The advantages of HDPE for chemical storage tanks

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There are several important areas in which chemical-grade high density polyethylene (PE-100 HD) differs from the polymers (PE-LLD or linear PE-MD/HD) typically used in rotationally moulded tanks. These are important when considering chemical storage tanks.

• Polymer-resin structure

The structures of the types of polymer are very different.

As the resins for rota-moulding need to be of low viscosity ('water like' when melted) to enable the moulding process to work without pressure, the material properties are always limited by the maximum possible molecular weight.

On the other hand, PE-100 grade resins have a much higher molecular weight, which requires high pressure production techniques to convert into products. There are therefore many more options for the basic molecular structure, as a much wider range of molecular weights can be tolerated by extrusion or press moulding techniques.

• Production of the tank

Rota-moulding requires a polymer with low viscosity because it is not possible to apply pressure on the melt during the fabrication process. The natural thermal shrinkage cannot be compensated and might therefore result in voids in thicker walls. With the extrusion and high pressure moulding techniques used with HDPE such problems do not occur.

• Ability to design to a known life

All plastics that are subject to stress will age with time.

Stress is automatically produced when a tank is filled with liquid. This means that that holding dangerous chemicals need to be manufactured from materials whose ageing behaviour has been accurately determined from long-term testing.

For PE-100 HD, long-term pipe pressure tests have been performed and extrapolated according to the international standard ISO/TR 9080. The results (referred to in DVS 2205 and EN 12573) allow engineers to design to a known working life with confidence.

In comparison, there is virtually no such long-term test data available for the polymers used in the manufacture of rota-moulded tanks - only single-spot hoop tests have been made.

Based on the single hoop tests it is clear that rota-moulded polymers will never reach the MRS-strength similar to PE-100. For instance, at 40°C with a hoop stress of 6 MPa, rota-moulded materials may reach 13.000 hours, whilst PE-100 has a design time of 200,000 hours at the same parameters.

• Material properties

The primary difference between the high density polyethylene used for manufacture of tanks and pipes, and the polyethylene used for rota-moulding, is the length of the ethylene molecules that make up each material.

PE-100 used for tanks and/or pressure pipes has a molecular weight of about 300.000 g/mole whilst the polyethylene used in the rota-moulding process, typically PE-LLD, has a molecular weight from 50,000-100,000. The PE-100 molecules are up to six times longer!

This extra length allows the molecules to create more 'knots and links' between them, increasing toughness, creep resistance and stress cracking resistance, whilst retaining an optimum level of crystalinity to also provide a high tensile strength and stiffness.

- **Environmental stress cracking resistance**

Over time, corrosive chemicals attack at the micro-cracks in any polymer surface. The degree to which this is resisted by the polymer depends on several factors, however, it has been shown via independent tests that PE-100 polymers have far superior ESC resistance compared to those resins used for rota-moulding.

This is reflected in the different standards that are employed to measure ESCR for pipe grade and rota-moulded polyethylene materials. For PE-100 the requirement is for a specimen immersed in surfactant at a temperature of 80°C to sustain a full load of 4MPa for 1000 hours (test standard EN 12814-3).

At present there is no requirement or standardisation currently in being for the ESCR of rota-moulded polymers. Initial discussions for a possible EN standard give a requirement of 15 hours at only 60°C, this being considered to be at the top end. At 80°C, test results are obviously much lower (1 to 10 hours). The different requirements reflect the difference in capabilities of the materials.

- **Design codes**

The pre-eminent design codes for fabricated thermoplastic chemical vessels are the DVS 2205 (a German Merkblatt guideline available in English) and the less demanding EN 12573.

Both codes are internationally accepted for thermoplastic chemical tank design.

They provide detailed design procedures taking into account long-term hoop stress, wind-loading (only DVS, not EN 12537), nozzles, manholes, temperature effects up to 60°C, and stress concentration factors.

In comparison, today's rota-moulding design standards provide only very limited calculations in the whole document to calculate the wall thickness. Effects such as temperature influence, long term creep and chemical ageing of the polymer are not considered at all because, as stated before, there isn't the data to support it.

- **Safety of connections**

Virtually all PE pipe and pipe fittings in Europe are manufactured from high density polyethylene, mostly PE-100.

This creates a problem when connecting to a rota-moulded polyethylene tanks.

The most common practice is to weld the HDPE pipe fitting to the rota-moulded tank wall. This leads to inevitable and well-documented failures. The two materials are effectively different molecular structure - the melt viscosity of rota-moulded polymer is much lower. Thus, the welds are highly susceptible to cracking, especially when exposed to oxidising chemicals.

There is no similar problem when welding HDPE pipe to an PE-100 tank as they are the same material, providing optimum weld strength and a life equivalent to the tank.