

# **EIA, EIP, KEE, Elvaloy®: Clarifying the Nomenclature of Geomembranes**

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## **Introduction**

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 to environmental 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. The tradename or product name for KEE is Elvaloy®.

KEE was invented by DuPont and the original 1973 patent has expired. KEE was developed to provide a solid plasticizer or polymer to replace liquid plasticizers that would make polyvinyl chloride (PVC) flexible without concerns of plasticizer migration. KEE is available under the Elvaloy® product name and is used to plasticize PVC geomembranes as discussed in detail below. Elvaloy® has been known by several acronyms, e.g., KEE, EIA, and 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 applications.

Compared to conventional polymeric and monomeric liquid plasticizers, KEE exhibits a higher molecular weight, which reduces plasticizer migration (Stark et al., 2005). Stark et al. (2005) show 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. In addition to a higher molecular weight, KEE is a solid plasticizer/polymer that does not break down, which also prevents migration from the geomembrane because it retains its large structure.

The molecular weight of traditional plasticizers, e.g., Phthalates, range from 200 to 530 g/mole (Stark et al., 2005). For comparison, KEE exhibits a molecular weight of 100,000 to over

260,000 g/mole or 500 times greater than the molecular weight of traditional liquid plasticizers. 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 its 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 liners, "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: standard grades (Elvaloy® 741 and 742) and Elvaloy® High Performance (HP) series grades that have an even higher molecular weight. Unfortunately, Elvaloy® has been known by several acronyms, e.g., KEE, EIA, and EIP, which has caused confusion in the industry. For example, 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 applications. The resulting blend of PVC resin and KEE is called EIA, which stands for ethylene interpolymer alloy or EIP, ethylene interpolymer. To clarify, EIA and EIP are two names for exactly the same polymer.

## **Uses & Applications**

While a variety of flexible vinyl applications were initially pursued for KEE, geomembranes are the first commercial use for Elvaloy®. Performance after direct contact with aggressive fluids was a good way to demonstrate and confirm the resistance of KEE to plasticizer migration. As a result of the excellent geomembrane performance in exposed applications, single-ply roofing products with Elvaloy® were introduced.

## **Strengths**

DuPont™ Elvaloy® 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
- Increased melt strength for thinner parts, improved foam cell structure, and increased thermoforming temperature window
- Reduced scrap and higher yields through improved flow and fusion characteristics, which allow for lower processing temperatures and a wider processing window for rigid PVC resin/materials

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

## **Weaknesses**

The cost of a PVC geomembrane formulated with Elvaloy® is higher than similar geomembranes formulated with a liquid plasticizer even if the liquid plasticized material meets the Fabricated Geomembrane Institute Specification FGI-1115 ([www.fabricatedgeomembrane.com](http://www.fabricatedgeomembrane.com)) requirement of a minimum average molecular weight of 400 g/mole. This is due to a significantly higher cost of KEE than 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 is that the resulting geomembrane will be flexible for a much longer time and exhibit a greatly extended service life. 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.

## **Applications**

Today, a wide variety of both supported and unsupported geomembrane products containing KEE, i.e., Elvaloy®, are available in the geomembrane and other industries in applications such as primary and secondary containment, as well as potable and non-potable water containment. When selecting a product with the appropriate level of 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.

## **Acronym Definitions**

EIA	ethylene interpolymer alloy
EIP	ethylene interpolymer
KEE	ketone ethylene ester is the chemical name.
Elvaloy®	DuPont Trademark under Registration # 73087617 and serial # 1058099.

## **References**

Fabricated Geomembrane Institute (FGI) (2015). "FGI 1115 Specification: Effective January 1, 2015." [http://www.fabricatedgeomembrane.com/?page\\_id=1522](http://www.fabricatedgeomembrane.com/?page_id=1522).

Stark, T.D., H. Choi, H., and Diebel, P. (2005). "Influence of Plasticizer Molecular Weight on Plasticizer Retention in PVC Geomembranes," *Geosynthetics International Journal*, 12(2), May, pp. 99-110.



*Engineered Polymer Technologies manufacturers supported and unsupported PVC, EIA and specialty polymer geomembranes. For more information, please visit <http://www.epttech.com>, send us an email at [info@epttech.com](mailto:info@epttech.com) or for immediate response call us at 908-558-0011.*