Clarifying the nomenclature of Elvaloy-based geomembranes: EIA, EIP or KEE

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Since the first flexible membrane liner (FML) was used as part of an environmental liner system, the geomembrane industry has always looked for innovative solutions for chemical containment applications. Although there have been many innovations over the last 50 years, one of the most significant is the introduction of ketone ethylene ester (KEE), which is a solid plasticizer. KEE is available under the Elvaloy trade or product name and is used to plasticize polyvinyl chloride (PVC) geomembranes, as discussed in detail in this article.

KEE was invented by DuPont, and the original 1973 patent has expired. DuPont developed KEE to provide a solid plasticizer or polymer to replace liquid plasticizers that would make PVC and other polymers flexible without concerns of plasticizer migration and loss. Plasticizer migration and loss usually results in the material becoming stronger but more brittle and susceptible to cracking.

Unfortunately, Elvaloy has been known by several acronyms, e.g., KEE, ethylene interpolymer alloy (EIA) and ethylene interpolymer (EIP), which has caused confusion in the industry. As a result, the purpose of this article is to clarify the meaning of KEE, EIA and EIP for geomembrane-related applications. Some people in the trade are not aware that a KEE-based geomembrane is a flexible PVC geomembrane with a new plasticizer.

Compared to conventional polymeric and monomeric liquid plasticizers, KEE exhibits a significantly higher molecular weight, which greatly reduces plasticizer migration (Stark et al. 2005) in PVC geomembranes. Stark et al. (2005) shows that increasing plasticizer molecular weight decreases plasticizer migration because the higher molecular weight yields a larger molecule that has greater difficulty migrating to the top surface of the geomembrane and out of the geomembrane. As a result, plasticizer migration and loss decreases with increasing molecular weight. In 2004 the Fabricated Geomembrane Institute (FGI) set the minimum plasticizer molecular weight at 400 grams/mole to ensure suitable long-term performance of PVC geomembranes in containment applications. This is the FGI Material Specification dated Jan. 1, 2017, and termed FGI 1117. A minimum plasticizer molecular weight of 400 grams/mole has worked well and created more consistency in the marketplace. However, recent applications, e.g., exposed and elevated temperature applications, have created a demand for even higher-performance PVC geomembranes and thus higher-performance plasticizers.

As a result, considerable interest has developed for use of higher molecular weight plasticizers, such as KEE. In addition to having a higher molecular weight, KEE is a solid plasticizer/polymer that does not break down, which prevents migration and loss from the geomembrane because it retains its large structure and remains a solid.

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The molecular weight of traditional plasticizers, e.g., phthalates, range from 200 to 530 grams/mole (Stark et al. 2005). For comparison, KEE exhibits a molecular weight of 100,000 to more than 260,000 grams/mole or 500 times greater than the molecular weight of traditional liquid plasticizers. A KEE molecular weight of 100,000 grams/mole is 250 times higher than currently required (400 grams/mole) by the FGI 1117 specification for PVC geomembranes.

KEE is a solid-phase (polymeric) plasticizer, not liquid, which helps explain its high molecular weight and resistance to migration. This allows the resulting geomembranes plasticized with KEE to maintain their flexibility for a longer time, resulting in a longer service life. Because of its flexibility and longevity, KEE-blended material is used for exposed single-ply roofing, environmental containment liner systems, "no-dig" water and sewer pipe repair liners, coated fabrics, footwear, and wire and cable coatings.

Two broad classes of KEE are available under the Elvaloy product name and are used to plasticize PVC geomembranes. These are the standard grades (Elvaloy 741 and 742) and Elvaloy High Performance (HP) series grades that have an even higher molecular weight. As a result of the confusion over the acronyms, the geomembrane industry most commonly uses EIA and KEE to describe PVC-blended geomembranes, which is only partially correct.

For geomembrane applications, PVC resin is blended with KEE to produce a flexible and durable geomembrane for environmental containment applications. The resulting blend of PVC resin and KEE is called EIA or EIP. To clarify, EIA and EIP are two names for the same polymer, which further causes confusion.

FIGURE 1 A 60-mil (1.5-mm) EIA/KEE geomembrane for a secondary containment application with a soil cover

Uses and applications

While a variety of flexible vinyl applications were initially pursued using KEE, geomembranes are the first commercial use for KEE. Performance after direct contact with aggressive fluids was a good way to demonstrate and confirm the resistance of KEE to plasticizer migration in harsh environments. As a result of the excellent geomembrane performance in exposed applications, single-ply roofing products with KEE were subsequently introduced. This has resulted in significant penetration of exposed roofs for commercial structures.

Strengths

KEE plasticizers/polymers enhance the characteristics of other resins by making them more durable, more flexible and longer lasting. Typical benefits of KEE-blended materials include:

- Improved performance under conditions in which a liquid plasticizer would migrate, such as outdoor exposure to weather or contact with chemicals. As a result, EIA or EIP geomembranes are being used for hydrocarbon and diesel containment applications.
- Increased melt strength for thinner parts, improved foam cell structure and increased thermoforming temperature window, which has facilitated welding individual sheets of EIA geomembranes.
- Reduced scrap and higher yields through improved flow and fusion characteristics, which allows for lower processing temperatures and a wider processing window for rigid PVC resin/materials.

- Reduced cost by enabling higher filler levels while meeting required impact properties.
- High-impact strength that meets or exceeds industry standards.

Weaknesses

The cost of a PVC geomembrane formulated with KEE is higher than similar geomembranes formulated with a liquid plasticizer even if the liquid plasticized material meets the Fabricated Geomembrane Institute specification FGI 1117 requirement of a minimum average molecular weight of 400 grams/mole. This is due to both a significantly higher cost (dollars/pound) of KEE as compared to standard liquid-based plasticizers and a greater percentage of KEE being needed to obtain a similar flexibility for the PVC and KEE blend. The real benefit of using KEE is that the resulting geomembrane will be flexible for a much longer time and exhibit a greatly extended service life even in exposed and/or harsh chemical environments. Therefore, if long service life is desired, a PVC resin and KEE blend should be considered even though it may have a higher initial cost. The FGI is exploring the possibility of creating a material specification for KEE-based PVC geomembranes to facilitate their specification and usage.

KEE applications

Today, a wide variety of both supported and unsupported geomembrane products containing KEE are available in the geomembrane and other industries in applications such as primary and secondary containment in harsh chemical environments, as well as exposed potable and nonpotable water containment.

When selecting a product with Elvaloy, it is critical that the product chosen for the application contains the correct level of Elvaloy combined with the appropriate component polymer to ensure the performance meets the project longevity requirements. It is not uncommon for these materials to have a full replacement, i.e., not prorated, warranty of 15 years because of the successful uses of these materials to date.

>> For more, search **Elvaloy** at www.GeosyntheticsMagazine.com.

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