



Life Expectancy of Firestone EPDM membranes

Firestone EPDM membranes are specifically designed for long term applications in lining (decorative, industrial, agricultural, environmental) and roofing projects.

Product presentation:

Firestone EPDM membranes are thermoset elastomers formed by vulcanizing (curing with heat and pressure) a synthetic rubber terpolymer. During vulcanization, the amorphous carbon chains of the polymer link in a 'matrix' structure and described as a cross-linked carbon chain. This is the reason for the products elasticity and flexibility; as the membrane is placed in tension the 'matrix' structure will flex and return to its original position once the tension force is removed. This elasticity is a major advantage in lining projects as the EPDM membrane will be able to afford significant differential movements of the substrate without being damaged.

Degradation mechanisms:

The anticipated service life of a membrane is related to many degradation mechanisms. It is extremely site-specific and material specific. Nevertheless, in normal applications (no contact with aggressive chemicals or radioactive compounds, excessive mechanical stress...) there are three main degradation mechanisms; temperature, ultra-violet radiation and atmospheric oxidation.

Heat exposure:

Temperature is a determinant factor for longevity. Increasing temperature will impact all membranes by increasing the chemical reactions rate and reducing their life expectancy.

Firestone EPDM membranes have a wide range of temperature resistance (from -45°C to 130°C) and are used extensively in regions of extreme heat exposure (e.g. Middle East). Nevertheless, like any other membrane on the market, its durability will be directly related to the average temperature.

If the EPDM membrane will be exposed to high temperatures, it is recommended to take contact with Firestone technical service in order to adapt the design and installation details.

Ultra-violet radiation:

Ultraviolet light can cause chain reactions and bond breaking of polymeric material. All membranes used in exposed conditions need to be stabilized against UV radiations.

Firestone EPDM membranes are UV stabilized by the addition of high concentrations of carbon black in their chemical composition (over 20 %). The carbon black is a very efficient UV stabilizer as it transforms the highly energetically UV light (that can break carbon to carbon bonds) into low energy IR (cannot break carbon chains). As a result, Firestone EPDM membranes have excellent UV performances. Their aging process is less influenced by UV exposition than many other types of membranes.

Atmospheric oxidation:

Oxidation is a key degradation mechanism affecting the long-term durability of membranes. Depending on the kind of rubber, oxidation by oxygen can cause molecular chain cleavage (degradation, softening) or cross-linking (hardening).

EPDM polymer main carbon chains are fully saturated (no double bonds). The reactive unsaturation (double bond) needed for cross-linking is placed in a side chain (diene) and doesn't affect the strength of the main carbon chain. Therefore, the oxidation of EPDM membranes will mostly



induce further cross-linking (vulcanization) of the polymer. This will result in a reduction of the molecular mobility that will increase the hardness and the tensile strength of the liner and reduce its elongation at break. These reactions are similar to the process of curing used during EPDM membrane production. This good oxidation resistance of the EPDM polymer is the reason why there is no need to add anti-oxidants into the composition of EPDM liners. Therefore, the durability of EPDM liners is not related to anti-oxidants quality, quantity or depletion.

Even if cross-linking is predominant in the oxidation process, there is some molecular chain cleavage taking place at the surface of the liner. This results in micro-cracks that are only visible with electronic microscopy after several years of exposure. Due to the cross-linked structure of the liner, those micro-cracks don't propagate (stay on the surface) and don't affect the mechanical properties of the liner.

This surface oxidation is the explanation for the "black fingers" effect when we touch the liner after several years of exposure. Some carbon black molecules located at the surface are not retained anymore by the polymer 'matrix' due to chain cleavage. The concentration of carbon black in the EPDM membrane composition is so elevated that it has no impact on the UV resistance of the membrane.

Accelerated aging and feedback from the field:

The Geosynthetic Institute (GSI) has run an artificial aging study with UV-fluorescent devices in order to estimate the lifetime of some exposed geosynthetics. Samples have been exposed to UV light, temperature and humidity in order to take into consideration the major degradation mechanisms of exposed liners (ASTM D7238). The results of the study show that the predicted half-life (time to reach 50% of the initial elongation at break) of EPDM membranes (1 mm thick) in the most demanding US weather conditions (Phoenix Arizona – UV radiation = 28 MJ/m²-month and average annual solar irradiance = 8004 MJ/m²) is 56 years.

The German testing institute SKZ have made a few years ago an important research on EPDM membranes durability. The conclusions of the study were that EPDM membranes should last over 50 years when exposed to Western Europe weather conditions.

In laboratory conditions, lifetime prediction for exposed geosynthetics is reasonably simulated but the extension of laboratory to field lifetime prediction is much more subjective. For EPDM membranes, this pretty long durability estimation from artificial aging is backed up by long term feedback from installed projects on the field.

Firestone synthetic rubber membranes are used in lining applications since the early 70's. The oldest Firestone irrigation reservoirs are located in the South of Spain and in the Canary Islands, two regions that are well known for their sunny and warm weather. The average annual solar irradiance in those two areas is respectively 6.307 MJ/m² and 7.200 MJ/m². One of the oldest Firestone irrigation reservoirs was built in 1973 and is still in service today with the same liner. The pond is located in Murcia, in the South of Spain, an area with elevated temperatures (average summer temperature = 27°C) and UV radiations (annual solar irradiance = 5.587 MJ/m²).

In conclusion

Durability of geosynthetics is mainly a function of temperature, UV exposure and oxidation.

Feedback from the field and artificial aging shows that Firestone EPDM membranes have an exceptionally long life expectancy even in extreme weather conditions. This is largely a function of its chemical composition (high grade polymer and elevated proportion of carbon black) and chemical structure (vulcanized and saturated carbon chains). Furthermore, the composition of the Firestone EPDM membrane will stay quite stable in time. The membrane does not contain any plasticizers or antioxidants likely to migrate or degrade and cause the EPDM membrane to age prematurely.