Why Do Polyethylene Tanks Crack?

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Materials crack when the forces (internal and external) at any particular point exceed the strength of the material at that same point. The forces are measured over an area so that we can distinguish between a force applied over a small area (very damaging) versus the same force that is spread over a large area (generally less destructive). Therefore, the forces are expressed in terms of force per area, the units we normally call pressure or, more commonly in mechanical systems, stress.

In many plastic parts, just the molding process will induce internal stresses. These internal stresses can be caused by several factors such as: orientations of the molecules as they are pushed into a mold cavity in a process such as injection molding, the pulling of the molecules as they move through a die in a process such as extrusion, pushing of the molecules when they are pressed between rollers or dies in processes such as calendaring or compression molding.

Rotational molding allows the molecules to tumble freely inside the mold, which results in parts that are relatively, stress free. However, even rotational molding can induce stresses. For instance, when there are differences in thickness between two areas within a part, the thicker area will shrink more than the adjacent thin area as the part cools. Because the thin area has already solidified as the thick area is still shrinking, the molecules that are along the boundary of the thick and thin areas will be stressed. (They have one end fixed in the cool thin area, but are being pulled into the thick area as it shrinks.) This is like stretching springs, which is obviously an internal stress.

Failure or cracking will normally not occur just from the internal stresses in a plastic part. However, these stresses remain in the parts for very long periods of time and, when added to an external stress, the sum can exceed the local strength of the material and a crack can occur. Note that the local strength of the material at any point is changing with time. The action of UV light and oxygen can break the molecular chains, thus decreasing their strength. (This process is called degradation.) **Therefore, the secret to avoiding cracks is to have low molding stresses, to avoid or limit the amount of degradation, and also to avoid external stresses.**

Tanks fail primarily from two major types of external stresses: chemical stress (microlevel) and mechanical stress (macrolevel). In most tank loading applications the total stress is a combination of the two.

Most polyethylene tanks develop external stresses over a lifetime of use. Regardless of the polyethylene material that the tank is manufactured from or the way it was molded, sometime during the service life of the tank, additional stresses will occur. Once this happens, or after it has happened repeatedly over considerable time, it is appropriate to think about replacing the tank. The nice advantage of polyethylene tanks is that they are very robust, easily spreading forces over wide areas (a property called toughness) and also resisting the chemical forces that cause degradation and mechanical forces. Therefore, with polyethylene tanks, you don't have to experience a premature failure due to unnecessary stress that causes cracks and failures.

Chemical Stress is really a combination of stress and degradation and happens when the stored chemical oxidizes or plasticizes the polyethylene. In other words, when a chemical leeches electrons from the molecular chain of polyethylene, the chain becomes susceptible to oxygen attack. This in turn will lead, over time, to the embrittlement of the polyethylene.

Chemicals can also have a mechanical effect on the tank because some chemical can act as plasticizers. A plasticizing chemical modifies the molecular structure of a polyethylene tank by making the wall soft and causing swelling and expansion. Fortunately, very few chemicals have a plasticizing effect on polyethylene. (This is not true of polyesters and vinylesters, which are far more susceptible to plasticizing effects.) Note also that if the molecules are tied together, as when crosslinked, the swelling is less, thus reducing the effect of chemical plasticizing.

Poly Processing Company prides itself in using the premier resins available for chemical storage. We have found over the past 30 years that crosslinked polyethylene offers a tremendous advantage over linear polyethylene and over fiberglass reinforced polyester and vinylester tanks when talking about chemical stress and attack. Let's look at some ways to anticipate chemical stress in a polyethylene tank, and then we will look at mechanical stress and ways ways to alleviate it.

1. Check the ESCR (Environmental Stress Crack Resistance) of the polyethylene tank you intend to put into service. The ESCR provides the tank manufacturer and end use customer with a measurable time frame for how long a polyethylene tank can withstand the corrosive effects of certain chemicals. Most linear polyethylene used for tank manufacturing is rated between 50 and 400 hours of continuous exposure to harsh chemicals. The high performance crosslinked polyethylene used by Poly Processing Company is rated for over 1000 hours of continuous exposure to harsh chemicals. (The same numbers are currently being used by linear resin manufacturers) This long exposure time for crosslinked Polyethylene results in tanks that have a long service life which translates itself into cost savings to the customer. Poly Processing's tanks have been in the field for over 20 years storing such harsh chemicals.

2. Make sure the tank(s) you are ordering are compatible with the chemical you will be storing. Poly Processing Company can help you with this.

3. Buy your tank from a reputable manufacturer, one that is able to minimize the internal stresses, which might result from improper molding. All rotational molding operations are not the same, and Poly Processing is well known as among the best, with tanks that are carefully designed to minimize molding stresses.

Now that we have talked a little about chemical stress, we can focus on mechanical stress and how to control it.

As the name implies, “mechanical stress” is caused when stress is applied by physical means. This stress can be caused by impacts, but can also be caused by stresses imparted from changes made to the tank structure.

The most common place for mechanical stress in a polyethylene tank is where a hole is cut to attach a fitting. Many times, when fixtures such as pipes, pumps, level indicators, or valves are hung onto a fitting, a binding effect is created causing a cantilevering action, this causes the polyethylene tank wall to expand and contract under stress and causes premature failure instead of expanding and contracting naturally.

It is interesting to note that if a crack develops due to this stress, the behavior of the crack is different depending on the polyethylene material the tank is made of. If the tank is manufactured from HDPE, the crack has a tendency to unzip or grow quickly which can lead to catastrophic failure. Due to the 3-D nature of the molecules in XLPE tanks, this unzipping effect is greatly reduced or eliminated and provides a much safer atmosphere for the end user. The failure in a xlpe tank will be leakage through a small crack, not catastrophic failure.

A second common area of failure is where fittings are welded on linear polyethylene tanks. Manufacturers have been trying unsuccessfully for years to weld fittings onto polyethylene tanks. There are two inherent problems with this:

1. Once the tank has completed its manufacturing cook cycle, the polyethylene is solidified. Any heating of the tank or tank area by hot air or plastic welders will cause greater oxidization in the area where the heat is applied and cause premature failure.
2. There are three types of polyethylene materials needed to weld a fitting to a tank. The tank material itself, the polyethylene fitting material, and the polyethylene welding rod material. These materials are not compatible with each other due to the density of the material, the way the material is formed (rotational molding vs injection molding vs extrusion molding). It is recommended in the chemical industry to never weld a fitting to a polyethylene tank.

Another cause of mechanical stress is the improper placement of a fitting. By nature, all plastic tanks are in a state of flux or movement due to temperature variance or liquid level in the tank at any given time. It is important that the fitting be placed at the right location. The fitting should be situated above the knuckle where the wall thickness is most even. This allows the tank to expand and contract without causing the fitting bolts to bind in the area of the cut or drilling holes.

Since plastic tanks expand and contract, it is important to use some sort of flexible connector or expansion joint with the correct flexibility to allow the tank to move naturally and alleviate binding in the fitting area. Expansion joints are commonly used and work well based on using the correct size and material. Poly Processing Company or your local distributor can help you make the correct choice.

One of the other products that work well with polyethylene tanks is flexible hose. A flexible hose is adequate to control vibration as well as moderate levels of expansion. Poly Processing Company recommends using care when choosing flexible hose for your application. It is important that the application does not have opportunity for compression. Flexible hose is really only good for expansion of the polyethylene tank.

Plumbing may also be used to allow expansion through the use of extra elbows and / or extra lengths of pipe.

Poly Processing Company can help you with these issues and give you the best ways to reduce stress in your tank.