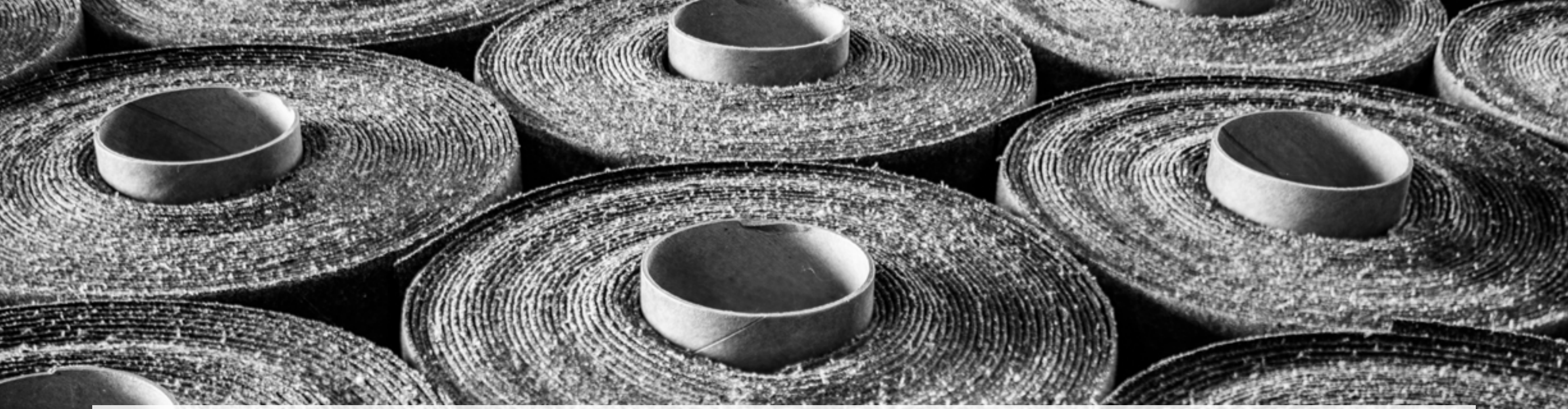

Paradiene 20/30
SBS-modified Bitumen Membrane Systems:
The Importance of Ultimate Elongation & Cyclic Fatigue

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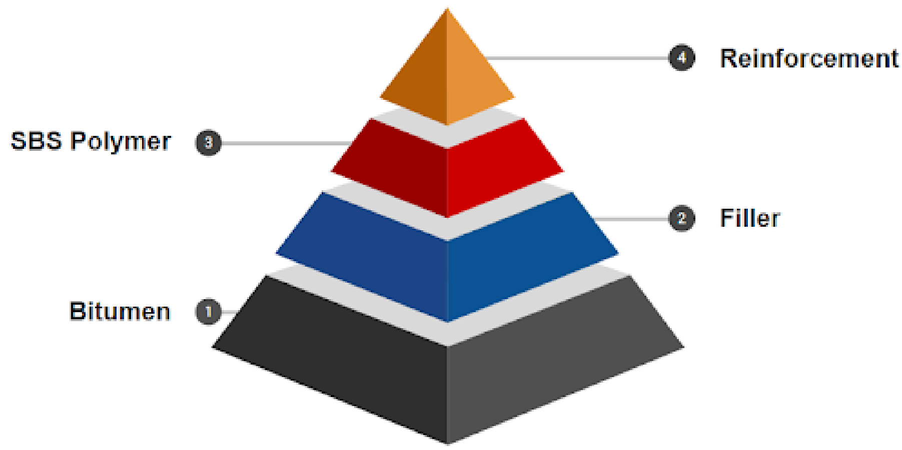
Introduction

There are certain physical properties that a high quality SBS-modified bitumen system (e.g., Siplast Paradiene 20/30 system) has that help enable it to maintain performance over decades of service on a roof. It starts with the asphalt blend, which drives some of the physical requirements for long term performance. The reinforcement combined with the upper and lower layers of SBS-modified bitumen determine the primary physical properties and performance characteristics of the sheet. In other words, what Siplast does prior to and during manufacture of the Paradiene 20 and Paradiene 30 sheets is a huge part of what leads to the roof's potential long service life. Of course, the installation, the design, and maintenance of the roof also play a big role. Assuming that those aspects are handled properly, it is the SBS-modified bitumen formulation combined with the reinforcement (i.e., the roof membrane) that composes the backbone of the system that sets up the installed roofing system for long-term success.

A high quality modified bitumen sheet starts with raw materials–bitumen, fillers, and SBS polymer, which are then constructed using reinforcement.



- For SBS-modified bitumen sheets, the bitumen (the asphaltic component) is the foundation. Bitumen comes from distilling

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crude oil, and there are many types and sources of the crude oil. Different sources of crude oil result in bitumens with varying physical properties, and importantly, not all bitumens can be readily modified. Selecting a suitable crude-oil source is critical to long term success.
- Fillers are inorganic minerals used to stabilize the blend and can add fire resistance properties.
- SBS polymers give the blend rubber-like properties. In other words, it makes the blend elastic so that it can flex as the roof expands and contracts during daily or seasonal temperature cycles. Determining the optimal amount of polymer is based on desired properties, such as softening point.
- Reinforcement is used for a number of reasons. It allows the sheet to be manufactured on a roll-to-roll process; it provides shape and stabilizes the roll in shipment; and it provides mechanical properties beyond waterproofing. Reinforcements can be polyester, fiberglass, or both (ASTM standards are provided in the next section).

When the SBS-modified bitumen blend is combined with the reinforcement by saturating the reinforcement with bitumen blend from above and below, the resulting composite asphaltic membrane sheet demonstrates a number of properties and characteristics such as *ultimate elongation* and *cyclic fatigue*. Let's take a close look at each of these.

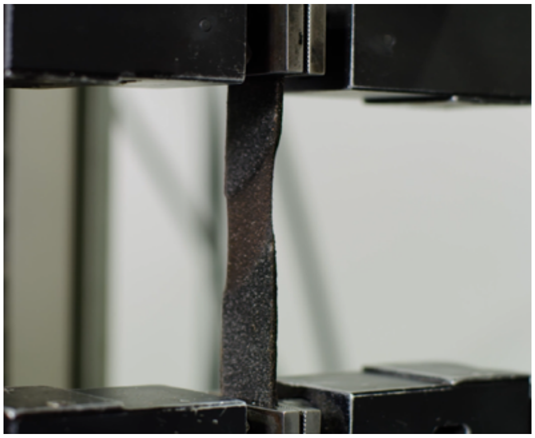
Ultimate Elongation

To understand Ultimate Elongation, it is important to understand what composes the ASTM standards for SBS-modified bitumen sheets, the physical property called Elongation at Peak Load, and how it is measured.

First, there are a number of ASTM standards that cover SBS-modified bitumen membranes.
- ASTM D6162 covers SBS modified bitumen sheets with *polyester* and *fiberglass* reinforcement.
- ASTM D6163 covers SBS modified bitumen sheets with *fiberglass* reinforcement.
- ASTM D6164 covers SBS modified bitumen sheets with *polyester* reinforcement.

The standards are written and formatted in a similar fashion. Each standard has different Types based on dimensions and masses, and different Grades based on surfacing. Each standard has specific requirements for myriad physical properties that vary based on Type and Grade.

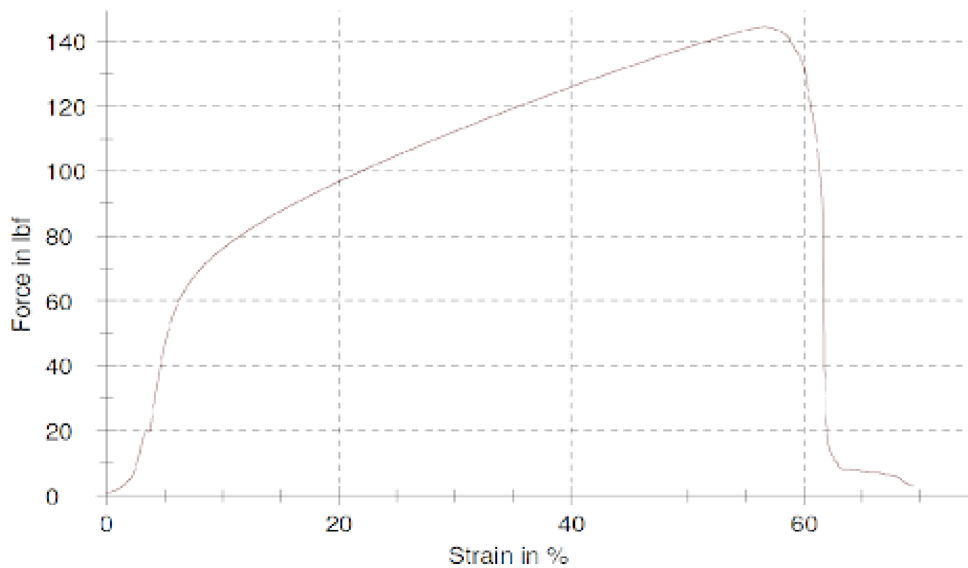
All three of the SBS standards require testing to determine "Elongation at Peak Load" at two temperatures–0°F and at 73°F. In the test, a narrow strip of the sheet is clamped on each end and then stretched. The instrument records how much force occurs when the reinforcement breaks. The percent elongation is recorded at this load–the peak load. The sample continues to stretch until the SBS-bitumen blend breaks. For many SBS sheets, the blend–the asphalt above and below the reinforcement–breaks quite quickly after the reinforcement breaks.



Importantly, the Elongation at Peak Load varies greatly between fiberglass reinforced SBS sheets versus polyester reinforced sheets. The chart below shows the ASTM standards' minimum elongation requirements for different reinforcement types; fiberglass does not stretch much at all, and, conversely, polyester stretches quite a bit.

Elongation at Peak Load	
D6162 - Polyester and Fiberglass reinforced D6163 - Fiberglass reinforced	% Elongation, min, at 73 F
Type 1	2
Type 2	4
Type 3	3
D6164 - Polyester reinforced	% Elongation, min, at 73 F
Type 1	35
Type 2	50

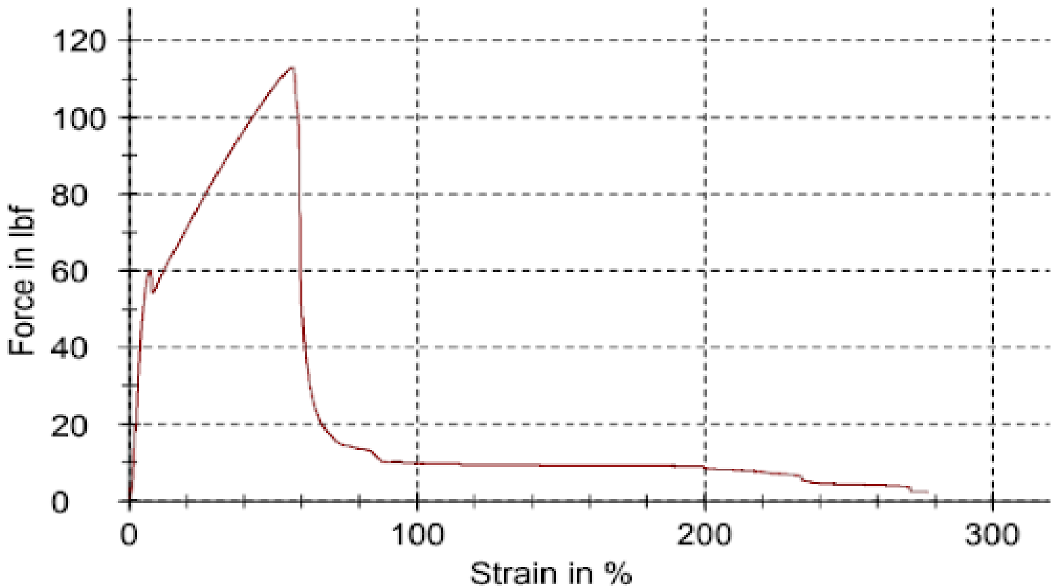
The graph below shows a non-Siplast polyester reinforced SBS-modified bitumen sheet with peak load at approximately 56-57% elongation. Looking closely at the tail, the load also drops off rather quickly after the reinforcement breaks. This is because the blend (the asphalt above and below the reinforcement) breaks quite quickly after the reinforcement breaks.



If the blend breaks shortly after the reinforcement breaks, the ability of the sheet to perform as a waterproofing layer may be compromised.However, with a high-quality SBS blend like that used for the Siplast Paradiene 20 and Paradiene 30 sheets, the blend is likely to stay intact for some period of time after the reinforcement breaks, helping to prevent leaks until the affected roof section can be repaired or replaced. (Finding and repairing any damage is but one reason why annual or biennial inspection and maintenance is important.)

The ability of the blends used for the Paradiene 20 and Paradiene 30 SBS-modified bitumen sheets to elongate (i.e., stretch) well past the point when the reinforcement breaks is called Ultimate Elongation. Interestingly, this physical property is <u>not</u> included in the three ASTM standards for SBS sheets.

This graph shows a high-performing Siplast Paradiene SBS-modified bitumen sheet that also has very high Ultimate Elongation.



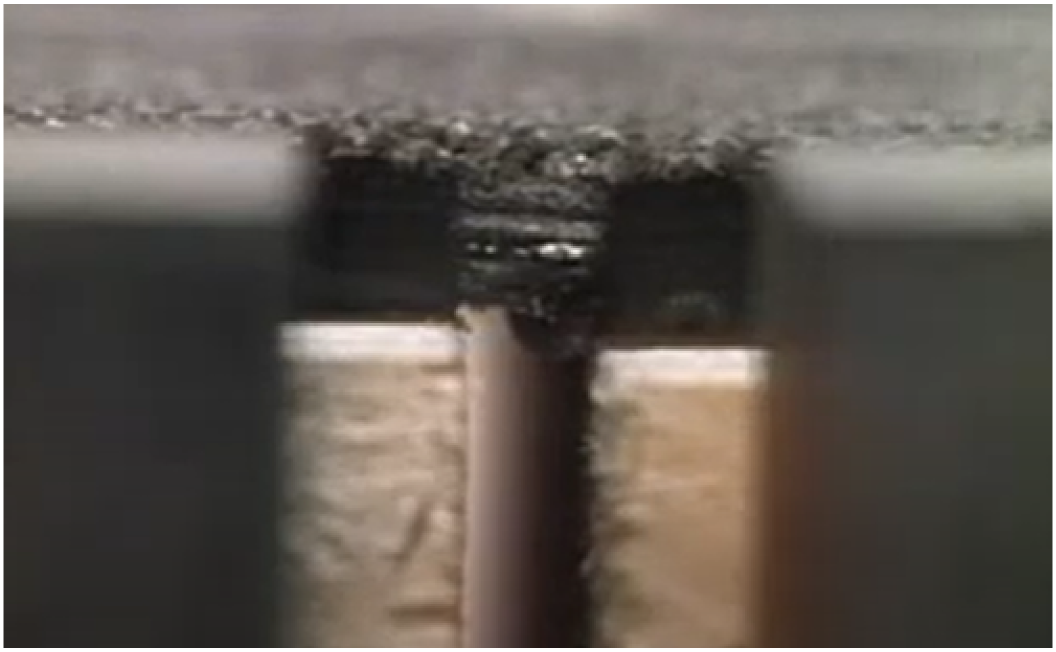
This Siplast Paradiene sheet also has its peak load at approximately 56-57% elongation, but the tail–the amount the blend stretches after the reinforcement breaks–reached approximately 240% Ultimate Elongation before the blend began tearing. That's a substantial amount of elongation which can help provide a significant cushion of waterproofing capability.

A high Ultimate Elongation can help provide a watertight 'reserve' if the reinforcement were to break. However, roofs often need the ability to withstand repeated cycles of movement. Realize that roofs do in fact move due to thermal changes that occur from summer to winter that can expand and contract a roof membrane. Perhaps more critical are the daily temperature swings that can also cause significant movement. To that end, let's talk about another property of the membrane – cyclic fatigue.

Cyclic Fatigue

Cyclic fatigue, loosely defined, is cyclic displacement of a modified bitumen membrane. "Constant cyclic displacement" is the phrase used in the scope of the ASTM test method for cyclic fatigue. That test method is ASTM D5849, Standard Test Method for Evaluating Resistance of Modified Bituminous Roofing Membrane to Cyclic Fatigue (Joint Displacement).

To run the D5849 test, a modified bitumen system (i.e., a base sheet and a cap sheet) is adhered to a substrate that has a small gap. The substrate moves apart and together for a large number of cycles. This stresses–fatigues–the SBS modified bitumen sheet just above the small gap. The photo below is a close-up of the cyclic fatigue test.



A number of years ago, five (5) SBS sheets from major manufacturers were tested according to the D5849 test method by a third-party nationally recognized test lab commissioned by Siplast. The testing was performed at 14°F with a 2mm gap. This is Test Condition #4 in the ASTM D5849 standard. For this research, new membranes were cycled 500 times, and aged membranes were cycled 200 times. Aged specimens were heat conditioned according to ASTM D5147, Section 12. The results are shown in the chart below.

D5849 Cyclic Fatigue Testing				
Manufacturer	New (500 Cycles)		Aged (200 Cycles)	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2
A	Fail	Fail	NT	NT
B	Fail	Fail	NT	NT
C	Pass	Pass	Fail	Fail
D	Pass	Pass	Pass	Pass
E	Fail	Fail	NT	NT

* NT means not tested

Manufacturer D is the Siplast Paradiene 20/30 system. As the results show, only one non-Siplast SBS modified bitumen sheet passed the requirements of D5849 for "new" membranes. Notably, that sheet did not pass the requirements for "aged" membranes. This was a one-time test regimen of a limited sample of competitors' SBS modified bitumen membrane systems. Your results may vary.

Summary

It's apparent from testing two physical properties–Ultimate Elongation and Cyclic Fatigue–that all SBS-modified bitumen membranes are not created equally. If Ultimate Elongation and Cyclic Fatigue are important physical characteristics for your building and long-term roofing requirements, including these physical requirements in your specifications can help ensure a high performing and long-term roof system. The Siplast Paradiene 20/30 membrane system can help you meet demanding specifications that include Ultimate Elongation and Cyclic Fatigue.

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Jim Kirby, AIA, is an architect for Siplast. His focus is Building Science, Industry Relations, and Compliance. He has a Masters of Architecture—Structures Option and is a licensed architect. His 30+ years in the roofing industry have covered low-slope, steep-slope, metal, and SPF roofing, as well as green roofs and rooftop solar. Jim writes and speaks about building science topics related to roofing, represents Siplast across numerous segments of the roofing industry, and helps manage Siplast's compliance documents and information. He is a board member for CRRC and SPRI, an active committee member for ARMA and ASTM, and a member of AIA, ICC, IIBEC, NRCA, and WSRCA.