Comparison of High Density Linear Resins To Crosslink Resins

Many documents have been published in the past comparing high-density linear polyethylene to crosslink polyethylene for use in rotational molding of storage tanks. These have generally supported the superior performance of crosslinked resins over linear. However, some recent sales documents have suggested that with the addition of certain improved UV protection additives, linear is now "as good as" crosslinked. While it is true that the performance of linear resins has improved and the volume of parts made with linear has increased (as has the volume made with crosslinked), a review of comparative performance of the two resins continues to support the conclusion that has long been firmly established in the scientific community, that is, crosslinked resins continue to be superior to linear in the key properties required of long-term storage containers. A point-by-point examination of these recent sales claims will reveal the continued superiority of crosslinked resins:

Recent Sales Claims

- **The major use of crosslink polyethylene is for use with petroleum-based products.** There is just as much crosslinked resin used throughout the general chemical storage market as there is in storing petroleum based liquids. Therefore, this sales claim is not true. From the standpoint of the producer of linear resin products, it may seem that crosslinked is used in just the petroleum market because so little linear is used there. The reason that the majority of petroleum-based products are stored in crosslink tanks is for safety. The end users of the crosslink tanks know that the crosslink material has superior chemical resistance for petroleum products (and for general chemicals as well).

- **858 million pounds of all resins were used last year, industry-wide, with the majority being linear.** When the entire rotomolding industry is considered, this statement is true. However, the bulk of the resin used in the linear market was used in the manufacture of toys, garden equipment, point of purchase displays and many other new markets – most highly cost sensitive and not particularly performance critical. It does not follow, therefore, that the increase in use of linear resins is an indication that crosslink resins are no longer superior or even preferred in high performance applications such as chemical storage tanks.

- **Crosslink resin is declining every year, presently 50% down from 10 years ago.** This statement is true. The reason that crosslink material sales have declined in the past 10 years is that some rotational molders have switched to linear materials for all of their products. The reasons for the switch to all liner resins are mainly cost and market pressure. This trend is alarming. The concern is that safety and long-term performance of the products will be compromised. Both short term and long term tests continue to reaffirm that crosslinked materials are superior. These tests also suggest that linear materials, even those that are additive-improved, have serious deficiencies in product performance and processing reliability.

- **The current shift in storage tanks is to use linear materials instead of crosslink materials.** Again the reason for this shift is cost, not performance! Linear materials are less expensive than crosslink and therefore can be sold as a finished product cheaper. If the bottom line is strictly cost, then linear resins will be the preferred choice. However, if performance, safety, and long-term properties are important, then crosslinked resins should be specified.

- **New linear resins have much greater UV resistance than crosslink resins. As a result of the new UV resistance packages in the latest linear resins, the expected life of a linear tank should be much longer than that of a crosslink resin tank.** The new linear

resins do have better UV inhibitors in them than in the past. The linear resins are using a hindered amine light stabilizer package, which has benefits over the UV inhibitor packages used in crosslink resins. However, this does not mean that the expected life of a linear resin tank will be longer than that of a crosslink resin tank. It simply means that because of the molecular characteristics of linear resins, this UV package can be used. Crosslink resins use a UV inhibitor package that has been proven to be very effective over several years of actual use.

- **Resin manufacturer's technical representatives suggest that the majority of storage tanks do not require crosslink. Their expected market for crosslink is mainly in the auto and tractor industries to contain petroleum products. They do not see crosslink resins as a cost-effective material for the majority of storage tanks.** Some technical representative may be suggesting the exclusive use of linear resins, especially those representatives who work for companies that do not sell crosslinked resins or from those whose major product is linear. Linear resins might be okay for some applications, but again, we are talking about costs and not performance.

The table below, taken from resin manufacturer data, will give some factual measurements to show that crosslink resins are safer and more durable than linear resins. Following the table is an explanation of the three most critical tests and why the results look like they do.

Comparison of Crosslink Resins Vs Linear Resins

Test Procedure	Units	Crosslink Resin	Linear Resin
Density ASTM D-1505	g/cc	.943	.941
ESCR Cond. A, F50 ASTM D-1693 10% Igepal	Hrs.	> 1000	< 100
Heat Distortion Temp. ASTM D-648 at 66 psi	Degrees Celsius	67°	65°
Low Temperature Impact ARM-Low Impact for 1/8" specimen	Ft. lbs.	75	70
Polyethylene Notch Test (PENT) ASTM F 1473 (176° F, 350 psi)	Hrs.	>1000	<10
Long Term Hydrostatic (LTHS) (Creep) At 140° F	Psi.	900	<500

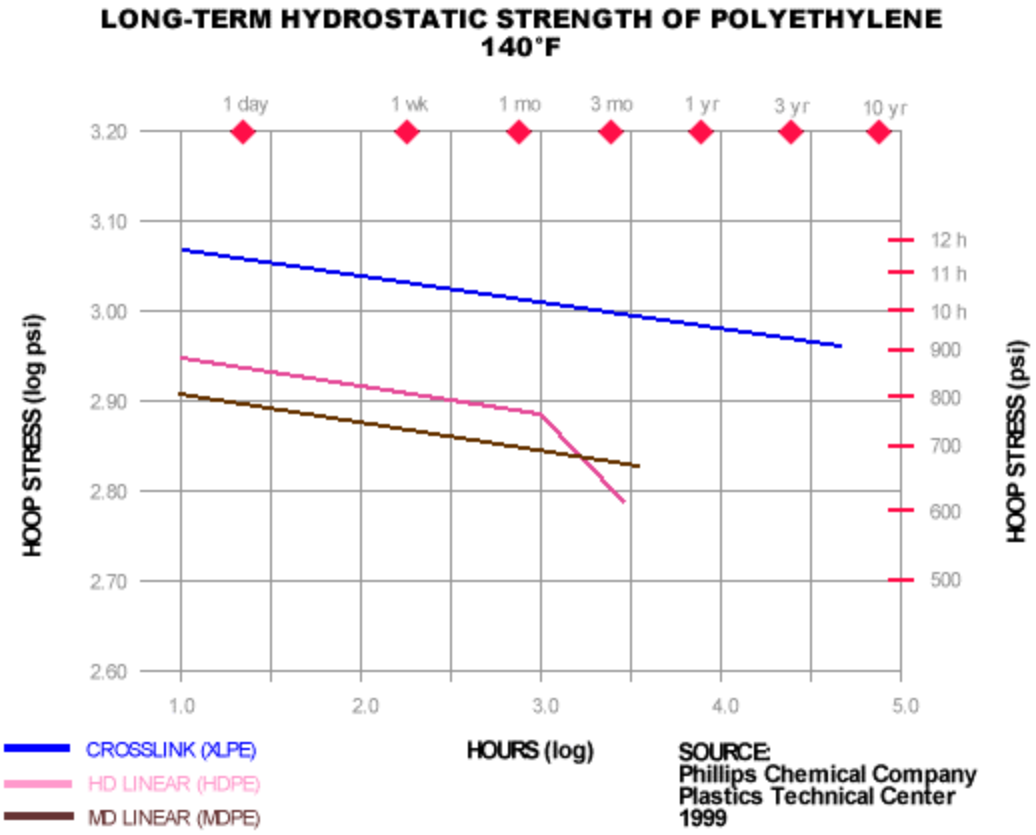
Environmental Stress Crack Resistance and Notch Sensitivity

Two tests which clearly show the differences between crosslink resins and linear resins are Bent Strip ESCR (ASTM D1693) and Polyethylene Notch Test (ASTM F1473). The Bent Strip ESCR uses Igepal (an anionic surfactant), while the Polyethylene Notch Test is performed in air (no surfactant).

Environmental stress cracking resistance (ESCR) is an indication of a material's resistance to slow crack growth. Slow crack growth resistance is an important property that can affect the long-term performance of tanks. The notch test (PENT) suggests the ability of the resin to resist degradation by unzipping, a problem associated with linear resins but not with crosslinked.

Long Term Hydrostatic Strength

LTHS properties are key to providing the continued strength necessary for tanks. This property is especially important in field applications where tanks can see elevated temperatures approaching 140°F. LTHS tests are conducted at both ambient temperature (73°F) and at elevated temperature (140°F) since actual field conditions are typically in this range.



The rapid deterioration in properties is indicated by a “knee” in the curve of hoop strength versus time. Even high performance HDPE will develop a LTHS knee at around 1000 hours (log 3), and some MDPE products will have a knee in less than 10,000 hours (log 5). This type of performance substantially reduces the expected long-term performance at elevated temperatures. Crosslink has been tested to 50,000 hours at 140°F and shows no signs of a knee.

Toughness

Another advantage that tanks made from crosslink resins have over tanks made from linear resins is overall toughness and lower notch sensitivity. While the lower notch sensitivity reduces the possibility of catastrophic failure, the toughness allows the tank to withstand heavy use without failure.

To compare these features, a multi-drop impact test of two linear resin tanks and a crosslink resin tank was conducted. Similar tanks molded from two linear resins and a crosslinkable polyethylene resin were filled with water at ambient temperature and dropped from a height of 27 feet. Both the linear resin tanks and the crosslink resin tank passed the first drop, with all

parts being creased on the sidewalls. However, both of the linear resin tanks catastrophically failed on the second drop. The failure was initiated from the crease that was generated by the first impact. The crosslink resin tank was dropped an additional eight times without failure. This test demonstrates that crosslink resin has superior toughness and a greater ability to withstand abuse. In addition, since both of the linear tank catastrophic failures were initiated at the crease, it demonstrates that crosslink resin tanks are less notch sensitive than linear resin tanks as is seen in the data for the PENT test. In service, any deep scratch, gouge or small crack will act as a notch. Even cracks generated by weathering or a slight chemical attack could behave as a notch.

Summary

If price is the only deciding factor for your purchase of a polyethylene storage tank, then the linear resin tank is the answer. But, if performance, safety and long-term properties are a concern, then you will definitely want to choose crosslink resin tanks for your application.