



KEY INDICATORS OF PERFORMANCE FOR THERMOPLASTIC POLYOLEFIN MEMBRANES

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ABSTRACT

(TPO)

SPEAKER

Missouri-Rolla)

(for

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Key Indicators of Performance for Thermoplastic Polyolefin Membranes

INTRODUCTION

ylene-butadiene).

(TPO)

TPO MEMBRANE FORMULATION

“Standar

(polypropylene), (polyethylene),
(b
opylene),
(ethylene-pr
rubber), (EP-diene rubber),
(ethylene-octene), (eth-

"crystalline"

40%,

(T)

(UV),

UV STABILIZER PACKAGES

(HALS),

COLORED TPO

"autox

(SR)

(ROOH)

**ASTM D6878 STANDARD
SPECIFICATION FOR TPO-
BASED SHEET ROOFING**

**ADHESIVES, PRIMERS, AND
CAULKS**

50%

20%

Table 1

**OZONE RESISTANCE
(ASTM D 6878, D 1149)**

(104°F).

Table 1 – Physical Requirements for TPO Sheet Roofing

Thickness, min., mm (in.)		
Sheet – overall	1.0 (0.039)	
Coating over fabric or scrim, weathering side only	0.305 (0.012)	
Breaking strength, min., N (lbf)	976 (220)	
Elongation at reinforcement break, min., %	15	
Tearing strength, min., N (lbf)	245 (55)	
Brittleness point, max., °C (°F)	-40 (-40)	
Ozone resistance, no cracks	Pass	
Properties after heat aging: (retained values)		
Breaking strength, % min.	90	
Elongation at reinforcement break, % min.	90	
Tearing strength, % min.	60	(EPA)
Weight change (mass), max. %	+/- 1	
Linear dimensional change, max., %	+/- 1	
Water absorption, max., mass %	+/- 3.0B	
Factory seam strength, min., N (lbf)	290 (66)	
Weather resistance: (retained values)		
Visual inspection	Pass	

- A. ASTM D6878
B. Test performed on top coating material only

**Heat Aging
(ASTM D 6878, D 573)**

**ACCELERATED WEATHERING
TEST WITH XENON ARC
WEATHEROMETER (WOM)
(ASTM D6878, G 155)**

(240°F)

Table 1

**ADDITIONAL TEST CRITERIA
FOR PERFORMANCE
PREDICTION**

**Accelerated Outdoor
Weathering Test with Q-Trac in
AZ (EMMAQUA Test in AZ)**

Filter Type:	Daylight
Irradiance:	0.35 to 0.70 W/m ² at 340 nm (42 to 84 W/m ² at 300 to 400 nm)
Cycle:	690 min light, 30 min light plus water spray
Black Panel Temperature:	80 ± 3°C
Relative Humidity:	50 ± 5%
Spray Water:	Deionized
Specimen Rotation:	Refer to ASTM G 155
Radiant Exposure:	10,080 kJ/m ² at 340 nm (604.8 MJ/m ² at 300 to 400 nm) Inspect at 7X magnification for aging

(equatorial

water),

90%

Real-Life Field Exposure

“exposu

Florida & Arizona Equivalent Sun Years				
	TUV mega joules		Total mega joules	
Yrs.	FL	AZ	FL	AZ
1	280	333	6588	8004
2	560	666	13176	16008
3	840	999	19764	24012
4	1120	1332	26352	32016
5	1400	1665	32940	40020

Table 2 – Total ultraviolet radiation (TUV), measured between 295 - 385 nm.

Figure 1



Figure 1 – Q-Trac natural sunlight concentrator.

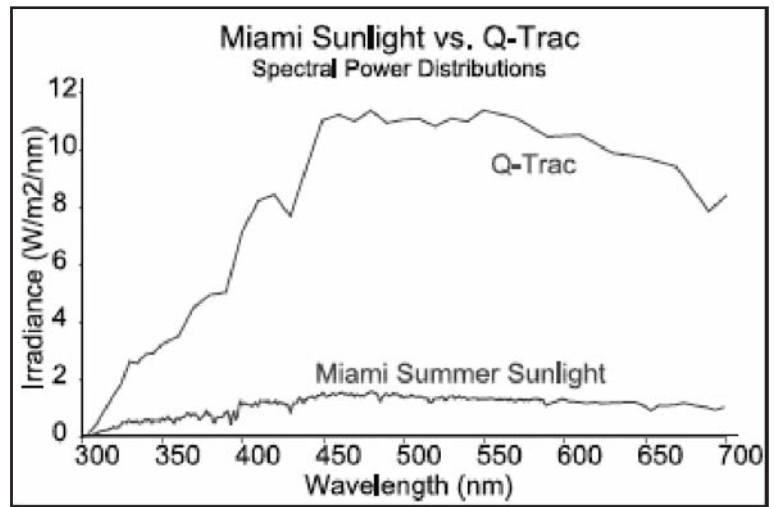


Figure 2 – The Q-Trac concentrates natural sunlight onto specimens, producing five times the TUV of one year in Florida.

TESTING, RESULTS, AND DISCUSSION

Comparison of UV Stabilizer Packages by Xenon Arc Weatherometer Testing to Failure

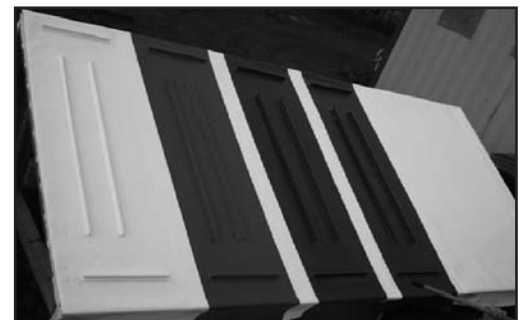


Figure 3 – Real-life field exposure farm.

(TUV)

(1400)

4¼
(1665 MJ/m2). Table 2 Figure
2

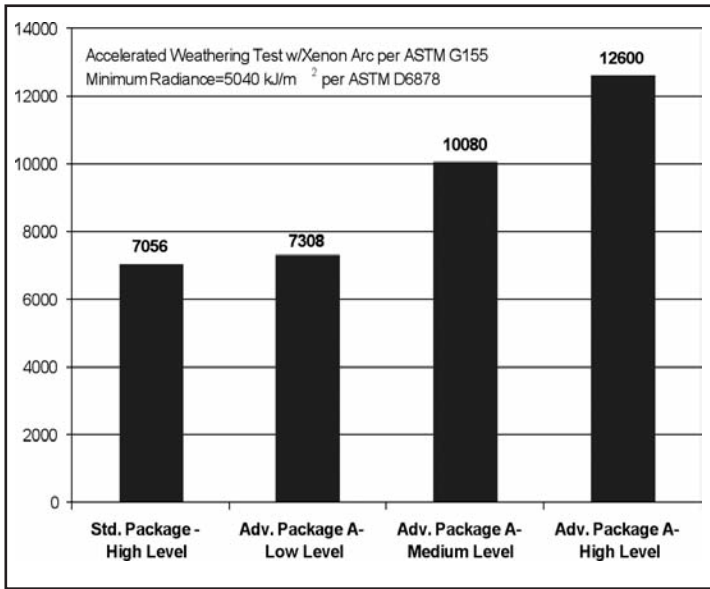


Figure 4 – Impact of UV stabilizer package types on green-colored TPO membrane integrity.

Figure 4

Comparison of UV Stabilizer Packages by EMMAQUA Exposure and Color Testing

Figure 5

Figure 4

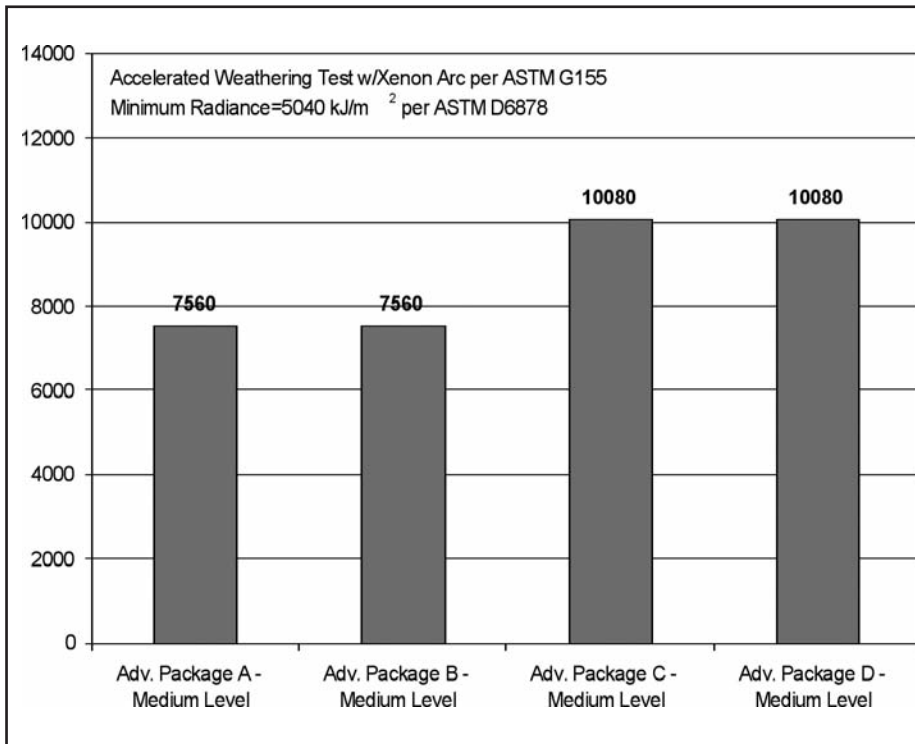
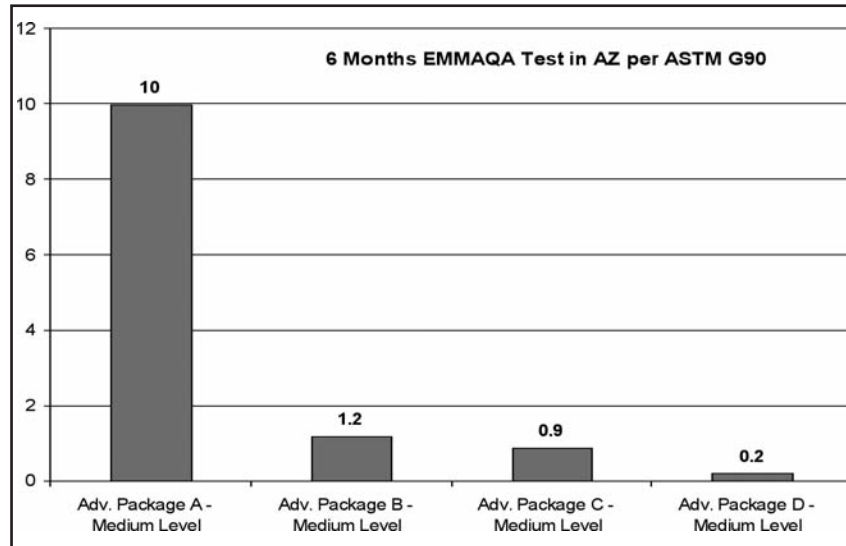


Figure 5 – Impact of advanced UV stabilizer packages on red-colored TPO membrane integrity.

(EMMAQUA)

Figure 6



Comparison of UV Stabilizer Packages by Xenon Arc Weatherometer and Color Testing

Figure 7

Figure 6 – Impact of advanced UV stabilizer packages on red-colored TPO membrane colorfastness.

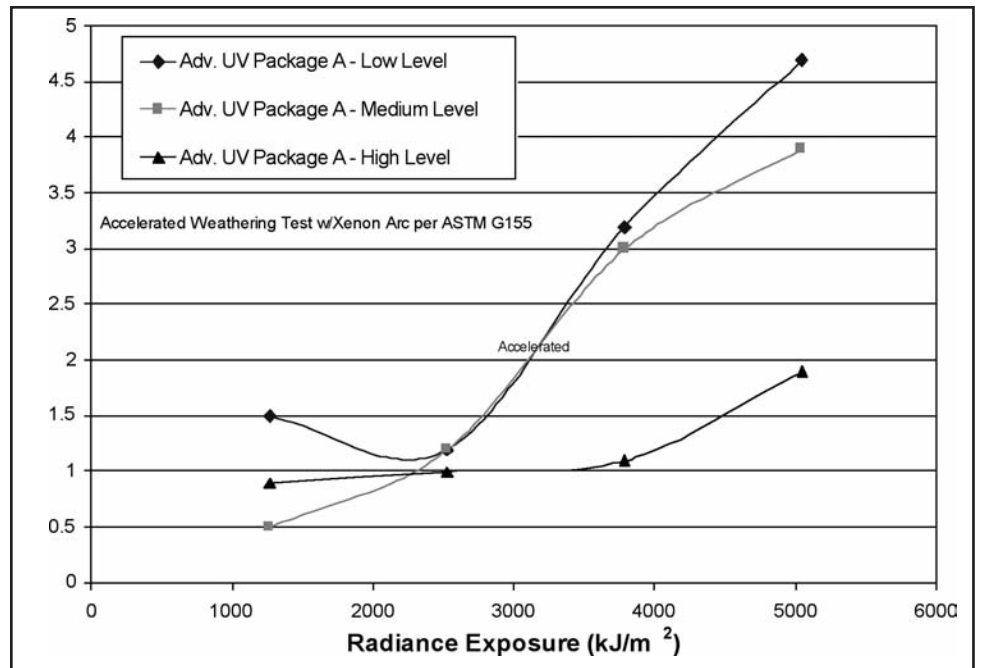


Figure 7 – Impact of levels of advanced UV stabilizer on the colorfastness of green TPO membrane.

Table 3
(Q-trac
EMMAQUA)

Color	Delta E		
	Company A	Company B	Company C
Material	TPO	TPO	Coated Metal
Red	1.3	na	5.8
Blue	0.6	3.5	1.3
Green	1.6	7.7	1.6
Terra Cotta	0.3	4.8	0.7

Figure 8 100%

Table 3 – Nine months of Q-Trac or EMMAQUA test in AZ.*

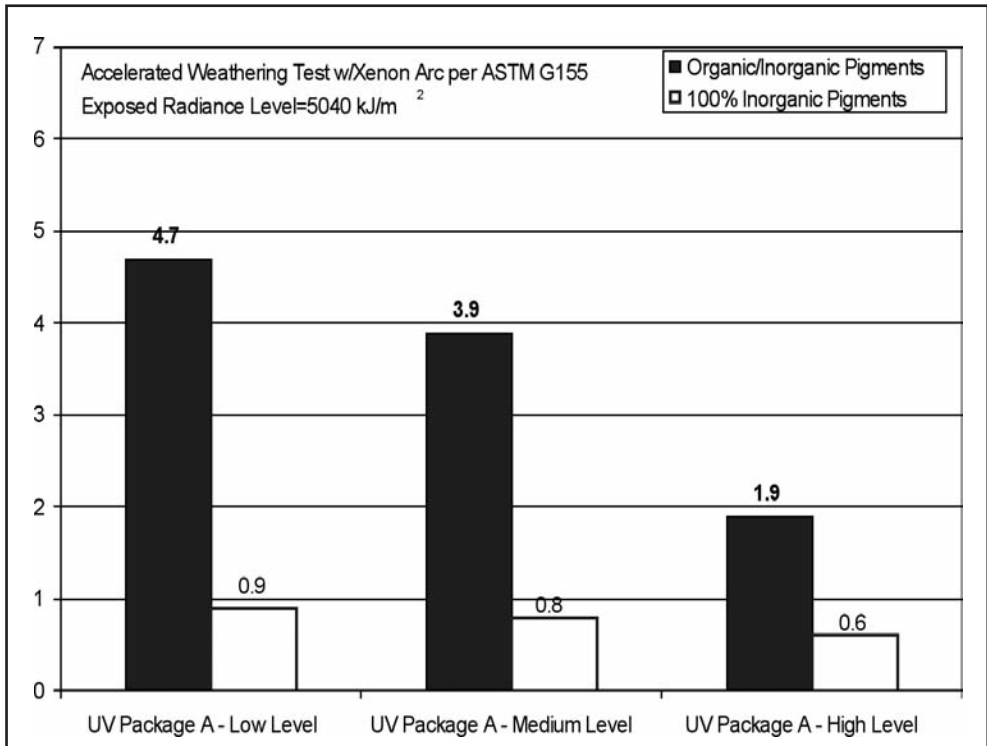


Table 4

Weld Performance

Figure 8 – Comparison of inorganic and organic pigment colorfastness impact for green TPO membrane.

Real-Life Weathering Correlation to EMMAQUA in AZ or Xenon Arc WOM

Types	Weathering Tests	Weathering Time	Accumulated Total UV (TUV) (MJ/m ²)	% Retained Tensile Strength	7X Microcracking
Accelerated WOM	Xenon Arc WOM at 0.35 w/m ²	8000 hrs (~11 months)	NA	82%	Yes
Accelerated WOM	Xenon Arc WOM at 0.35 w/m ²	6000 hrs (~8 months)	NA	94%	No
Accelerated Outdoor	EMMAQUA in AZ	48 months	5680 (4X of 1420)	89%	Yes
Accelerated Outdoor	EMMAQUA in AZ	36 months	4260 (3X of 1420)	91%	Yes
Accelerated Outdoor	EMMAQUA in AZ	24 months	2840 (2X of 1420)	96%	No
Accelerated Outdoor	EMMAQUA in AZ	12 months	1420	96%	No
Real Life Field Exposure	Field Test in South Florida	5 Years	1400	98%	No

Table 4 – Percent retained tensile strength of aged white TPO membrane.

(i.e.,
action),

“welding

(i.e.,

bonds)
(i.e.,
high).

Table 5

Maximum Seam Peel Strength (PLI)	Days Heat Aged 0	Days Heat Aged 1	Days Heat Aged 4
Commercial TPO membrane	60(±6)	53(±6)	58(±7)
Alternate TPO membrane	35 (±3)	10(±7)	2(±1)

(FTB)

Table 5 – Heat seam peel strength* of 45-mil reinforced TPO membranes.

(PLI) (ASTM D-413).

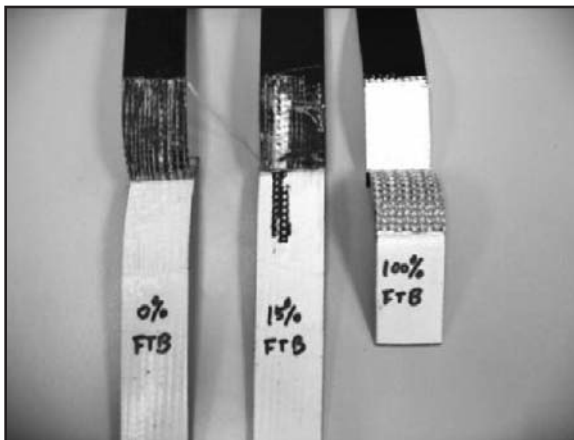
100%

0%

Figure 9

Table 5

Table 6



100%

Figure 9 – Peel failure modes of welded TPO.

TPO 1

	600°F	800°F	1000°F	1148°F
6 FPM				
10 FPM				
12 FPM				
16 FPM				

TPO 2

	600F	800F	1000F	1148F
6 FPM				
10 FPM				
12 FPM				
16 FPM				

TPO 3

	600°F	800°F	1000°F	1148°F
6 FPM				
10 FPM				
12 FPM				
16 FPM				

Table 6 - Welding window with 100% FTB for commercial TPO samples.

Combined Adhesive/Caulk and TPO Membrane Accelerated Heat Exposure Testing

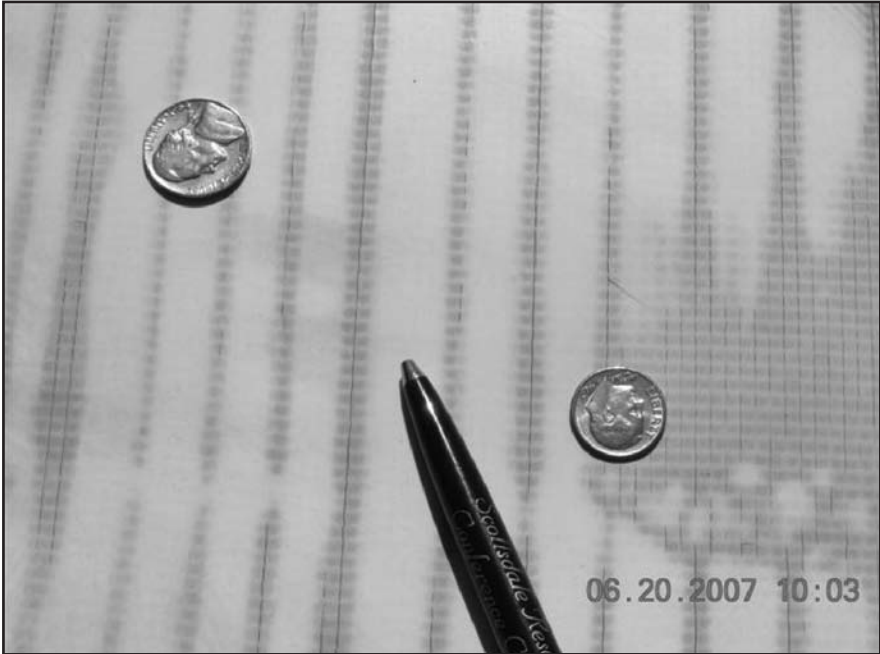
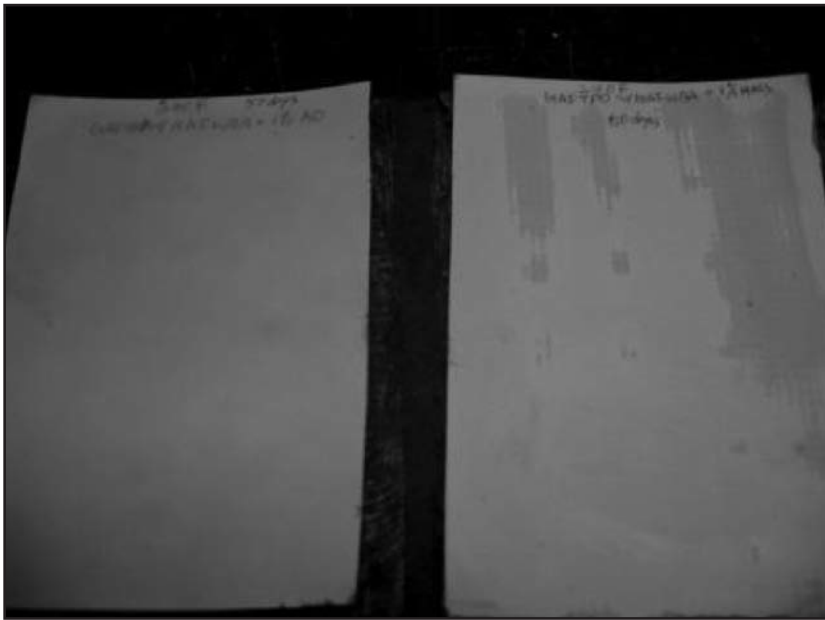


Figure 10 - Water-based adhesive fully adhered TPO failure at extreme temperatures.



(A)

(B)

Figure 11 – Combined adhesive and TPO membrane heat exposure test results at 240°F.

Figure 11

240°F

CONCLUSIONS



