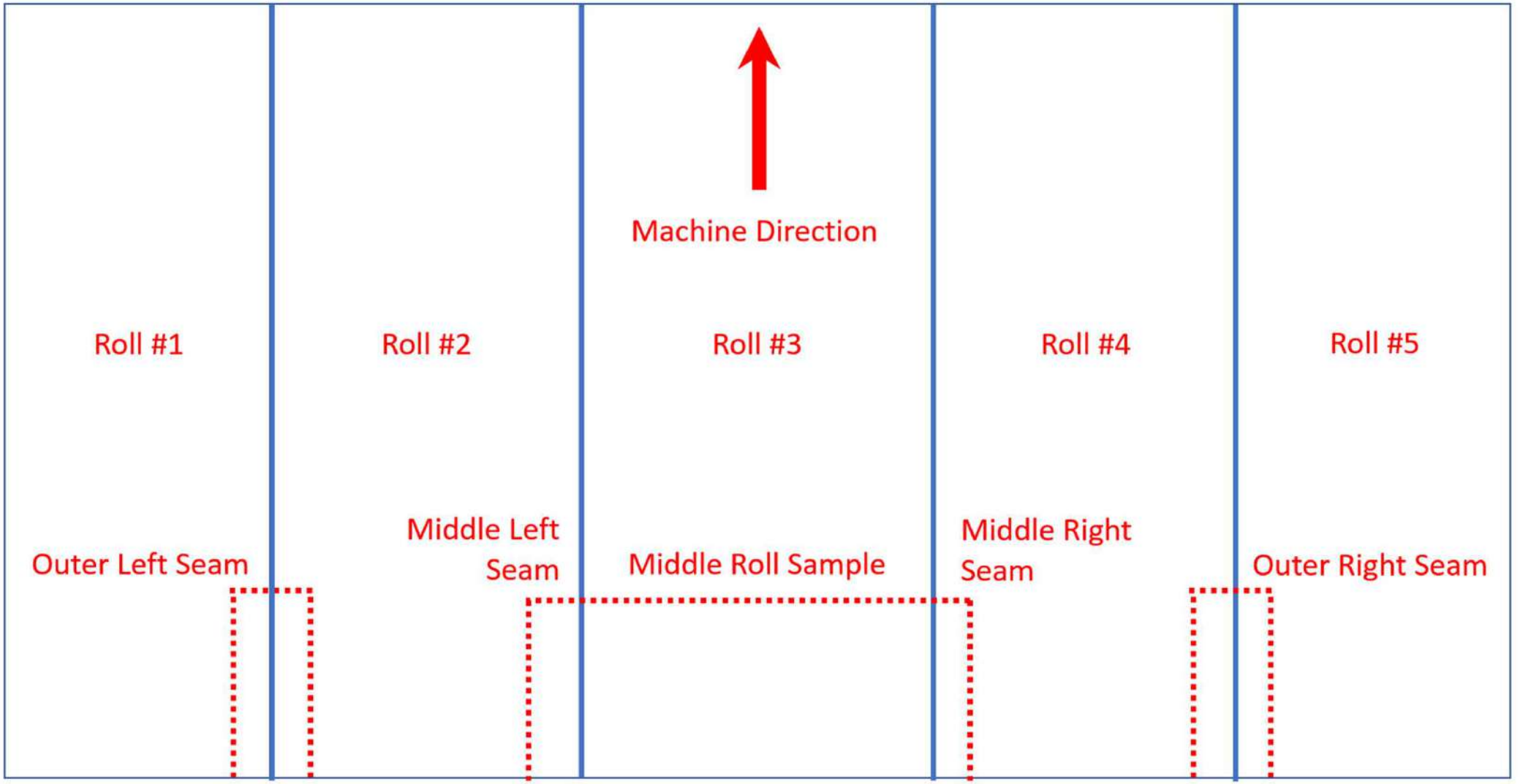


Sampling

- Panel = 5 rolls @ 2.2 m (7.2 ft) wide
- 4 seams
- Panel = 10.8 m wide
- Need to sample parent & 4 seams

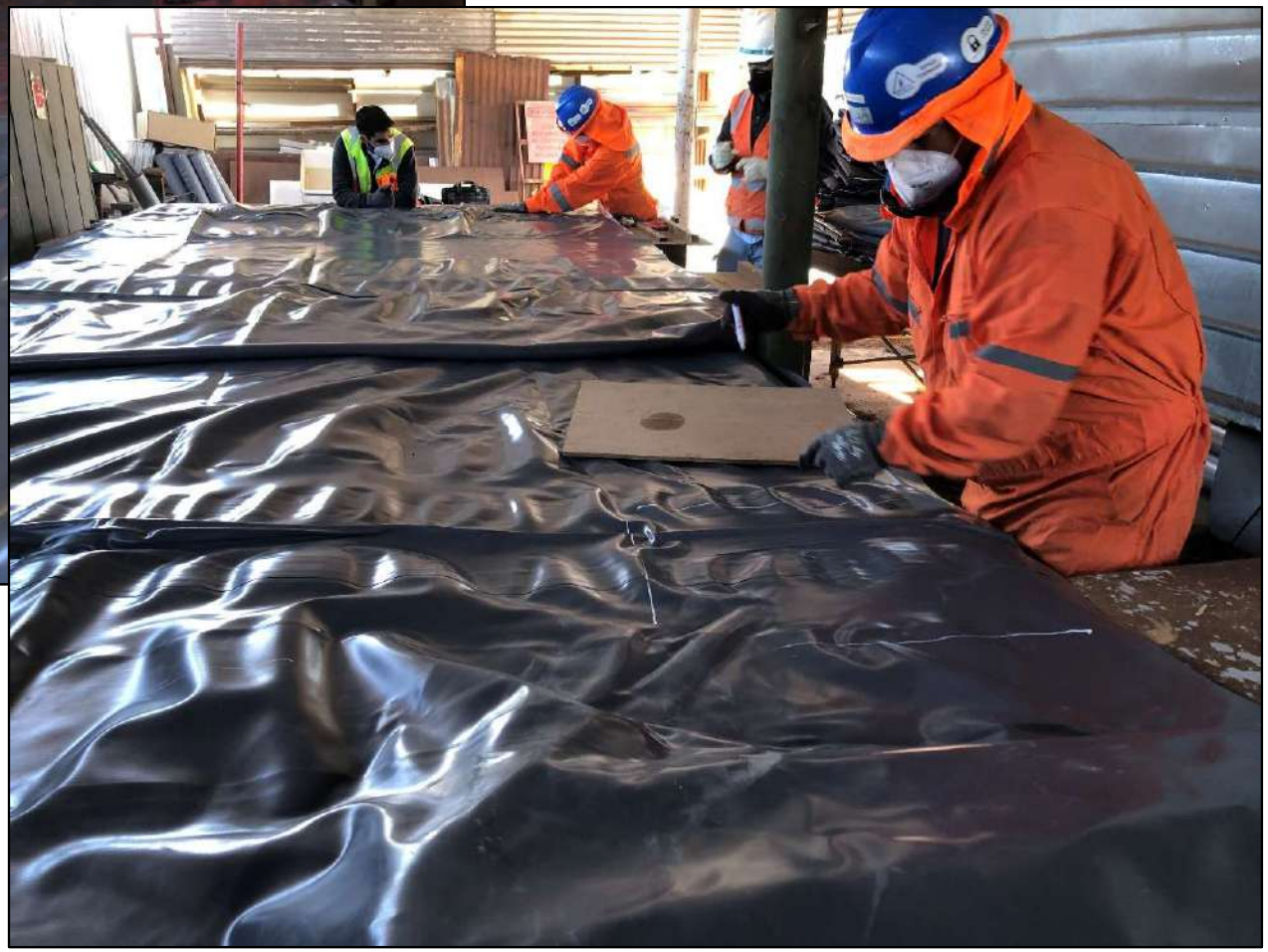
- Middle roll (parent) + 2 seams = 2.4 m wide & 1 m long
- Sample outer 2 seams = 0.45 m wide & 0.6 m long

Sampling



30 mil thick PVC Geomembrane Panel – comprised of five rolls

Sampling



Sampling

JP Kline
Director of Testing Services
Geotechnics
544 Braddock Avenue
East Pittsburgh, PA 15112

Sampling

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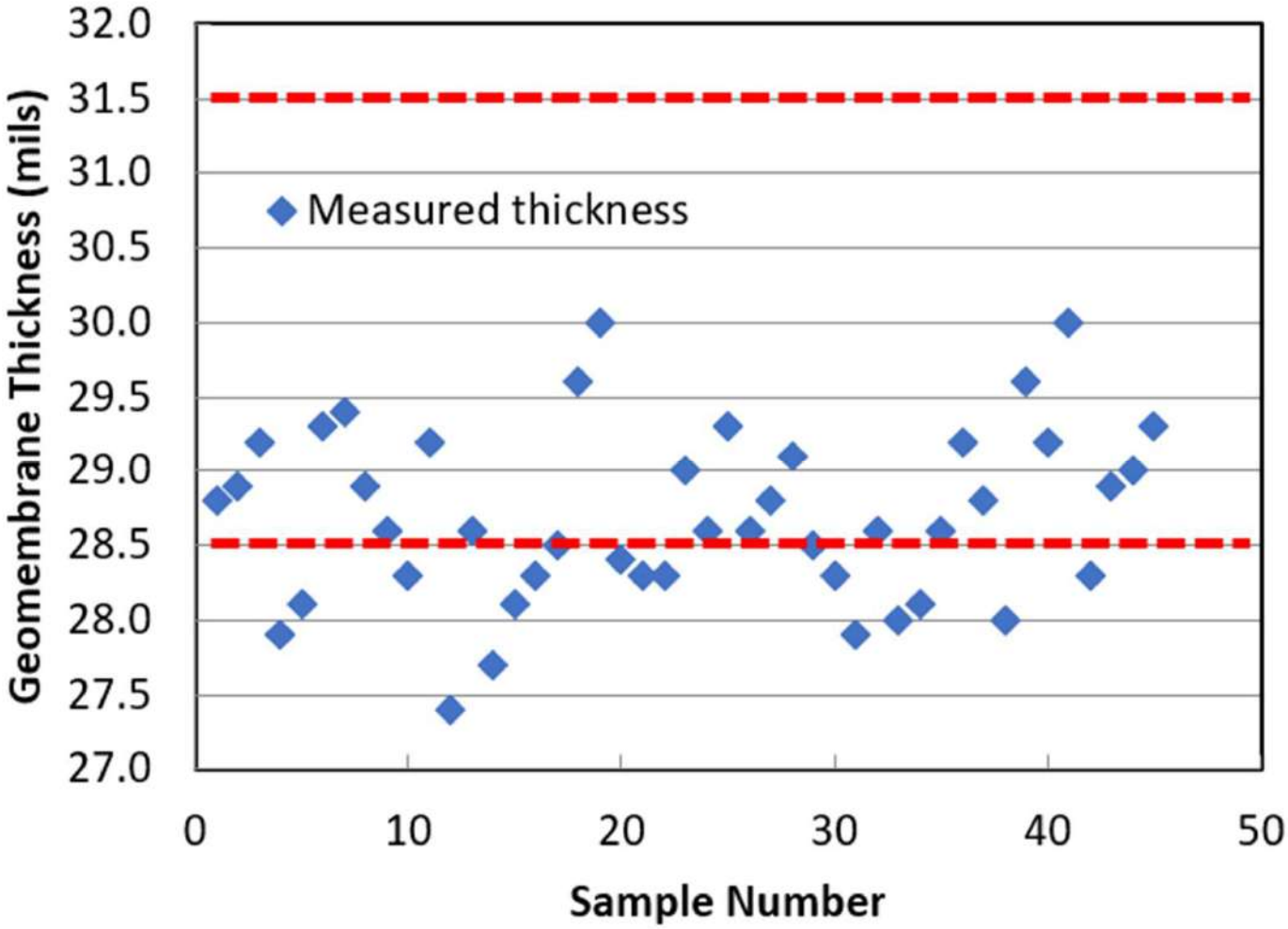
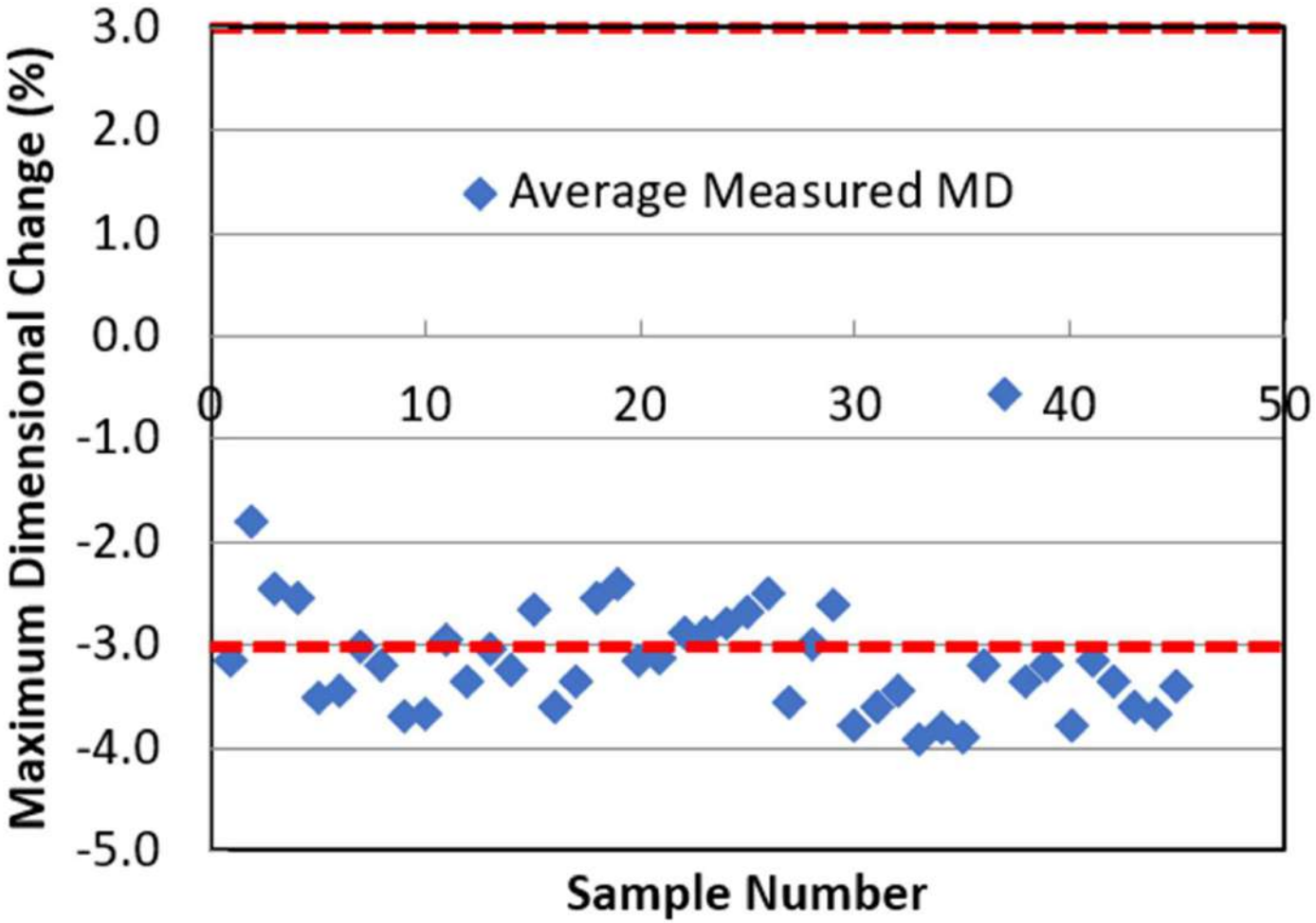
Thickness – ASTM D5199

- At least one panel met spec = shipment meets
- Some below 28.5 mils b/c tightly wound for over 5 years in desert ~104^{0}F (40^{0}C)
- Layer #6
- 30 mil±1.5 mil



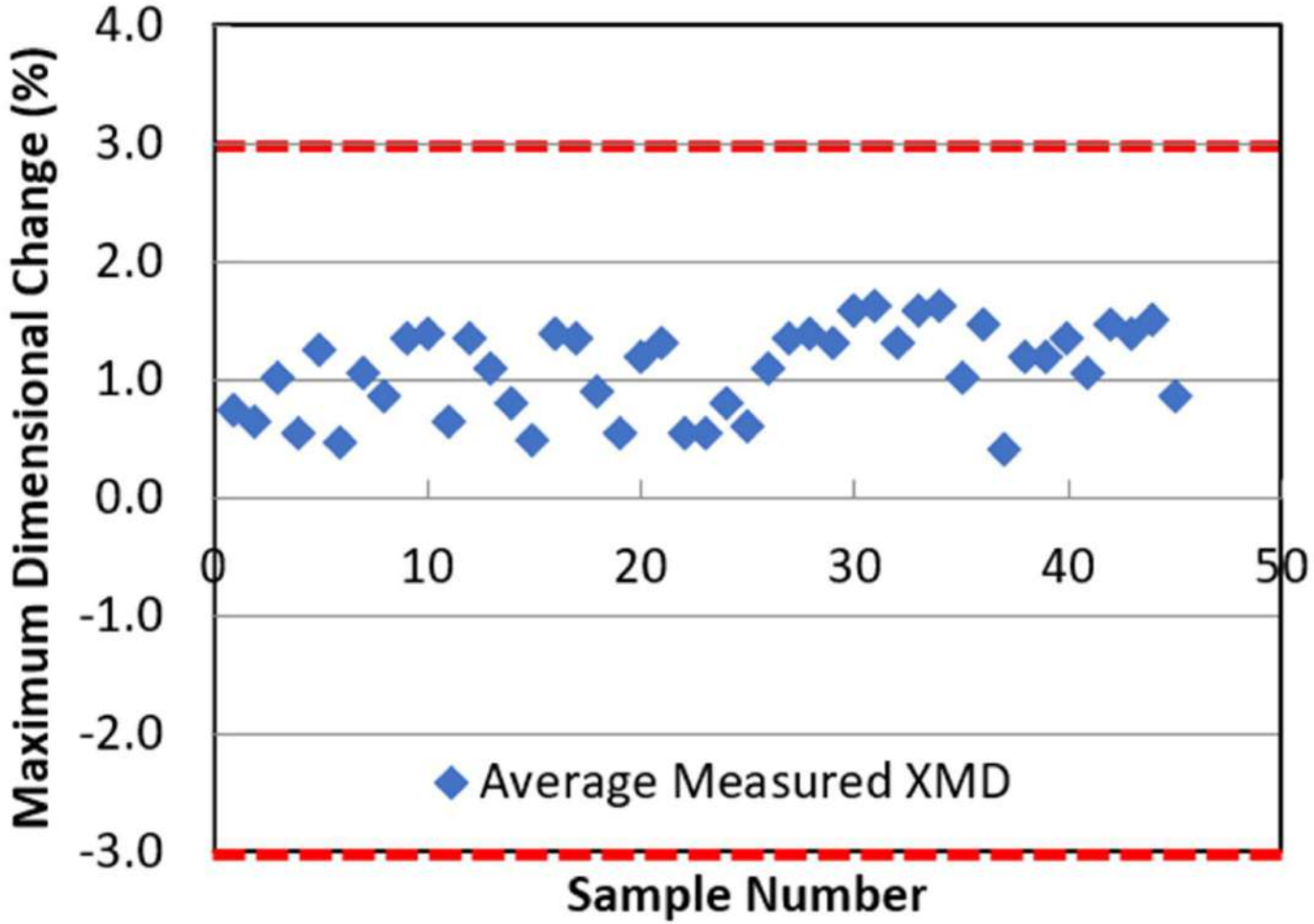
Dimensional Stability – ASTM D1204

- 15 panels less than -3% MD
- 15 panels meet spec (= shipment meets



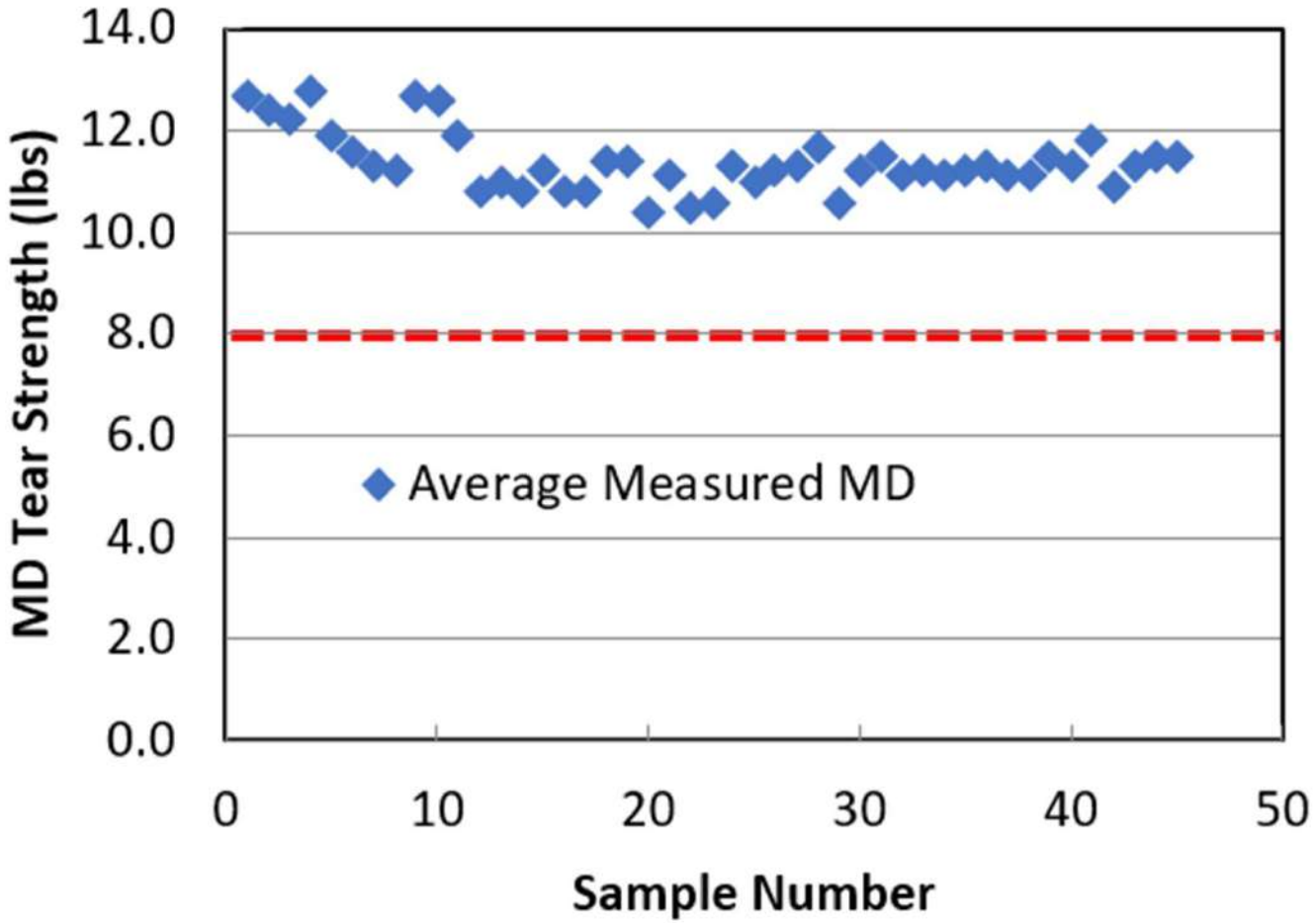
Dimensional Stability – ASTM D1204

- 45 panels b/t ± 3% XMD
- 45 of 45 panels meet spec = shipment meets



Tear Strength – ASTM D1004

- 45 panels greater than 8 lbs in MD
- 45 of 45 panels meet spec = shipment meets



Tear Strength – ASTM D1004

- 45 panels greater than 8 lbs in XMD
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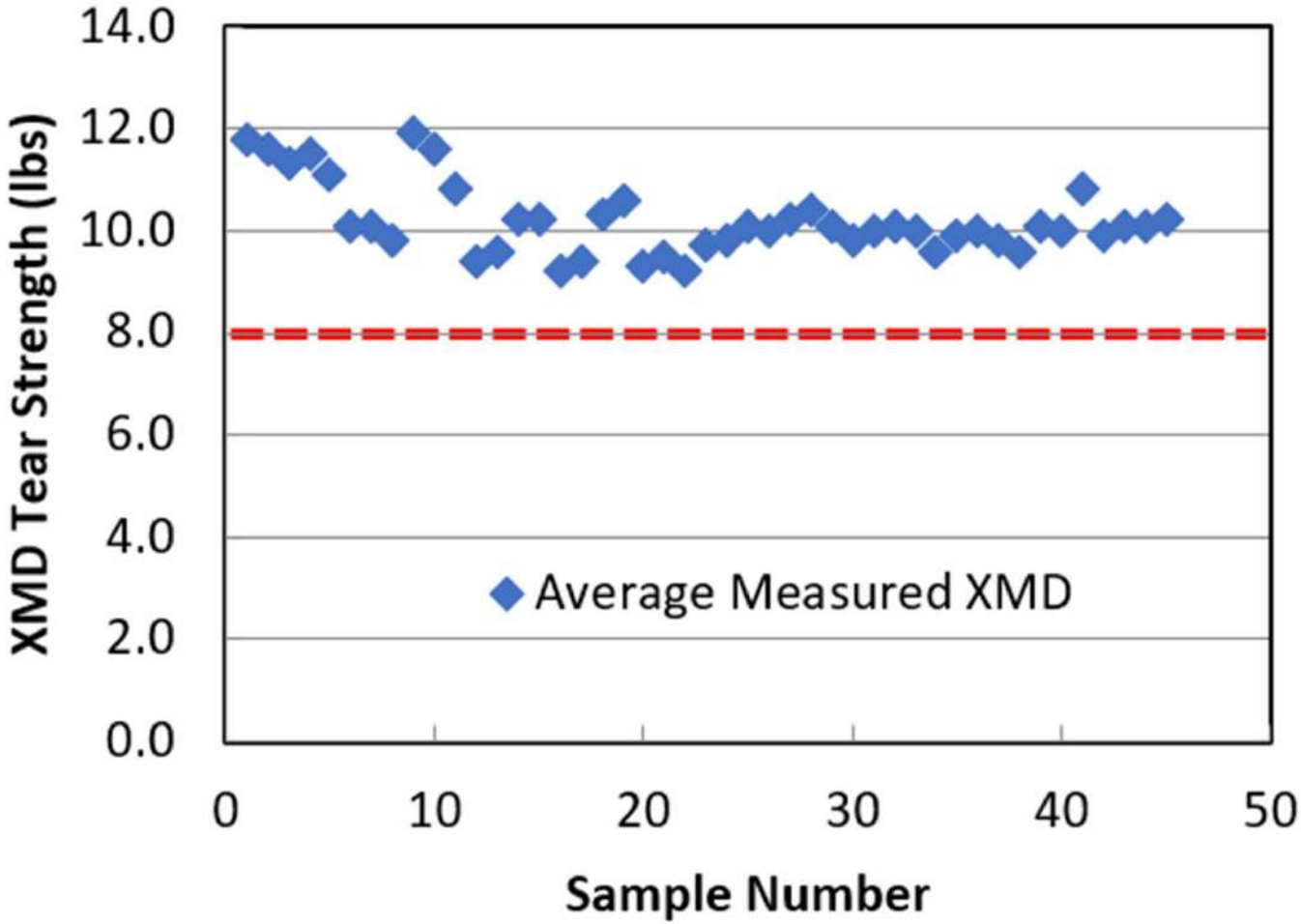
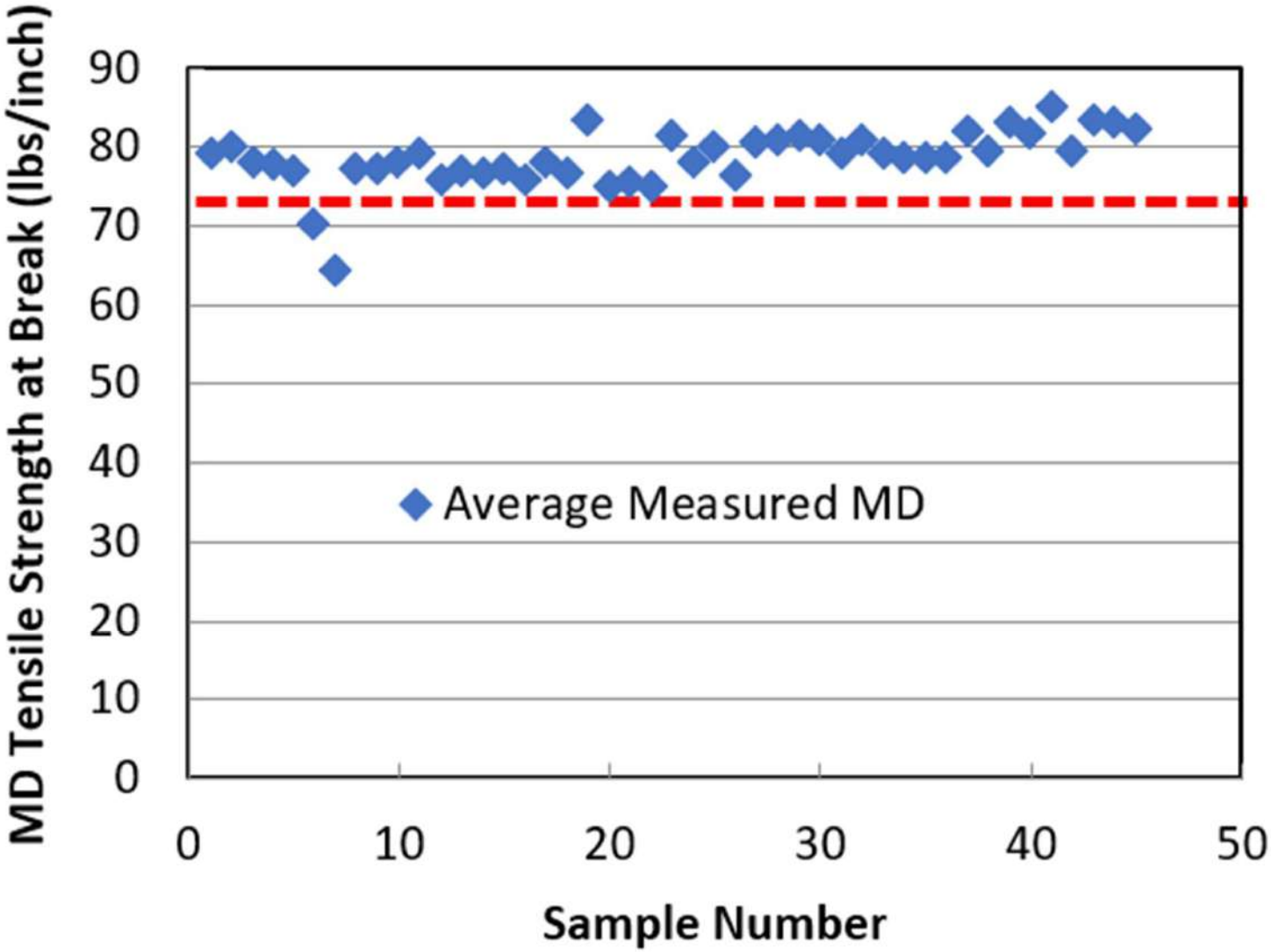


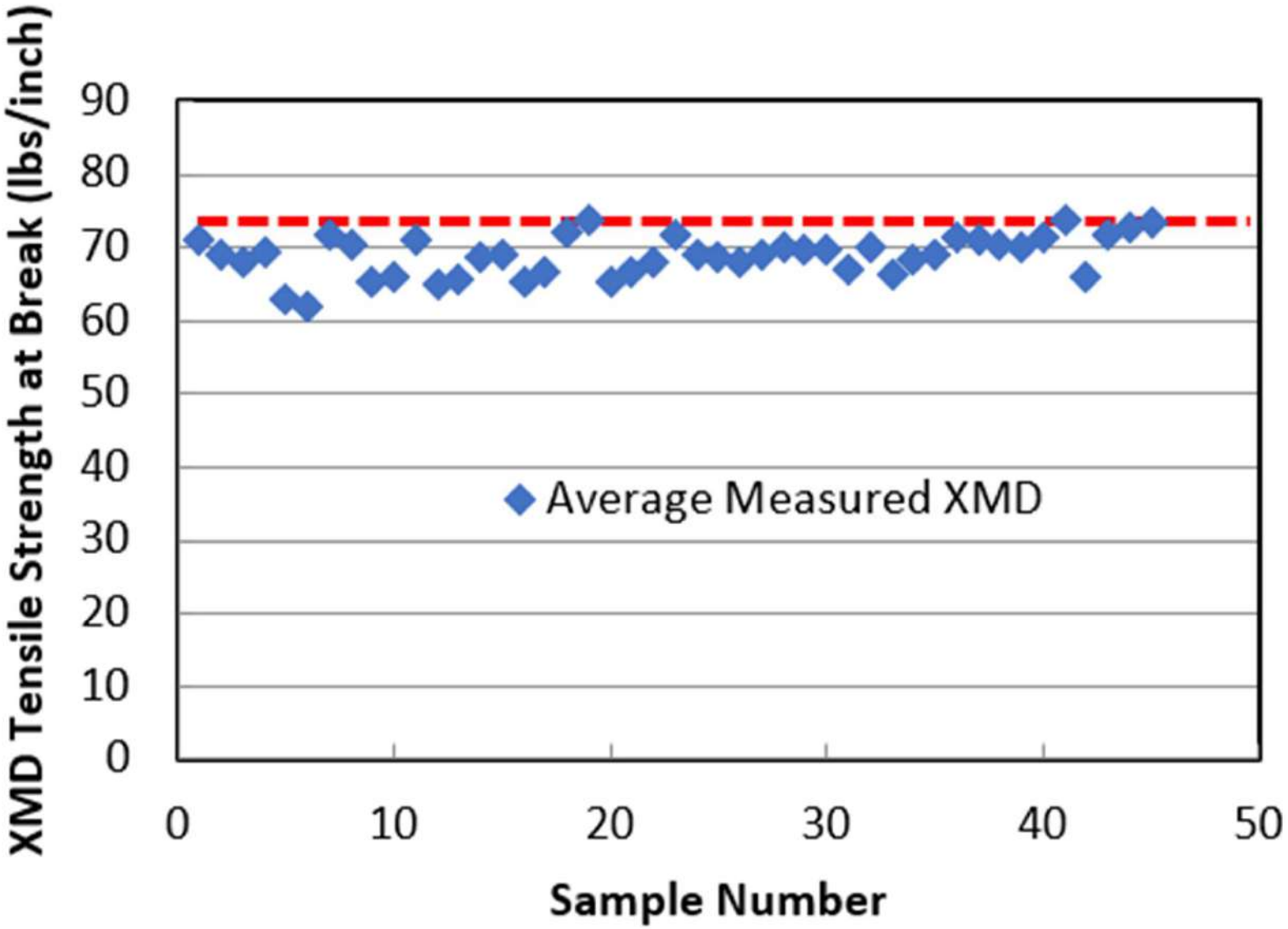
Tensile Strength @ Break – ASTM D882

- 43 panels greater than 73 lbs/inch in MD
- 43 of 45 panels meet spec = shipment meets



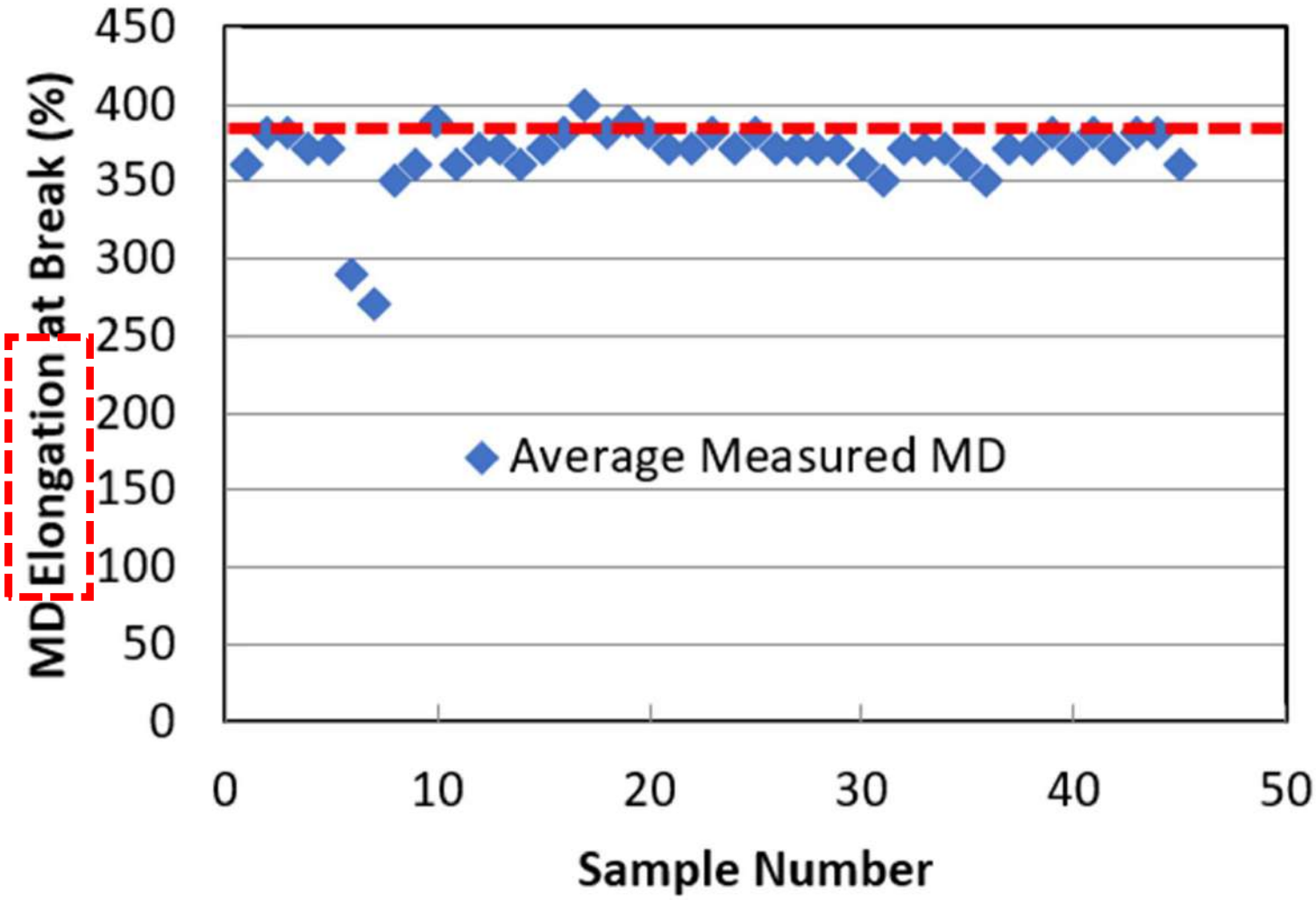
Tensile Strength @ Break – ASTM D882

- 3 panels greater than 73 lbs/inch in XMD
- 3 of 45 panels meet spec = shipment meets



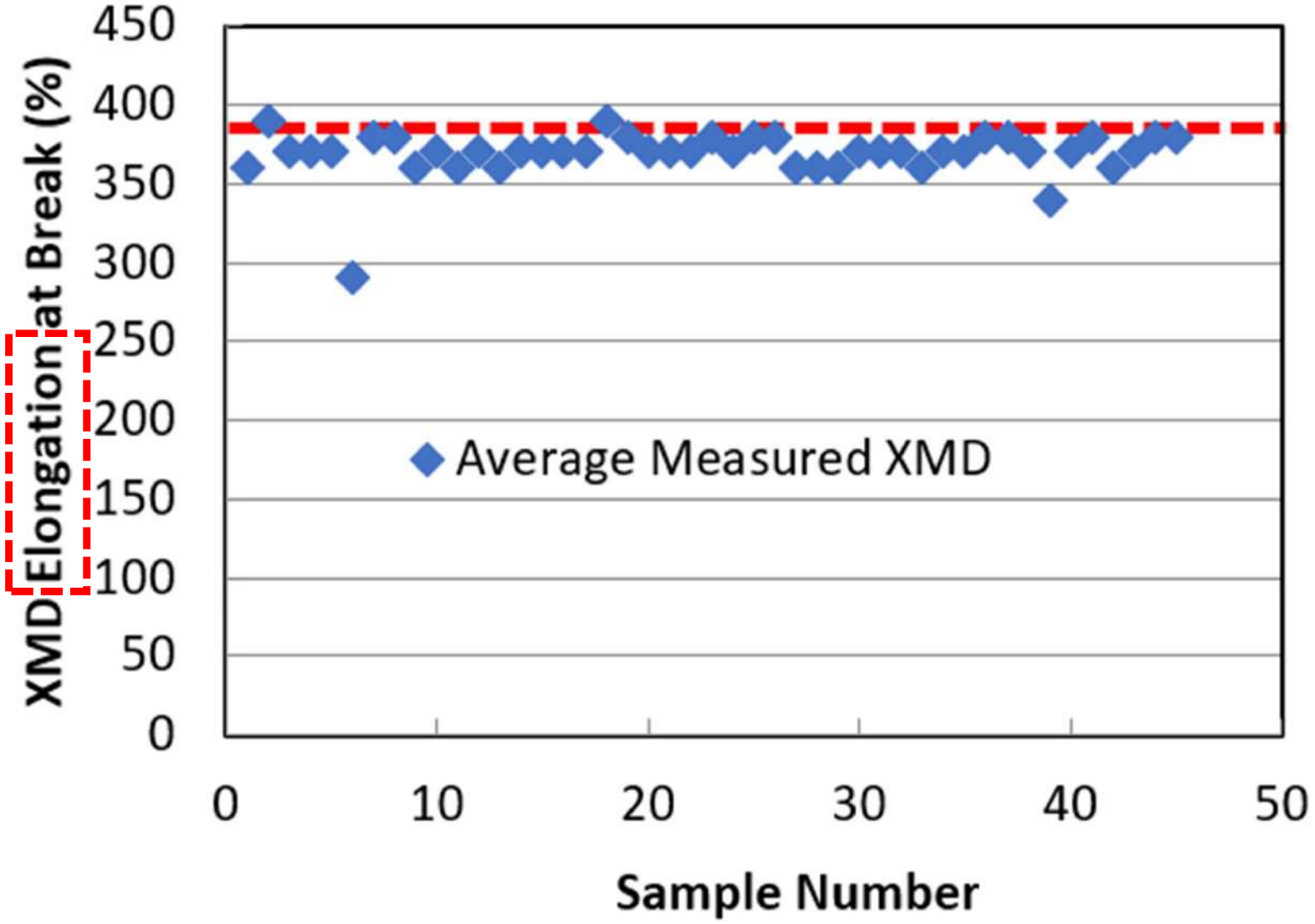
Tensile Elongation @ Break – ASTM D882

- 15 panels greater than 380% elongation in MD
- 15 of 45 panels meet spec = shipment meets



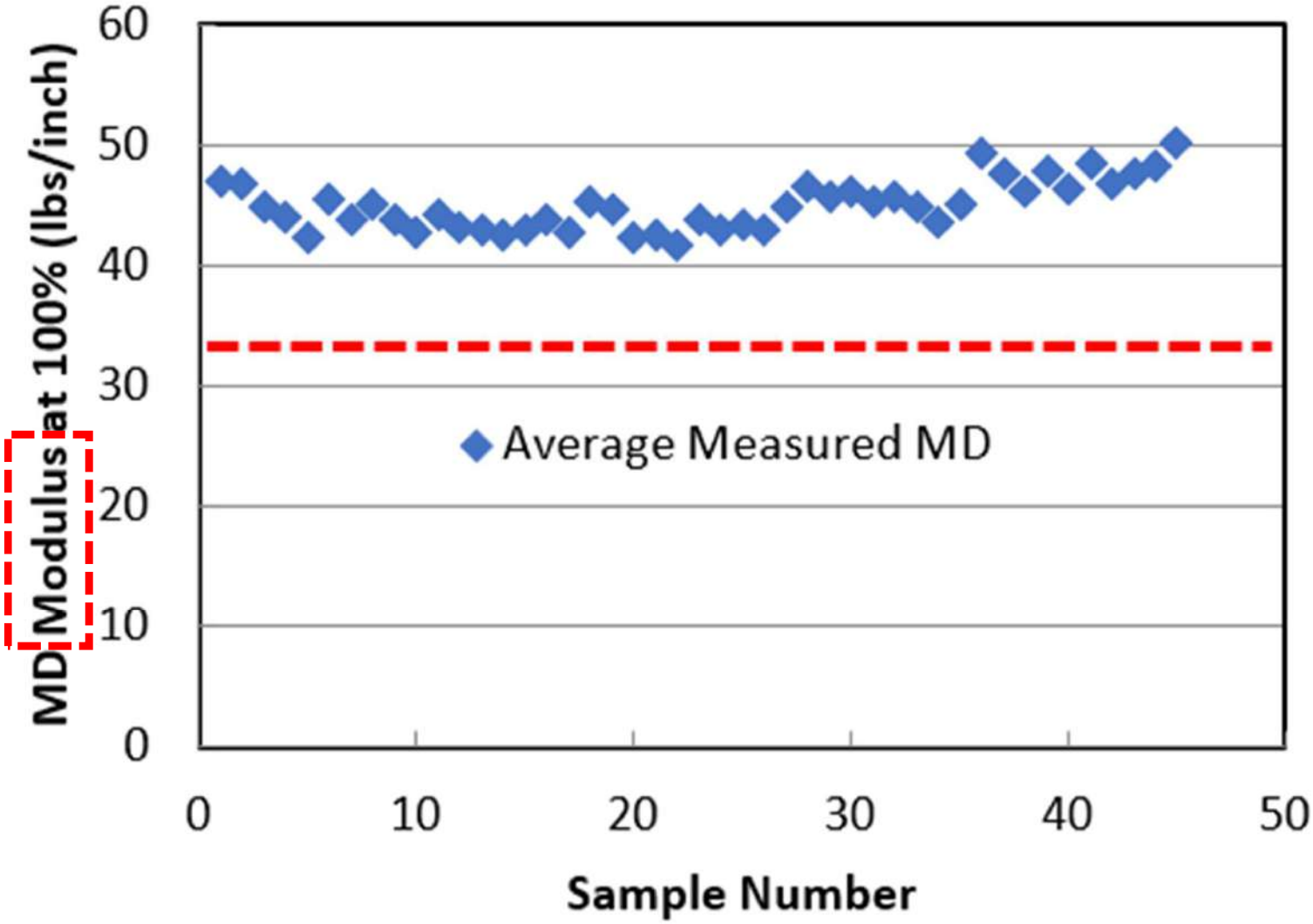
Tensile Elongation @ Break – ASTM D882

- 13 panels greater than 380% elongation in XMD
- 13 of 45 panels meet spec = shipment meets



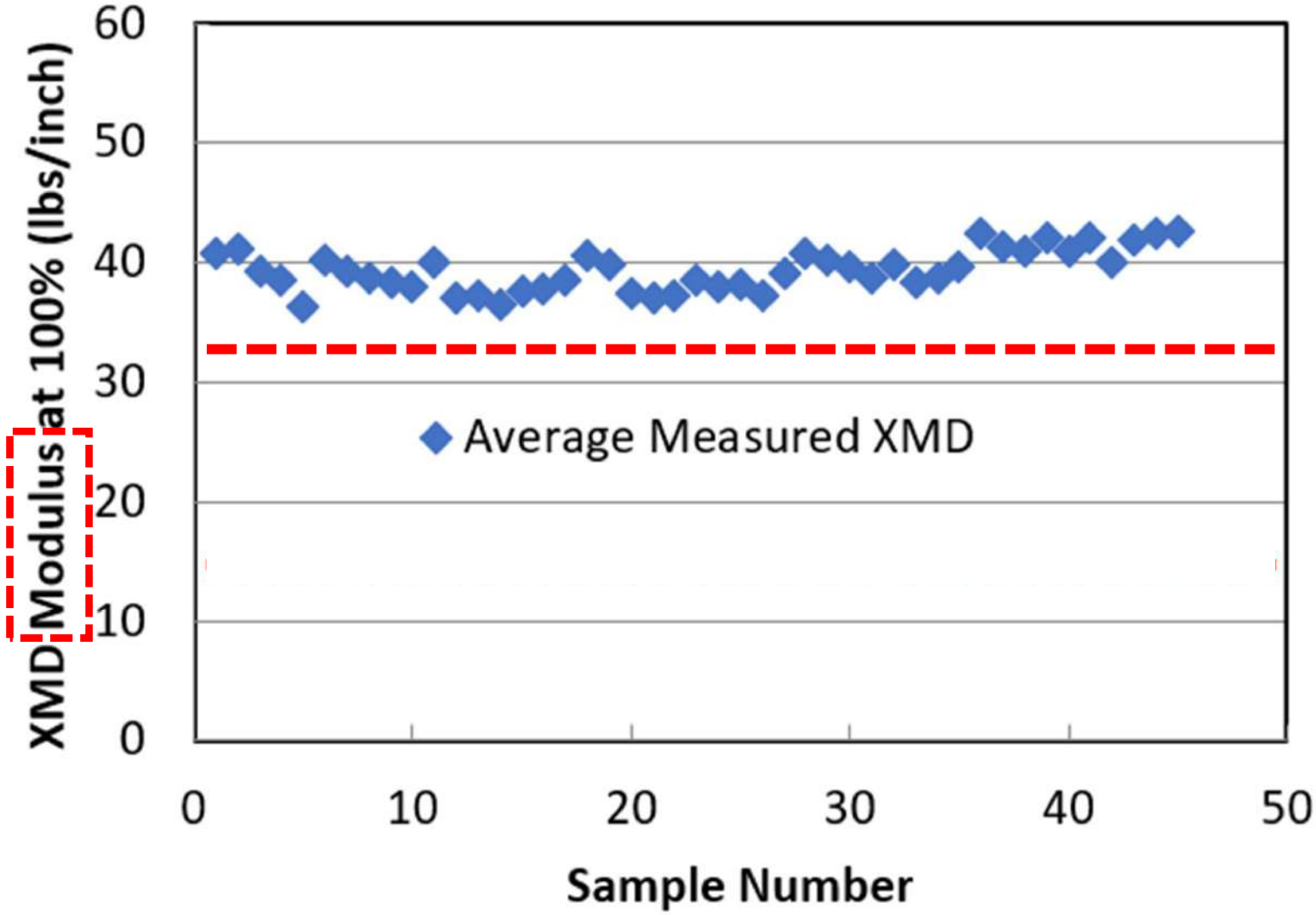
Tensile Modulus @ 100% Elongation – ASTM D882

- 15 panels greater than 32 lbs/inch in MD
- 15 of 45 panels meet spec = shipment meets



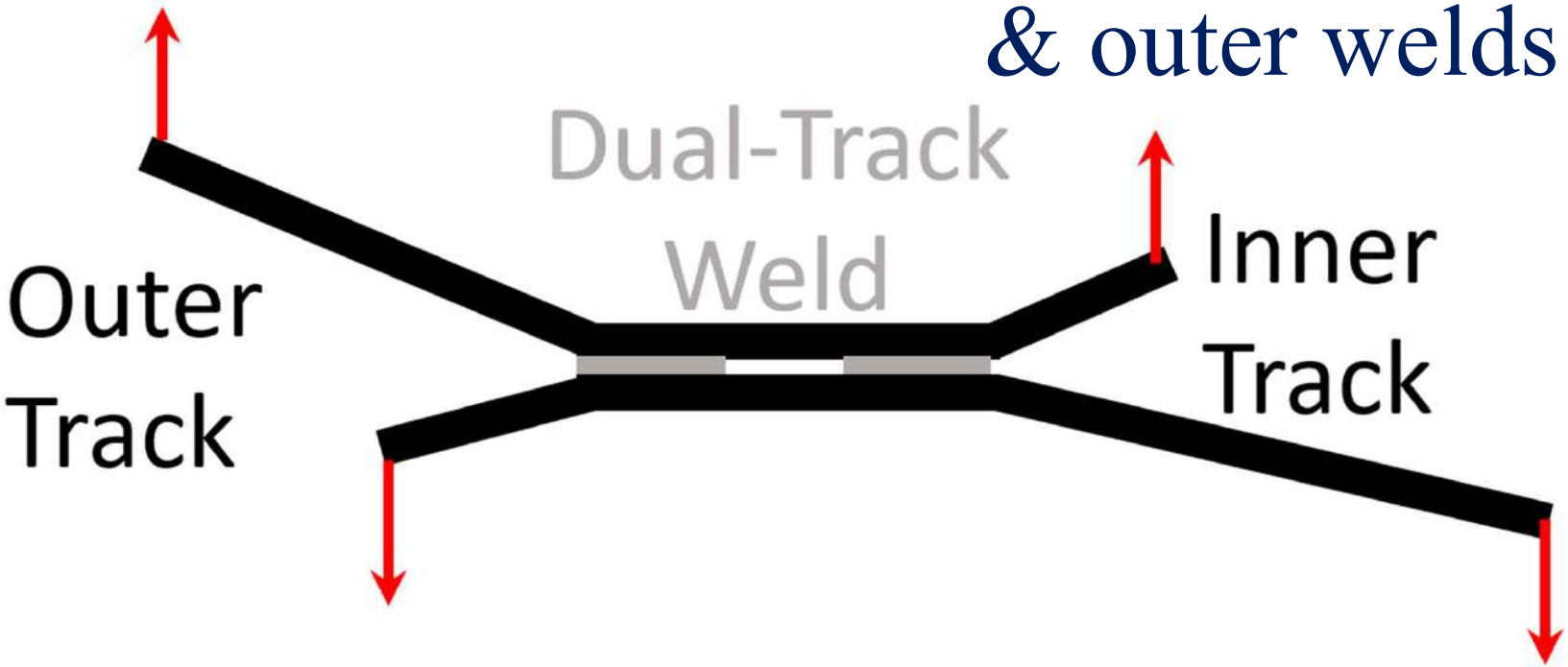
Tensile Modulus @ 100% Elongation – ASTM D882

- 45 panels greater than 32 lbs/inch in XMD
- 45 of 45 panels meet spec = shipment meets



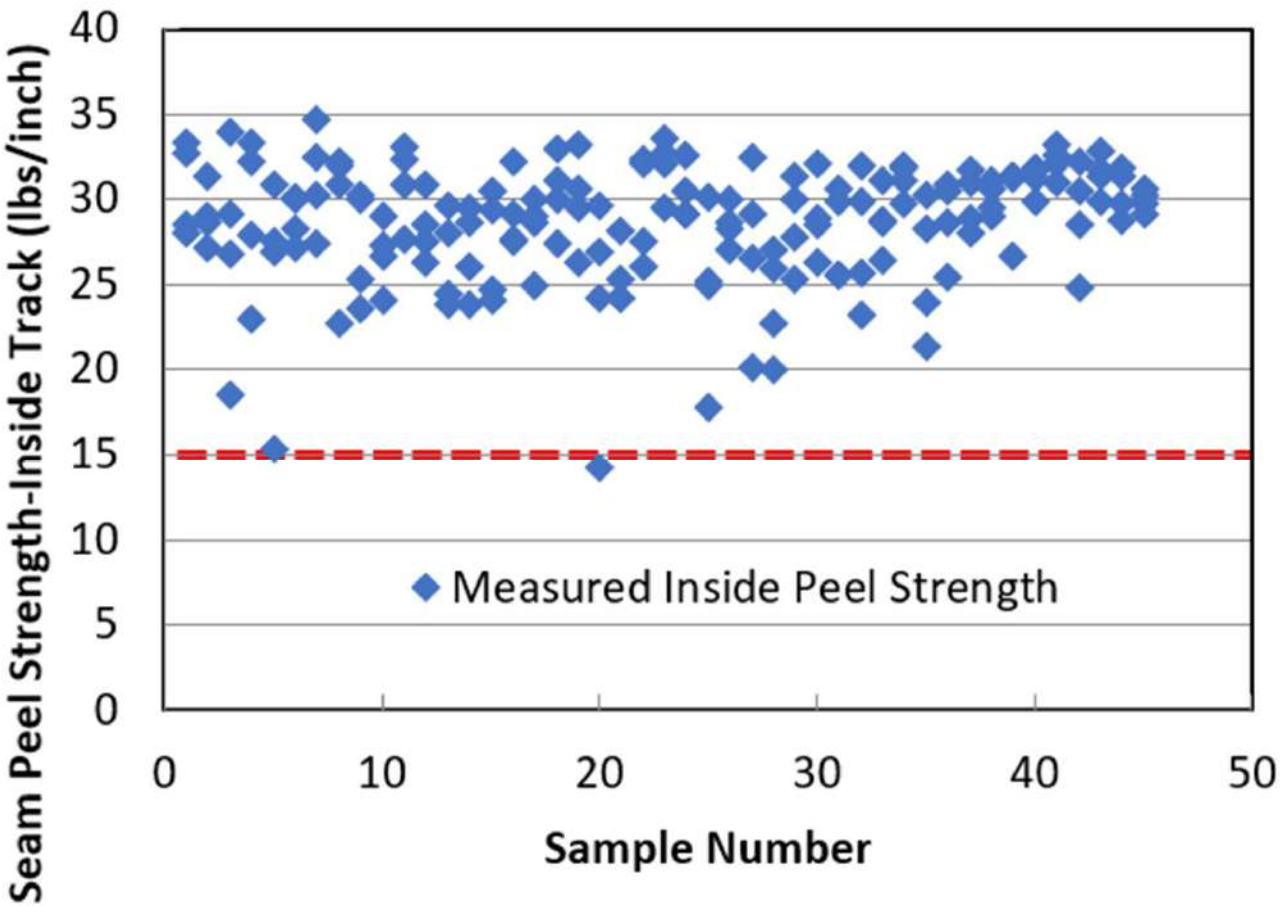
Seam Peel Strength – ASTM D882

- Peel strength > 15 lbs/inch
- 180 seams tested
- 4 seams/panel * 45 panels = 180 seams
- Tested inner and outer tracks
- 179 of 180 seams meet spec
- Test Inner & outer welds



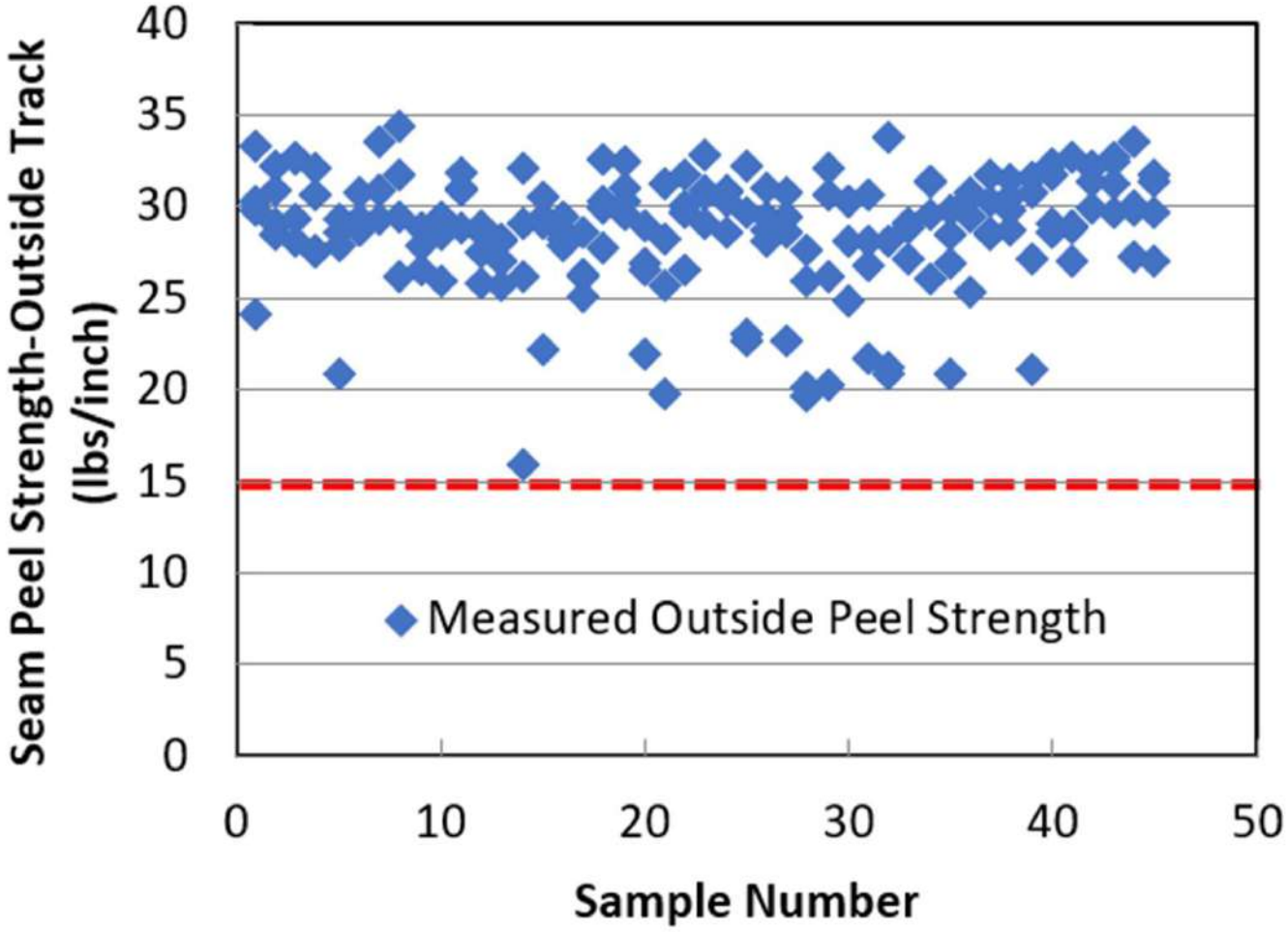
Seam Peel Strength – ASTM D882

- Inner track
- 179 of 180 seams meet spec = shipment meets
- 1 of 180 seams = 14.3 lbs/inch < 15 lbs/inch
- Shipment meets



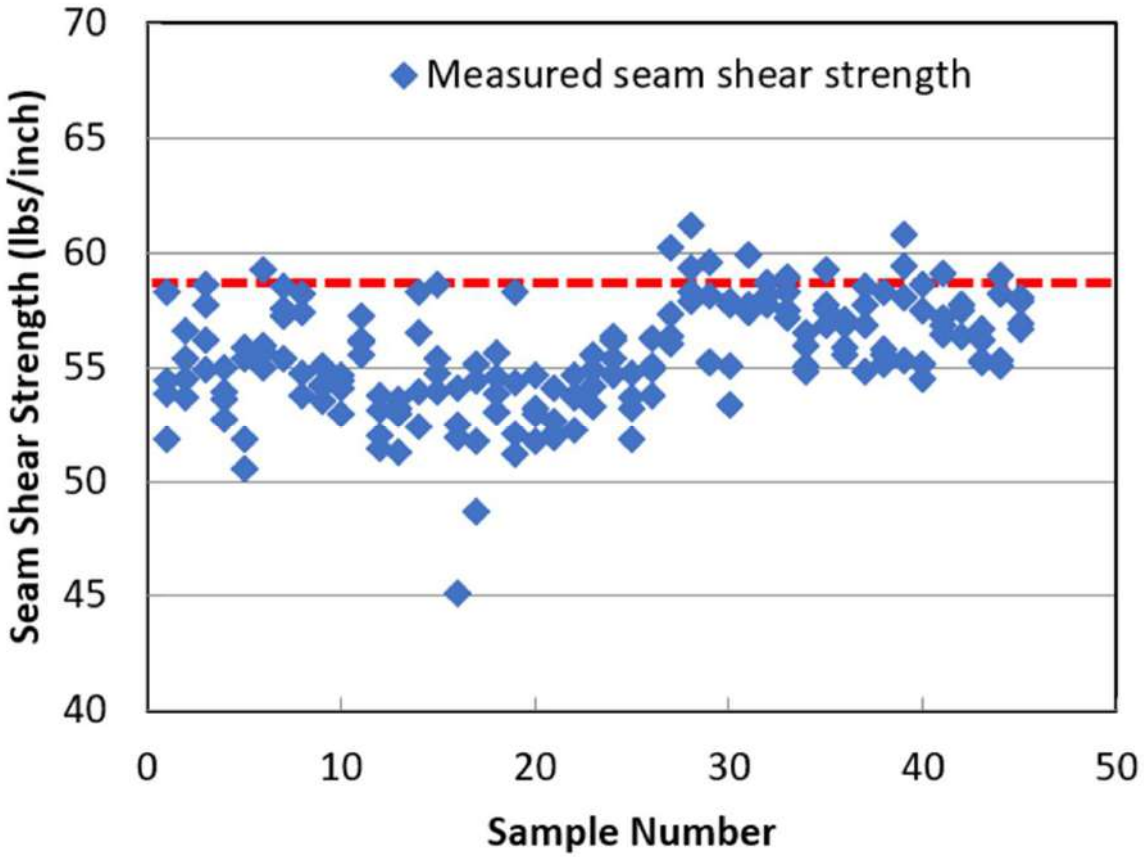
Seam Peel Strength – ASTM D882

- Outer track
- 180 of 180 seams meet spec = shipment meets
- Peel strength > 15 lbs/inch



Seam Shear Strength – ASTM D882

- Shear Strength > 58.4 lbs/inch
- 18 of 180 seams meet spec = shipment meets
- 176 of 180 seams > 51.3 lbs/inch
- One seam from every panel meets spec = Shipment meets



Seam Shear Strength – ASTM D882

- Peel strength more important than shear
- Ponds only ~3 ft (1 m) deep
- Not long or steep slopes
- Exposed to elevated temperatures in salar for five years

Seam Shear Strength – ASTM D882

- Peel strength more important than shear
- Ponds only ~3 ft (1 m) deep
- Not long or steep slopes
- Exposed to elevated temperatures in salar for five years
- Data from ASTM D3405 – Heat Aging of Plastics without Load indicates 30 to 35% drop in seam peel strength
- Install ASAP but still meets spec

Outline

- Lithium Triangle
- COVID
- San Pedro De Atacama
- Drive to Salar De Atacama
- Factory Fabricated PVC GM
- Testing Requirements
- Sampling
- Test Results
- Installation
- Summary

FGI Desert Installation Guideline

https://cdn.prod.website-files.com/5977726d80d12837b9592f43/614cd65b3ac3a0065517a1b9_FGI-Desert-Installation-Guideline-2021-9-4-21-FINAL.pdf

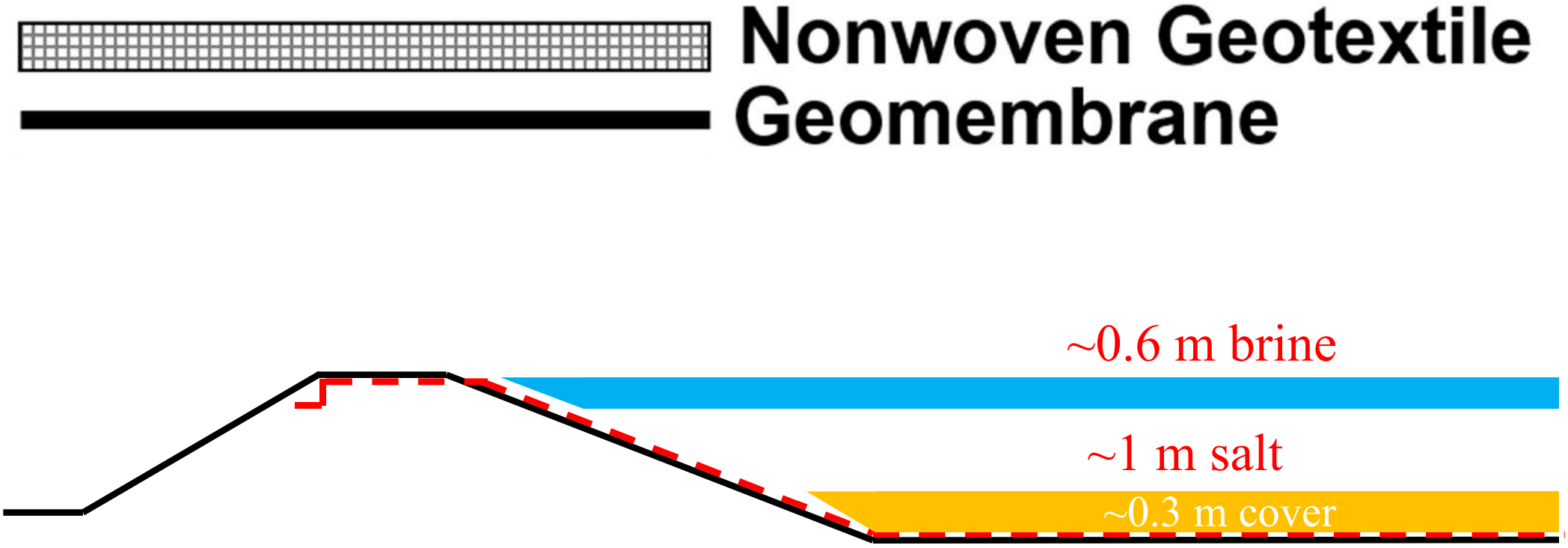
FGI Fabricated Geomembrane Institute

Guideline for Desert Installation of Fabricated Geomembrane Panels

Fabricated Geomembrane Institute

August 12, 2021

Typical Bottom Liner System



- 0.3 m thick protective cover
- 1 m thick salt zone
- 0.6 m for liquid brine
- Extend GM over berm - erosion

Solar Pond Best Practices

- White or other light color reinforced GM - bottom and berm slopes
- White or other light color unreinforced GM - bottom and berm slopes
- Weld using thermofusion welds
- If reinforced GM used, can omit bottom and/or top GT
- Perform leak location survey after protective salt layer is placed
- Place colored tarp on top of protective salt layer as warning layer

2007 Geosynthetics Magazine

Massive mining evaporation ponds constructed in Chilean desert

The Salar de Atacama in Chile is the site of the largest PVC geomembrane installation in the world—more than 16 million ft.² utilized in mining operations since 1996.

By Dominic Berube,[1] Patrick Diebel,[2] Andre Rollin,[3] and Timothy D. Stark[4]

Photo 1 | In constructing the evaporation ponds, after the PVC liner is deployed, electrical leak-detection tests are done (see page 32).

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Summary

- Solar evaporation ponds – long & successful use of geomembranes
- Factory fabrication => harsh environment
- Good durability even exposed in Salar for five years
- Recommend installing ASAP

Questions and Comments????

Thank you for attending!!

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Brian Fraser & Justin Gouthreau
Layfield Geosynthetics

Tuesday, May 5, 2026
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