Flexible Geomembrane Terminology and Descriptions
FGI Specification Review Subcommittee

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List of common Flexible Geomembranes (in polymeric alphabetical order) described herein:

1. Chlorosulfonated Polyethylene – Reinforced (R-CSPE)
2. High Density Polyethylene (HDPE)
3. Linear Low-Density Polyethylene (LLDPE)
4. Linear Low-Density Polyethylene - Reinforced (R-LLDPE or R-PE)
5. String Reinforced Polyethylene (R-SRPE)
6. Woven Coated Polyethylene (WCPE) - Reinforced (R-WCPE)
7. Polypropylene - Reinforced (R-PP)
8. Polyvinyl Chloride (PVC)
9. PVC + Ethylene Interpolymer Alloy (EIA) [PVC + KEE] – Reinforced (R-EIA)
10. Polyurethane - Reinforced - (R-PU)

1. Chlorosulfonated polyethylene - Reinforced (R-CSPE):

Chlorosulfonated polyethylene (CSPE) geomembrane (R-CSPE), formerly known as Hypalon, is a synthetic rubber material noted for its very good resistance to chlorine and other chemical disinfectants used in water treatment and very good flexibility and excellent long term UV stability. CSPE was first developed as a geomembrane in the mid 1970's in the United States. R-CSPE is produced as a reinforced material using an internal polyester fabric scrim laminated with a CSPE film coating on both sides. It is available in standard thicknesses of 36, 45 and 60 mil (0.91, 1.14, 1.5 mm). The material is certified to NSF/ANSI 61, allowing it to be used for drinking water applications.

R-CSPE can be factory fabricated and field installed using thermal wedge welding and chemically fused using special adhesives. The material initially is manufactured as a

thermoplastic, however over time it undergoes a molecular cross linking process into a thermoset. As the material cures to a thermal set, it demonstrates excellent long term retention of its tensile strengths, chemical resistance, coating thickness and UV stability. It does become more difficult to weld as it cures and requires special techniques performed by experienced CSPE welding technicians. Repairs on CSPE have been performed on materials over 35 years old. R-CSPE is available in a multitude of colors including black, white, tan, blue and green. It can also be produced with various other custom colors.

Common Applications:

R-CSPE is primarily used in municipal water containment applications as a geomembrane liner for waterproof reservoirs, clearwells and above ground tanks and as a floating cover in reservoirs for protection of potable water. It is also used as a baffle curtain in both potable and wastewater treatment. R-CSPE is a flexible geomembrane designed for long term containment of water in municipal water applications. A manufacturers specification for this type of geomembrane can be downloaded from this link for projects: https://www.burkeind.com/wp-content/uploads/2025/04/Burke_Industries_Hypaflex_Specification_SN-002.pdf.

2. High Density Polyethylene (HDPE):

HDPE is a thermoplastic geomembrane barrier widely recognized for its cost-effectiveness, excellent chemical resistance, UV stability and durability. Standard HDPE materials today are typically have limited flexibility and are manufactured using medium density polyethylene (MDPE) resins, which improves its stress crack resistance and extrusion processing. To ensure longer-term performance, HDPE is stabilized with carbon black and various performance antioxidants, and UV stabilizers. HDPE has been produced in United States since the mid 1980's and today is one of the mainstream liner materials used for a variety of environmental containment applications.

HDPE has a higher crystallinity structure (40–50%) which results in very good overall chemical resistance and durability. This higher crystalline structure results in HDPE being a more rigid and stiff material. The higher crystallinity also results in lower yield elongation properties (12–15%), which reduces its flexibility and elongation. It also makes HDPE more susceptible to permanent deformation in applications requiring higher elongation, multiaxial and cyclic loading properties. HDPE is not a suitable choice of liner for factory fabrication and needs to be 100% field welded using thermal fusion including hot wedge and extrusion welding methods. HDPE smooth sheet has a higher co-efficient of thermal

expansion and contraction making it more susceptible to wrinkles and creases resulting from temperature fluctuations. Wrinkles, folds and creases with HDPE can be reduced using higher opacity white skin surface colors exposed to the surface. HDPE is available both in smooth and textured grades. HDPE geomembranes are manufactured in standard thicknesses of 30, 40, 60, and 80 mil (0.75, 1.00, 1.5, and 2.0 mm), and typically available in black or white. HDPE has a lower coefficient of friction than other geomembranes so it is available in both a smooth and textured surface.

Common Applications

Based on its excellent overall chemical resistance and UV stability, HDPE is commonly used in a variety of exposed applications. HDPE is extensively used in municipal and hazardous waste landfill for liners. It is also frequently used in mining for tailings and processed water and in municipal wastewater treatment applications. In oil and gas, it is frequently used for produced water ponds. It is not recommended in applications requiring higher flexibility, elongation or exposed to cyclic loading. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: GM-13; https://geosynthetic-institute.org/grispecs/gm13.pdf.

3. Linear Low-Density Polyethylene (LLDPE):

LLDPE geomembranes have very good flexibility, durability, and chemical resistance for barriers commonly used in civil engineering and environmental applications to control fluid and gas migration. With very good UV stability and chemical resistance, LLDPE is typically manufactured in standard thicknesses of 30, 40, 60, and 80 mil (0.75, 1.00, 1.5, and 2.0 mm).

LLDPE can be factory-fabricated or field-installed using thermal wedge, hot air or extrusion welding. Compared to HDPE, LLDPE has a lower crystalline structure allowing LLDPE to be both factory fabricated and field seamed using thermal welding by wedge hot air and extrusion welded. Similar to HDPE, LLDPE has a relatively low interface friction angle, however, it is available with a textured surface to help increase frictional resistance. It is also one of the more economical geomembrane options, offering a good overall balance of performance and cost. LLDPE has a relatively high thermal expansion rate resulting in wrinkles with temperature fluctuations. This can be minimized by using white color skin layers which helps to reflect UV light and reduce the sheet temperature. LLDPE geomembranes are produced to GRI GM17 specifications. It is typically available in black or white sheet colors. It is a good choice of material for mid to long-term exposed applications.

Common Applications:

Standard applications for LLDPE include factory fabricated tank liners for fresh and produced water in upstream oil and gas in both earth lined ponds and above ground storage tanks. It is also a good choice of material for municipal landfill caps and closures. Based on its overall very good chemical resistance, it is also used in mining for tailings and in agriculture for irrigation canal linings and in mining tailings applications. Based on its multiaxial properties, it is well suited in projects with poor or inconsistent soil compaction resulting in potential soil deformation problems. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: GM-17; https://geosynthetic-institute.org/grispecs/gm17.pdf.

4. Linear Low-Density Polyethylene – Reinforced (R-LLDPE):

LLDPE-R geomembranes also commonly referred to as reinforced polyethylene (RPE), is a thermal plastic barrier material noted for its good flexibility, durability and good overall chemical resistance. It also has very good UV stability and is commonly used in exposed applications. LLDPE-R liners incorporate a layer of internal reinforcement (fabric scrim) between layers of LLDPE barrier film. It is commonly used in civil engineering and environmental applications requiring higher tensile and tear properties, exceptional tensile strength and puncture resistance at a lower weight and thickness to meet those demands. LLDPE-R is typically manufactured to GRI GM25 specifications in standard thicknesses of 30, 36, 45, and 60 mil (0.75, 0.91, 1.14, and 1.5 mm).

LLDPE-R can be factory-fabricated or field-installed using thermal wedge or extrusion welding. Due to its higher crystallinity compared to other polymer based flexible geomembranes, field welding is generally recommended for thicknesses of 60 mil and above. LLDPE-R is available in both a smooth and textured surface for those applications that require higher interface friction. LLDPE-R incorporates higher performance at a lower cost to weight ratio giving the specifier those options when warranted. It is commonly available in black, white, tan and grey colors. As a reinforced material, LLDPE-R provides very good dimensional stability, reducing the number of wrinkles as a result of thermal expansion and contraction.

Common Applications:

Based on its good UV stability and chemical resistance, LLDPE-R is commonly used as an exposed geomembrane in a variety of wastewater treatment ponds and produced water ponds. Its high tensile strength properties also makes it a good choice in applications with

long and steep slopes or vertical slope applications with above ground storage tanks. LLDPE-R is also a good choice of material for long term exposed applications. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: GM-25; https://geosynthetic-institute.org/grispecs/gm25.pdf.

5. Woven Coated Polyethylene (WCPE): :

WCPE geomembranes are thermal plastic barriers noted for their lighter weight, good flexibility, durability and cost effectiveness. Unlike R-SPE string reinforced, WCPE materials are reinforced with a layer of woven HDPE fabric scrim coated with a thinner impervious LDPE layer on both sides. Commonly used in short to mid-term environmental liner, residential and industrial covers requiring good tear, tensile, and puncture resistance properties at a lower weight, cost and thickness to meet those demands. WCPE provides good overall chemical resistance and is typically available in thicknesses ranging from 10 mil through 60 mil (0.25 to 1.5 mm). WCPE geomembranes are most commonly available in a black color, however other colors are available. There are also a variety of multi-reinforcement scrim configurations available for more aggressive applications. WCPE can be produced in accordance with GRI GM30 specifications in standard thicknesses of nominal 30 and 40 mil (0.75 and 1.00 mm), meeting both category 1 and 2 of the specification. WCPE can be factory fabricated into very large custom size panels, reducing the amount of field welding required. Factory fabrication is done using thermal hot air and wedge welding methods. WCPE can be thermal wedge welded in the field typically for thickness of 20 mil (0.50 mm) and thicker. WCPE material also has very good cold temperature properties.

Common Applications:

Lighter weight WCPE from 10 to 20 mil (0.25 to .50 mm) are typically used in short term, less critical applications including interim rain-shed covers for landfills, industrial fabric applications, e.g., hay tarps, grain covers, soil stockpiles, building covers, and for non-critical seepage control applications. Mid to heavier weights 24 – 60 mil (0.61 to 1.5 mm) mil are more commonly used in agricultural containment applications including irrigation canals, ponds, reservoirs and decorative golf course ponds. They are also commonly used in oil and gas for water, sludge, mud pits and full pad containment. WCPE is a good choice of material for short to mid-term exposed applications. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: GM-30; https://geosynthetic-institute.org/grispecs/gm30.pdf.

6. String Reinforced Polyethylene Lightweight Barriers (R-SPE)::

String Reinforced Polyethylene lightweight barriers are produced for interim exposed applications designated as 5 to 15 years dependent of thickness. These lightweight barriers are used where good flexibility and tear resistance are a primary design consideration. Commonly used in cover applications such as interim rain-shed covers for landfills, stockpile covers, or remediation covers. The string reinforcement consists of polyester yarns in an open pattern sufficient to achieve the specification stated in GRI-GM22. The strings/yarns often consist of polyester filaments but other polymers have been successfully used such as nylon. R-SPE are commonly available in thicknesses of 8, 12 and 20 mil (0.2, 0.3, and 0.5 mm) but can be manufactured in heavier weights up to 40 mil (1.0 mm). R-SPE is provided in factory welded fabricated panels designed to fit the application it is being specified for.

Common proven field installation seaming methods for 8 or 12 mil (0.2 and 0.3 mm) lightweight scrim reinforced polyethylene is by sewing with a portable handheld sewer in a double stitch configuration. R-SPE 20 mil (0.5 mm) thick or thicker products can be field welded thermally with a hot air welder.

Common Applications:

Common temporary cover applications for R-SPE are landfill interim rain-shed covers, stockpile covers, or soil remediation covers. R-SPE is also commonly used in the energy markets as short term water, sludge or mud-pit liners. They are also used in the residential home markets as crawlspace liners. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: GM-22; https://geosynthetic-institute.org/grispecs/gm22.pdf.

7. Polypropylene – Reinforced (R-PP): :

R-PP geomembranes are a thermoplastic barrier material with very good flexibility properties and good overall chemical resistance and UV stability. Flexible Polypropylene

Geomembrane resin is a reactor TPO (Thermoplastic polyolefin) manufactured using the Catalloy process (as opposed to mechanical blends of TPO) creating an alloy of rubber (EPR Ethylene Propylene Rubber) and polypropylene. This makes it more flexible like rubber while allowing for the workability of a thermoplastic. R-PP is reinforced with a polyester fabric scrim laminated between two layers for polypropylene film providing the material very good tensile, tear and barrier properties. It is also available in non-reinforced grade material providing excellent flexibility and multiaxial properties. R-PP is noted for its combined flexibility and weldability. It can be both factory and field by thermal fusion including thermal wedge, hot air and extrusion welding. R-PP provides overall good chemical resistance and UV stability. Standard grades of R-PP are available in thicknesses of 30, 36, 45 and 60 mil (0.75, 0.91, 1.14 and 1.5 mm) but can range from 20-100mil (0.5 to 2.5mm. Its standard colors are black, tan and white. The reinforced scrim in R-PP provides very good dimensional stability and reduces the impacts of thermal expansion and contraction of the material. The material is available in potable water grade that is certified to NSF/ANSI 61, allowing it to be used for drinking water applications.

Common Applications:

RPP is a good choice of material for projects requiring very good flexibility and factory fabrication. The material is commonly used in municipal water, wastewater ponds, and water reservoirs as floating covers, liner systems, and baffle curtains. It is also used in in agriculture for irrigation canals and water reservoirs. Its reinforced properties makes it very suitable for steep slopes and high vertical walls in above ground storage tanks. RPP is a good choice of products for mid to long term exposed applications. It is also a good choice of material for cold temperature installations. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: FGI-1118; https://cdn.prod.website-files.com/5977726c80d12837b9592f29/5be50147971f79d969993b03_FGI-fPP-Spec-2018-FINAL-Revised-11-2-18.pdf and GM 18; https://geosynthetic-institute.org/grispecs/gm18.pdf.

8. Polyvinyl Chloride (PVC): :

PVC geomembrane is a highly flexible thermoplastic barrier material produced from PVC resin compounded with plasticizers, heat stabilizers, UV stabilizers, and other performance additives. The formulation is engineered to deliver specific mechanical

properties including excellent flexibility, elongation, puncture resistance, and chemical resistance.

PVC geomembranes in the USA have been used for agriculture water retention and containment since the 1960s. PVC continues to be used today based on their high flexibility, ability to conform to subgrade, and field-friendly installation characteristics. In most long-term containment designs, the material is installed in a backfilled buried condition to minimize UV exposure and plasticizer loss.

PVC geomembrane is manufactured as sheet by either calendaring or extrusion processes. Industry standard thicknesses include 10, 20, 30, 40, and 60 mil (0.25, 0.5, 0.75, 1.00, 1.5 mm) with 30 and 40 mil being the most common for industrial and critical containment service. Unreinforced PVC geomembrane is produced in accordance with ASTM D7176. PVC geomembranes are available in both unreinforced monolithic sheets and reinforced constructions.

PVC manufactured roll stocks are factory fabricated into large panels to reduce field seams and accelerate installation. PVC seams can be made using thermal fusion primarily thermal wedge, hot air or RF welding as well as chemical fusion. Because of the material's flexibility, seams can be dual-track welded and subjected to continuous air-channel testing to verify seam integrity and peel strength along 100% of the seam length.

Common Applications:

PVC is commonly used in backfilled agricultural applications including irrigation canals and reservoirs for raw water storage. It is also used in municipal wastewater ponds and decorative ponds including golf courses. With its excellent tensile elongation and multiaxial properties, it is an excellent choice of material for landfill caps and closures. For longer term applications, PVC should be backfilled with soil covering. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: FGI-1126; https://cdn.prod.website-files.com/5977726d80d12837b9592f43/68b742747143ae02633590fc_FGI-1126-PVC-2025-9-1-25-FINAL.pdf.

9. PVC + Ethylene Interpolymer Alloy (EIA) [PVC+KEE] – Reinforced (R-EIA)::

EIA (PVC + KEE) geomembranes is a highly flexible thermoplastics barrier material produced from polyvinyl chloride (PVC) resin with the addition of ethylene interpolymer alloy (EIA). EIA has been used for years in the roofing industry for membranes and uses ketone ethylene ester (KEE) plasticizer, which is a solid non liquid based plasticizer. Compared to standard liquid based plasticizers used in most standard flexible PVC materials, the KEE solid plasticizers prevents the surface migration of liquid based plasticizers ensuring longer term retention and better performance of certain mechanical and endurance properties. PVC EIA geomembranes provide good overall chemical resistance and UV stability and noted for their flexibility and durability. Chemical resistance should be confirmed for each specific application with the manufacturer. Similar to standard PVC, PVC EIA products provide very good flexibility and cyclic loading properties.

PVC EIA materials are more commonly available in reinforced grades and thickness of 30, 36, 45 and 60 mil (0.75, 0.91, 1.14, and 1.5 mm). Unreinforced PVC's can also be produced using KEE solid plasticizers. PVC EIA materials provide a very good welding window and normally welded using thermal fusion methods including hot wedge, hot air, radio frequency (RF) and chemical fusion using special adhesives. PVC EIA is available in potable water grades including NSF/ANSI 61. The reinforced scrim in PVC EIA limits the impacts of thermal expansion and contraction of the material.

Common Applications:

Specific potable grade PVC EIA's are used for geomembrane liners, floating covers and baffle curtains for municipal and industrial water storage. It is also a good choice of material for municipal wastewater applications. Specialty formulations are available for secondary containment of hydrocarbons including diesel, aviation and crude oil tank farms, geofoam protection, and storages. Its reinforced properties makes it very suitable for steep slopes and high vertical walls in above ground storage tanks. Formulations can vary to accommodate installation in bottom liner systems, covers, and containment applications. EIA PVC geomembranes are designed for mid to long term applications and are used in municipal and industrial water installations and suitable for secondary containment of hydrocarbons, including diesel, aviation, and crude oil. An industry developed specification for this type of geomembrane can be downloaded from this link for projects: GM-34; https://geosynthetic-institute.org/grispecs/gm34.pdf.

10. Polyurethane (PU) – Reinforced(R-PU):

R-PU is a reinforced thermoplastic geomembrane barrier produced from polyurethane, which has good flexibility. It is a reinforced material designed for both primary and secondary containment of fuels and other aggressive chemicals and also comes in potable water versions. PU materials bridge the gap between synthetic rubber and thermal plastics. They are noted for their high abrasion resistance, ultra-low temperature flexibility and can be produced on exceptionally high strength fabric scrims providing very high mechanical properties including tensile, tear, puncture and burst strengths. PU can be factor and field welded by thermal wedge, hot air or radio frequency (RF) methods. It also has very good extreme cold temperature workability properties. The polyester or nylon reinforced scrim in R-PU limits the impacts of thermal expansion and contraction of the material.

Common Applications:

Polyurethane PU geomembranes offer very good chemical resistance to most hydrocarbons, making the product a good choice for both primary and secondary containment. Applications include military-specified liners and fuel and water pillow tanks, collapsible/portable tanks, chemical suits, dock shelters, water bladder materials, inflatable boats, petroleum tank farms, tank seals, fuel cells for race cars, and oil boom materials. PU are used in mid to long term exposed applications. A manufacturers specification for this type of geomembrane for a double tank line can be downloaded from this link for projects.

/https://cooleygroup.com/wp-content/uploads/2025/05/CoolThane-L4090NESUE_Product-Sheet.pdf. Other R-PU products are available for other applications from the manufacturers.

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