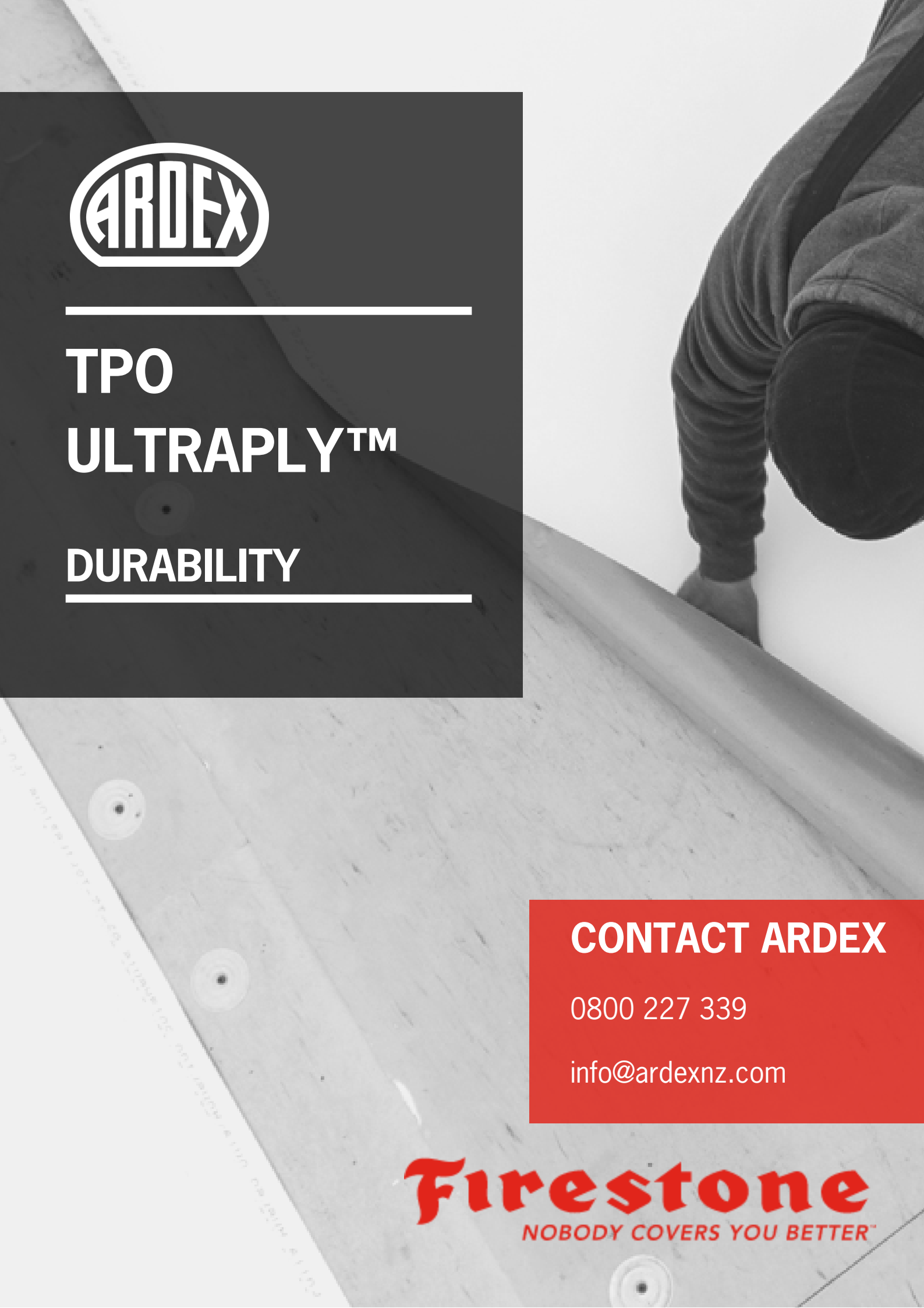

TPO ULTRAPLY™

DURABILITY

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SUPERIOR DURABILITY

FIRESTONE ULTRAPLY™ TPO

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EXCEPTIONAL BUILDING PERFORMANCE STARTS AT THE TOP

A building's roof is its first line of defense against the elements. Any discussion on building durability must therefore include the careful consideration of the roofing system.

Thermoplastic polyolefin (TPO) membranes, available in the market since the late 1990s, are one of today's fastest growing roofing products. Unfortunately, there are many examples of premature failure on TPO roofs which have not stood the test of time and the market is still experiencing issues with many TPO membranes which are failing to perform after 5 to 10 years of exposure.

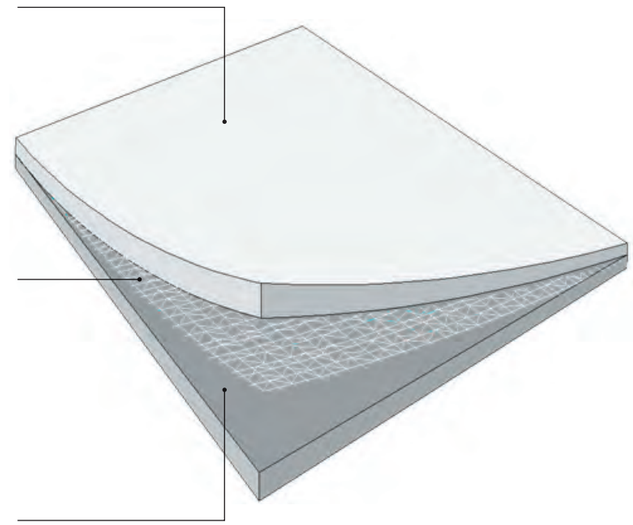
But, not all TPO membranes are the same.

High quality TPO membranes are ultimately rooted in good chemistry. A solid formula is essential to engineer a polymer that can withstand UV weathering, heat aging and achieve the desired physical properties in the long term. The high-quality formulation of Firestone Building Products' UltraPly TPO roofing membrane, which has remained unchanged since 1996, ensures the long-term performance of the roof with properties that provide excellent weathering, ozone and chemical resistance.

TPO MEMBRANE CONSTRUCTION

TPO roofing membranes generally consist of three layers:

The top ply, or 'weathering layer', consists of a TPO compound and a weathering package that allows it to resist damage and degradation from UV radiation, heat and the elements that the membrane will face over the course of its life. TPO membranes with a thicker top weathering ply tend to perform better and for longer.



The scrim layer (reinforcement) is sandwiched between the top and the bottom ply. It is typically made from polyester and provides dimensional stability and physical strength (tear resistance, tensile strength, puncture resistance etc.) to the membrane.

The bottom ply provides strength, durability and weldability. It does not contain a high weathering package.

Firestone's UltraPly TPO roofing membrane is constructed in a way that at least 40% of the top ply weathering layer is above the scrim layer (at the scrim location), which provides outstanding weather resistance to the membrane.

Some TPO membranes have a thinner top ply, or even have 2 top ply layers and 1 bottom layer, with the very top layer having a weathering package and the intermediate layer having reduced to no weathering package. This is a way of reducing the product's cost at the expense of its performance.

What matters most is not the total thickness of the membrane or just the thickness over the scrim.

The top weathering ply is the key component to the membrane's weathering performance.

The thicker the top weathering ply is, the better the membrane will perform.

THE KEY TO DURABILITY

The are two key factors that can be most destructive to any roofing product over a long period of time: **intense UV exposure** and **high heat** from sunlight or other sources.

The ability of TPO roofing membranes to resist aging from heat exposure and UV radiation is critical, and is directly related to the formulation of the different layers of the membrane - in particular of the top ply - and the thickness of the layer over scrim. UV and heat stabilizers are mainly required in the exposed top ply of the membrane. TPO membranes with more and appropriate protection in this layer will perform better

First UltraPly TPO roof (Las Vegas, USA)

FORMULATION: THE RIGHT CHEMICAL BALANCE

Finding the right balance between all the chemical components present in a TPO roofing membrane to design a formulation that performs in the long term is a challenge that has always been of primary concern for Firestone Building Products. Non-halogenated fire retardants, for example, provide TPO membranes with fire resistance without negatively affecting the UV stabilizers.

A correct balance between fire retardants, antioxidants, UV stabilizers and polymer content also has an important impact on the weldability of the membrane.

Firestone's expertise with flexible polyolefin membranes dates from the early 1980s, when the company initiated an ambitious R&D program including a 10-year field project where installations of flexible polyolefin roofing membranes were tested and monitored in varying climatic conditions.

The first Firestone UltraPly TPO roof was installed in 1996 in Las Vegas, Nevada (USA) and it is still in good condition today, even after more than 25 years of intense sun exposure.

HEAT AGING

As per the Arrhenius equation, for every 10° C rise in temperature, the chemical reaction rates double. This means that every 10° C increase in the temperature of the roofing membrane reduces the product's service life by half. When a TPO roofing membrane, which is meant to be used in exposed conditions and under direct sunlight, is not designed properly, this has a significant impact on the service life of the product. The light color of the membrane helps to reduce its temperature only up to a certain extent.

Firestone Building Products uses the right amount of heat stabilizers in the formulation of the UltraPly TPO roofing membrane, which allows it to resist heat degradation from the manufacturing process onwards.

UltraPly TPO has undergone several heat aging (oven aging) tests and complies with the stringent heat aging requirements posed by the ASTM standard. As per the latest ASTM D6878 standard, the membrane is conditioned at 116° C for 224 days and needs to retain its physical properties, such as breaking strength and elongation, by at least 90% of the value of the unaged sample. UltraPly TPO passed the test with flying colors.

This heat aging test is currently not enforced by European standards. A competitive test carried out shows that UltraPly TPO has one of the best heat aging resistance.

UV RADIATION: A CHALLENGE FROM NATURE

Exposure to ultraviolet (UV) radiation may cause the significant degradation of many materials. UV radiation causes photo-oxidative degradation, which results in a breaking of polymer chains, produces free radicals and reduces molecular weight, causing deterioration of the mechanical properties and leading to useless materials, after an unpredictable time.

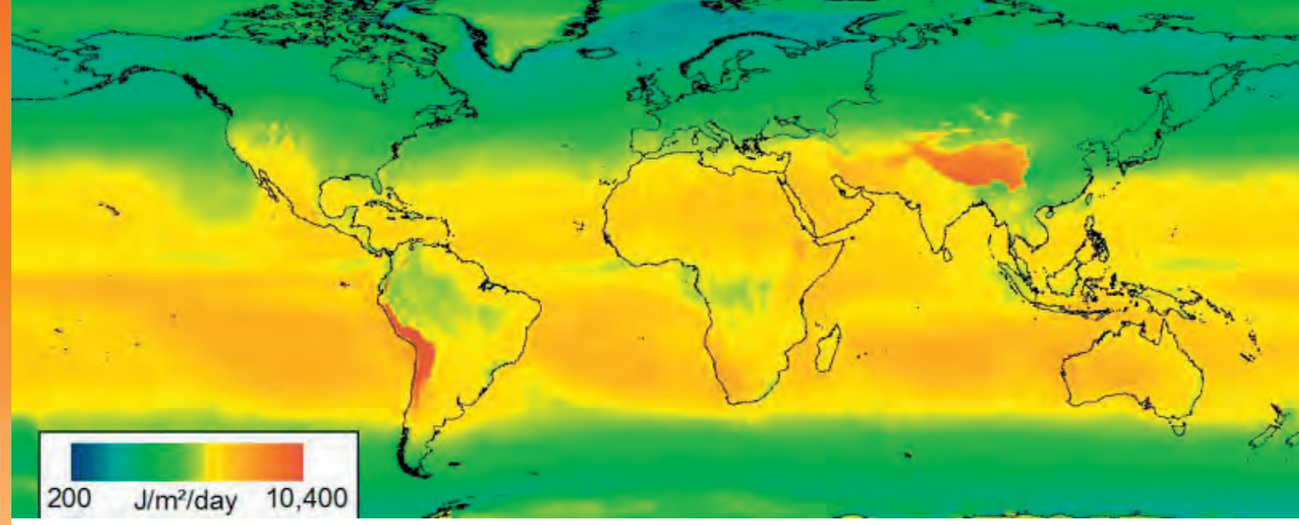
On waterproofing membranes, damage by UV radiation is the main reason for weathering and loss of mechanical properties (cracking). Almost all synthetic polymers require UV stabilization against adverse environmental effects. It is necessary to find a means to reduce or prevent damage induced by environmental components such as heat, light and oxygen.

The ability of TPO roofing membranes to resist aging due to heat exposure and UV radiation is critical, and is directly related to the formulation of the different layers - in particular the top ply- and the thickness of the layer over scrim. UV and heat stabilizers are mainly required in the exposed top ply of the membrane. TPO membranes with appropriate protection in this layer will perform better. UV stabilizers are critical in providing weathering resistance and long-term durability. Heat stabilizers also help to resist heat degradation and the antioxidant package contributes significantly to ensure weldability over time. All these additives should be used in the right amount to achieve the best results.

UltraPly TPO is the perfect example where the right balance between polymer and additives is achieved resulting a very durable roofing membrane with extreme resistance against UV and heat aging.

When tested as per the EN 1297 standard (artificial aging by long term exposure to the combination of UV radiation, elevated temperature and water) the UltraPly TPO membrane meets the European Union for Technical Approval in Construction (UEAtc) requirements even after 7,500 hours, whereas the standard requirement is only 1,000 hours.

In addition to a visual inspection for defects (blisters, cracks, holes, scratches, indentations, etc) membrane samples are also tested on foldability at low temperature (-35°C). The performance of UltraPly TPO is better than any value declared by other TPO membranes.



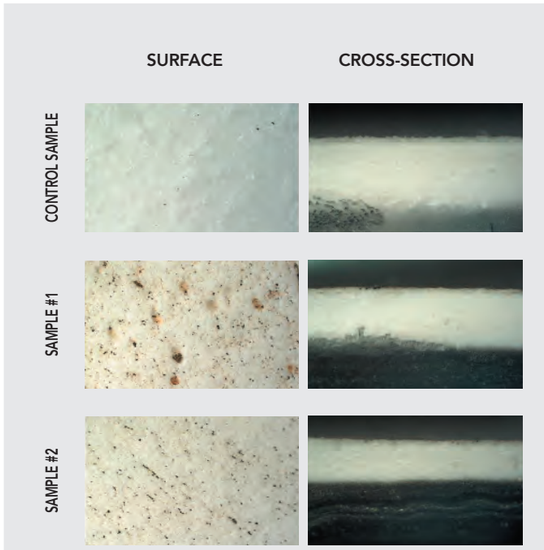
PERFORMANCE IN THE REAL WORLD

Yearly UV exposure levels vary a lot around the world. The performance of a roofing membrane is therefore highly dependent on where it is being used.

Firestone's UltraPly TPO roofing membrane has been used in very high UV exposure regions around the world with excellent results, even after several decades. Tested time and time again, it has proven to work extremely well in different weather conditions for over 25 years.

The first UltraPly TPO roof, installed in Las Vegas (USA) in 1996, is still performing very well under the intense sun of Nevada, even after 25 years of exposure.

Similar success stories have been observed in Europe and Asia. Firestone conducted chemical and physical tests on the very first UltraPly TPO roof installed in Europe, on an industrial building near Pamplona (Spain). The membrane showed no cracking of crazing and no loss of thickness, even after 20 years of exposure in a region with one of Europe's highest UV levels.



First UltraPly TPO roof in Europe (Pamplona, Spain). Sampling done in July 2019, 20 years after installation .

Firestone's Ultraply™ TPO roofing membrane is compounded using a proper balance of flexible polyolefin polymers, high quality UV, heat and ozone stabilizers, antioxidants, non-halogenated fire retardants and pigments.

The right chemical balance - the correct formulation - is key to the long term performance of the membrane.

With an unchanged formulation since 1996, UltraPly TPO exhibits excellent lab and real-world results, even after several years of exposure.

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