Use of High Performance PE Materials (PE 4710) in Geothermal Applications

HDPE pipe has enjoyed much success as ground loops and underground header piping because of its light weight, corrosion resistance and the ability to easily weld joints. Typical specifications modeled from IGSHPA reference pipe standards ASTM F 714 and ASTM D 3035. The actual polyethylene material properties in these standards are specified in ASTM D 3350 and articulate variables such as the resin density, melt index, and tensile strength.

In the IGSHPA "Design and Installation Guide"[1], HDPE pipe materials are designated by PE 3608 or PE 3408 (PE 4710 is also acknowledged). The first number is the ASTM D 3350 designation for the density of the resin. The second number designates the environmental stress crack resistance, a measure used to signify pipe performance and sometimes longevity. The last two numbers designate the Hydrostatic Design Stress, by which the pipe's pressure rating is calculated.

In the late 80's, high performance PE resins were introduced in Europe. More recently in the mid 2000's, HDPE pipes manufactured with PE 4710 resin have become popular in water and industrial pressure applications. ASTM, AWWA, IGSHPA and other organizations acknowledge the superior performance of high performance PE resins.

"The latest generation of high density PE pipe materials, known as high performance materials (e.g. PE 4710), are, for the most part, produced from bimodal resins. Pipe made from these materials are characterized by truly exceptional and unique resistance to slow crack growth (SCG), significantly improved long term performance, higher pressure ratings or increased flow capacity, and improved chemical resistance, all of which are achieved without compromising any of the other traditional benefits that are associated with the use of PE pipe."[2]

HDPE pipe made from PE 4710 resin will allow a designer of geothermal systems, to design lighter pipe, with the same pressure rating and performance characteristics as PE 3608. Additionally, because the wall thickness is less, an added benefit of increased water flow and better thermal conductivity are two other positive features.

The following are comparisons between PE 3608 and PE 4710 HDPE piping materials with respect to properties involved in geothermal design:

Table 1-Pressure Rating Comparison between PE 3608 and PE 4710 HDPE pipe at 73.4 degrees F

Dimension Ratio	Pressure Rating PE 3608	Pressure Rating PE 4710
SDR 9	200 psi	250 psi
SDR 11	160 psi	200 psi
SDR 13.5	128 psi	160 psi

Table 2-Comparative Water Flow Increase for 1 SDR Increase from PE 3608 to PE 4710[3] (Example SDR 13.5 PE 4710 vs. SDR 11 PE 3608)

System Pressure	200 psig	160 psig	130 psig	100 psig
Capacity Increase	15.4%	12.0%	10.4%	7.3%

Table 3-Comparative Thermal Resistance Decrease for 1 SDR Increase from PE 3608 to PE 4710

Pressure Rating	PE 3608 SDR Reqd.	Thermal Resistance	PE 4710 SDR Reqd.	Thermal Resistance
200 psi	SDR 9	0.175	SDR 11	0.141
160 psi	SDR 11	0.141	SDR 13.5	0.117

You can see from Table 3, by virtue of a thinner pipe wall, based on substituting a one less SDR PE 4710 pipe, the thermal performance of the pipe can be improved by 20%.

Another benefit of being able to substitute a lower SDR PE 4710 pipe of the same nominal size, and therefore a larger pipe ID, is the lower head loss in the system. The head loss is directly related to the ID, so SDR 13.5 1 ¼" pipe will have approximately 4% less head loss than SDR 11 1 ¼" pipe. Though minor, it could allow the designer to lower his pump requirements.

A detrimental effect of a larger ID, is the flow rate required to reach turbulent flow-a Reynolds number of 2500. Comparing similar diameters with a 1 SDR difference (SDR 13.5 to SDR 11), the Q required for the thinner wall pipe will be 2.5 to 5% greater, depending on the diameter. Most designs are well above the minimum for turbulence, so this increased flow requirement seems less significant.

In conclusion, the benefits of PE 4710, increased pressure rating, stress crack resistance and resulting longevity increase, along with better economics, should be considered in any geothermal design. These high performance HDPE resins give the designer another tool to make geothermal systems more competitive and viable as alternative energy systems benefiting the public at large.

References:
1) Page 4-5, Ground Source Heat Pump Guide-Design and Installation Guide, IGSHPA, 2009
2) Page 54, Handbook of Polyethylene Pipe, Second Edition, Plastic Pipe Institute, 2008
3) TN 41/2007, High Performance PE Materials for Water Piping Applications, Plastic Pipe Institute, 2007