

Test Report for the Poly Processing Company Crosslinked vs. Linear Polyethylene Tanks

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1- Introduction:

Three types of loading tests were developed by Dr. R. Al-Zubi [Ref. 1] to compare the mechanical properties of Crosslinked Polyethylene (XLPE) tanks to the mechanical properties of Linear Polyethylene (LPE) tanks. Drop Tests, Pressurization Tests, and Impact Tests were performed at the Poly Processing Facility in French Camp on October 26, 2001.

2- Test Procedures

a- General Test Procedures for Drop, Pressurization, and Impact Tests

- i. See Reference [1] for test protocols developed by Al-Zubi.
- ii. Two 2800 gallon tanks were used for each test: one tank made from Crosslinked Polyethylene (XLPE), and the other made from Linear Polyethylene (LPE).
- iii. All tanks were filled with water.
- iv. Tests were performed at ambient temperature (~60 - 70 °F).
- v. All tests were performed at the French Camp, CA facility between 7:30 A.M. and 12:00 P.M. on 10/26/01.
- vi. Video pictures and photographs were taken during all tests.

b- Test Procedure for Drop Test

- i. A 6" tall PVC riser fitting was fitted to the top of each tank. The tanks were filled until water flowed out of these risers.
- ii. Any debris was removed from the drop zone.
- iii. Two web straps were passed under each tank and crossed underneath the tank at 90 degree angles. The straps were spaced evenly on each tank, and the four ends of the straps were attached to the hook of the crane.
- iv. An 18 ft. long rope was taped to the side of each tank.
- v. Each tank was briefly lifted to a 3 to 6 ft. height and gently set down.
- vi. Using the rope as a guide, each tank was lifted to an ~18 ft height using a crane.
- vii. After a hold period of less than 1 minute, the tanks were released and allowed to free fall on to a concrete surface.
- viii. The crane did not subject the tanks to any forces after they were released and allowed to fall to the ground.

c- Test Procedure for Pressurization Test

- i. Notches were cut in a standard 2" diameter tank fitting at the bottom of each tank as described in Reference [2]. A pipe plug was used to seal this fitting.
- ii. Each tank was filled with water up to ~1 ft. below the top of the tank.
- iii. The tanks were capped-off using the same type of lid used for standard QC testing of tanks prior to shipment.
- iv. A 5.5 h.p. water pump was connected to a standard 2" diameter tank fitting at the bottom of each tank. Note that this pump connection was made 180 degrees away from the notched, plugged tank fitting. The 5.5 h.p. pump was supplied by United Rentals, and was a Multiquip Model OP-202TH Contractor Pump manufactured in Carson, CA.
- v. The water pump was used to pressurize each tank until failure was detected. Failure occurred when tank failure resulted in significant water leakage or catastrophic failure.
- vi. Tank pressure was monitored using a dial gauge during the tests.
- vii. Time-to-failure was monitored using the timer built-in to the video camera.

3.- Data and Results

a- Drop Test

DROP TEST DATA		
	LINEAR POLYETHYLENE (LPE)	CROSSLINKED POLYETHYLENE (XLPE)
Date of Test	10/26/01	10/26/01
Plant Location	French Camp, CA	French Camp, CA
Test Administrators	Al-Zubi/Weick	Al-Zubi/Weick
Tank Serial #	C-01-13104	C-01-13103
Tank Color	White	Yellow
Resin Type	Linear	Crosslinked
Tank Resin Weight	Shot Weight: 575 lb	Shot Weight: 575 lb
Tank Filled with	Water	Water
Total Weight of Tank	28,000 lb	28,000 lb
Video Included?	Yes	Yes
Pictures Included?	Yes	Yes
Drop Height	~18 ft.	~18 ft. – 1 st drop ~18.5 ft. – 2 nd drop
No. of Drops until Break	1	2

LPE Test Results

- **Visual Account of Test** - The tank ruptured in one drop.
- **Visual Examination of Fractured Surfaces** - The fractured surfaces were “clean”, and appeared to be due to brittle failure. Fracture appeared to be at the web strap locations.

XLPE Test Results

- **Visual Account of Test** - The tank survived the first drop without any sign of failure. The tank ruptured after the second drop.
- **Visual Examination of Fractured Surfaces (After the Second Drop)** – Localized regions of the fractured surfaces appeared to be more ductile due to the presence of elongated plastic strands where failure could have initiated. Fracture lines appeared to propagate from this localized region in a brittle manner, and the fracture also appeared to follow the web strap locations.

3- Data and Results (continued)

b- Pressurization Test

PRESSURIZATION TEST DATA		
	LINEAR POLYETHYLENE (LPE)	CROSSLINKED POLYETHYLENE (XLPE)
Date of Test	10/26/01	10/26/01
Plant Location	French Camp, CA	French Camp, CA
Test Administrators	Al-Zubi/Weick	Al-Zubi/Weick
Tank Serial #	C-01-13010	C-01-12407
Tank Color	White	Yellow
Resin Type	Linear	Crosslinked
Tank Resin Weight	Shot Weight: 575 lb	Shot Weight: 575 lb
Tank Filled with	Water	Water
Total Weight of Tank	28,000 lb	28,000 lb
Video Included?	Yes	Yes
Pictures Included?	Yes	Yes
Maximum Pressure prior to Failure	9 psi	10 psi
Time to Failure		

LPE Test Results

- **Visual Account of Test** - The pump stalled and was restarted during the test. The tank ruptured in a catastrophic manner along multiple fracture lines.
- **Visual Examination of Fractured Surfaces** - The fractured surfaces were “clean”, and appeared to be due to brittle failure. Fracture did not occur at the

precut Notch described in Reference 2. Instead, fracture appeared to either occur or propagate through the bolt locations.

XLPE Test Results

- **Visual Account of Test** – Rupture occurred at the top of the tank along a localized 6 to 8 inch crack that opened-up after the pressure reached 10 psi. This rupture led to significant water leakage, and the pump was stopped at that time. The localized crack opened-up along one of the curved, recessed surfaces at the top of the tank.
- **Visual Examination of Fractured Surfaces** - The fractured surface appeared to be more ductile due to the presence of elongated plastic strands in the cracked region. Fracture did not occur at the precut Notch described in Reference 2.

4- Conclusions

Drop tests and Pressurization tests caused catastrophic failure of the Linear Polyethylene (LPE) tanks. An LPE tank broke after only one drop from ~18 ft., and pressurization led to catastrophic rupture of an LPE tank at 9 psi. Visual inspection of the fractured surfaces showed that these tanks appeared to fail in a brittle manner. This type of failure could be indicative of the unzipping effect of the polymer chains in LPE.

Drop tests and Pressurization tests did not cause immediate failure of the Crosslinked Polyethylene (XLPE) tanks. An XLPE tank survived the first drop from ~18 ft., and broke only after the second drop from ~18 ft. Pressurization of an XLPE tank caused a localized 6 to 8 inch crack to open at 10 psi, and the tank did not fail in the same catastrophic manner as the LPE tank. Visual inspection of the fractured surfaces showed that failure was more ductile, and occurred in localized regions. This localized ductile failure did not lead to complete rupture of the tank in the pressurization tests. However, localized ductile failure did appear to initiate failure lines that led to complete rupture of the XLPE tank after the second drop.

References:

- [1] Al-Zubi, R., *Testing Protocol - Crosslinked vs. Linear Polyethylene Tanks*, Poly Processing Company, Internal Document, 8/13/01, Rev. 1.
- [2] Weick, B., *Procedure used to Cut Notch for Pressure Testing of Crosslinked vs. Linear Polyethylene Tanks*, Poly Processing Company, Internal Document, 10/24/01.

Note from Poly Processing Company: The results from the Impact Tests were inconclusive and therefore, not published.