

Understanding ASTM D4434: PVC Classification Types and The Role of Reinforcement in PVC and PVC KEE

PVC roof membranes are the preferred membranes for many specifiers and building owners due to their durability, longevity and proven track record of performance for fire resistance, chemical resistance and high reflectivity. [ASTM D4434 is the Standard Specification for Poly\(Vinyl Chloride\) Sheet Roofing](#). The specification contains the requirements for three different types of PVC: Type II, III and IV.

PVC, like TPO, its thermoplastic cousin, consists of at least three layers: the cap, reinforcement or scrim, and core. Additional layers may include a fleece backing or a lacquer coating. The cap provides protections such as UV durability, resistance to biological growth, and chemical resistance. The reinforcement has a strong impact on the dimensional stability, tensile strength and other physical properties of the membrane. The core is the unexposed bottom layer, and generally is not as UV resistant and is often a different color than the cap. It provides durability to the overall membrane, including water resistant properties.

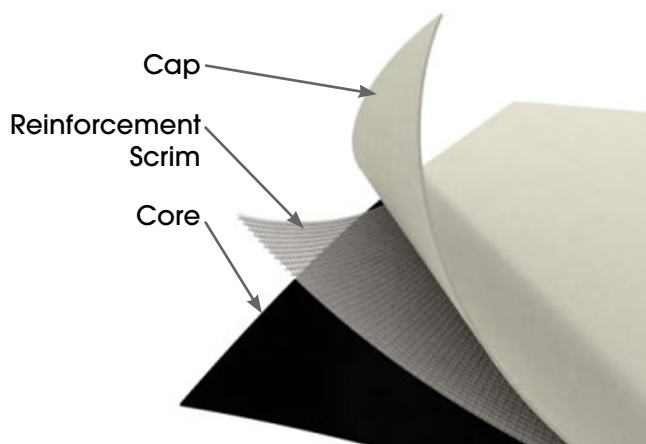
While ASTM D4434 does not call out specific reinforcement requirements, Type II membranes typically contain a fiberglass reinforcement. Type III

and IV membranes most commonly have a polyester reinforcement. The impact of the reinforcement on the complete membrane properties are similar to the reinforcement or scrim properties in other roof membranes, such as SBS Modified Bitumen membranes. The scrim provides reinforcement for the PVC, supporting dimensional stability, puncture resistance, and the ability for the membrane to be manufactured. As a result, the reinforcement is one of the items that determines the ASTM specification to which the membrane is tested, and it impacts many of the results of the tests referenced within the specification. This article discusses the different classifications within ASTM D4434, including the reinforcement differences, to provide clarity for specification and help determine comparability of materials from different manufacturers.

Classification of PVC Membranes per ASTM D4434

ASTM D4434 contains the requirements for three different types of PVC: Type II, III and IV. The specific type can be referenced in specifications to help provide more comparable membranes, or to establish a specifier's preference for membrane properties.

The specification has requirements for 14 different membrane properties, with key requirement differences among the different types for overall thickness, breaking strength, elongation, what property is tested after heat aging (tensile strength vs. breaking strength), tearing strength, and linear dimensional change (See Table 1 from ASTM D4434). **Each of the properties that differ between the membrane types has a potential impact on the performance of the membrane.** Whether that property is critical is dependent upon the project type, attachment method, location and design performance intent.



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A note on ASTM D6754

KEE membranes that meet ASTM D6754 Standard Specification for Ketone Ethylene Ester Based Sheet Roofing have different requirements than membranes tested in accordance with D4434. Per the definition in the specification, membranes that meet D6754 have KEE as the primary polymer (>50% of total polymer content). The remaining polymer content is PVC. It is important to note that ASTM D4434 membranes may or may not contain KEE polymer; however, a majority (>50%) of the polymer content must be PVC. For more information on PVC KEE membranes tested per ASTM D4434 compared to KEE membranes tested to ASTM D6754, refer to [this white paper](#).

Type II membranes must contain a reinforcing scrim that has minimum impact on the tensile and elongation

properties. As such, they typically contain a fiberglass reinforcement. Type II membranes have less stringent requirements for tearing strength, breaking strength and puncture resistance compared to the other types within the specification. The most notable differentiator between Type II membranes and the other two types is that Type II must have lower dimensional changes in the aged membrane. The membrane must be a minimum of 45 mils thick.

Type III and IV membranes typically contain a polyester scrim. Type III must contain a scrim and have a minimum thickness of 45 mils. Type IV must contain a scrim and have a minimum thickness of 36 mils. Table 1 shows the differences in minimum properties such as breaking strength and tear strength between Type III and Type IV. In general, Type IV membranes are required to meet higher pressures and loads than Type III.

The importance of these properties and their impact on project performance are outlined in the next section.

Table I: Physical Requirements for Poly(Vinyl Chloride) Sheet

Property	Type II	Type III	Type IV
Overall thickness of PVC sheet, min, mm (in.)	1.14 (0.045)	1.14 (0.045)	0.91 (0.036)
Thickness over scrim, min, mm (in.) ^A	0.40 (0.016)	0.40 (0.016)	0.40 (0.016)
Breaking strength, min N (lbf/in.)	245 (55)	890 (200)	1223 (275)
Elongation at break, min, %:			
Machine direction	250	15 ^B	25 ^B
Cross-machine direction	220	15 ^B	25 ^B
Seam strength, min, % of tensile or breaking strength	75	75	75
Retention of properties after heat aging:			
Tensile strength, min, % of original	90	...	...
Breaking strength, min, % of original	...	90	90
Elongation, min, % of original	90	90	90
Tear resistance, min, N (lbf)	45.0 (10.0)	...	...
Tearing strength, min, N (lbf)	...	200 (45.0)	400 (90.0)
Low temperature bend	pass	pass	pass
Accelerated weathering test:			
Cracking (7x magnification)	none	none	none
Crazing (7x magnification)	none	none	none
Linear dimensional change, max, %	0.1	0.5	0.5
Change in weight after immersion in water, max, %	+/- 3.0	+/- 3.0	+/- 3.0
Static Puncture Resistance	pass	pass	pass
Dynamic Puncture Resistance	pass ^C	pass ^C	pass ^C

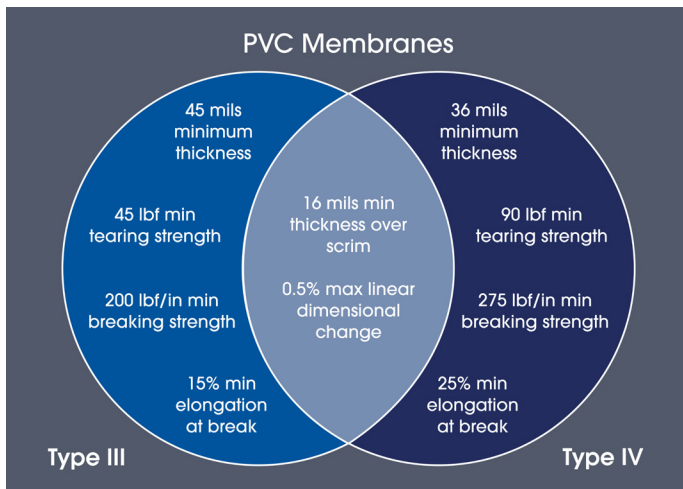
^A Above the cross points of any fabric or fiber and the surface exposed to the weather.

^B For reinforcing fabric only; elongation of PVC material shall be the same as Type II.

^C For Type II products, dynamic puncture shall be evaluated at an energy level of 10 J min. For Type III products, dynamic puncture shall be evaluated at an energy level of 20 J min.

Table 1. Source: ASTM D4434-21

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PVC Membrane Type III and IV similarities and differences

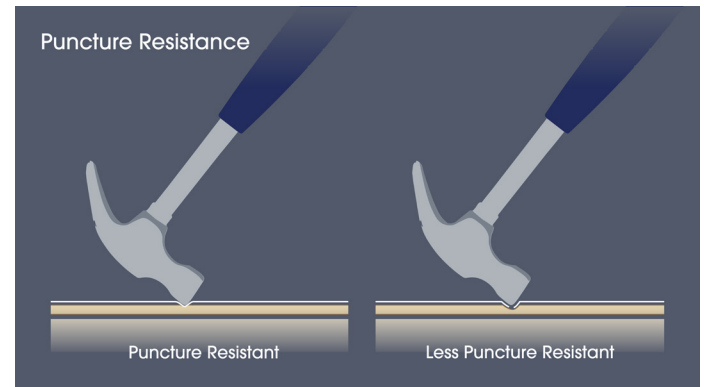
Physical Property and Performance Differences per ASTM D4434

Tensile and Elongation

The different types of membranes have different tensile and elongation characteristics. The standard differentiates this through different requirements for two properties: minimum breaking strength and elongation at break. Both breaking strength and elongation at break are tested before and after heat aging to ensure the properties do not degrade significantly. Breaking strength is directly influenced by the reinforcing scrim within the membrane. Type IV membranes have the highest breaking strength minimums, followed by Type III. Type II membranes have a minimum breaking strength that is 72% less than Type III, reducing the amount of force the membrane can take before breaking. This is important when the membrane is stressed at a fastener penetration.

In addition to breaking strength, these membranes are tested for tearing strength. Tearing strength measures how much force is required to either start a tear (tear resistance testing for Type II) or propagate a tear (Type III and IV). This property, in combination with the breaking strength, plays an important role in mechanically attached membranes where the membrane pulls on the attachment points under wind pressure. In fact, some Type II membranes are not intended to be mechanically attached at all.

Type II membranes, on the other hand, have the highest minimum elongation at break. This is because the standard requires that the polymer is the primary driver of these properties. That is not true of Type III and IV, where the reinforcement layer reduces the amount of elongation. In a properly designed roof system, the roof membrane should not be allowed to elongate the more than 220% (250% in the machine direction) required of Type II membranes, especially in adhered systems when the membrane must tolerate board joint movement. **This is the equivalent of a ¼" board joint expanding to more than ½" or more drastically, a 100-foot long building expanding to 200-feet!**



Puncture resistance illustrated with a hammer falling

Puncture Resistance

Puncture resistance is an important property for evaluating the durability of a membrane during its use. **Membranes with higher puncture resistance may have less damage from dropped tools, foot traffic and general debris.** The membrane classification type is indicative of the expected puncture resistance. A membrane's puncture resistance is very dependent on the scrim and the method used to test for puncture. ASTM D4434 calls for impact testing per ASTM D5635 which is a membrane only test. Type III and IV membranes must pass puncture resistance at an energy of 20 J, whereas Type II membranes have a lower limit of 10 J of energy. Type III and IV membranes are designed to withstand more puncture force and, as a result, may be more robust to these forces than Type II. Puncture resistance also depends on the substrate beneath the

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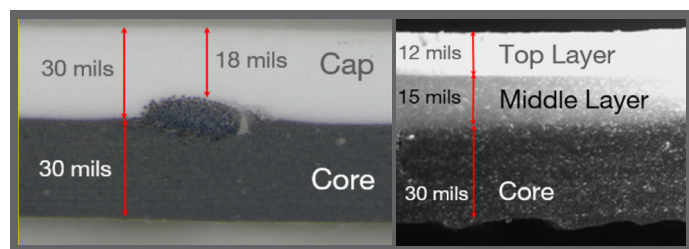
membrane, such as coverboards. Fasteners and plates that are immediately beneath the membrane can also affect puncture resistance when impacted. Therefore, system impact tests, such as those for hail, may be more indicative of in service performance.

Dimensional Changes

Type II membranes are known to have a lower percent dimensional change after aging, due to the fibreglass scrim. The maximum amount of change is 0.1% compared to a 0.5% maximum for Type III and IV. While the percent difference between the two numbers appears large, **the actual difference of 0.4% equates to less than a half inch within a 10 foot roll.** This small amount of dimensional change is generally able to be accommodated by the adhesives and components in adhered systems.

Accelerated Weathering Performance

All types of PVC membrane are subjected to the same options for accelerated weathering testing, with the same pass/fail criteria. After accelerated weathering, membranes need to have no cracking when viewed under 7x magnification. Unlike the other properties highlighted, this property relies upon the formulation of the cap portion of the membrane. The cap typically includes UV additives to enhance the weathering capabilities of the membrane. Biocides are added to the cap for fungal growth control. However, not all manufacturers choose to resist these elements in the same way: some manufacturers chose to rely on a thin protective coating for increased fungal resistance instead of putting the biocide in the cap; other manufacturers will have a 2-layer cap above the scrim



Images both show 60 layer membranes, with 2 different weathering layer thicknesses.

with only the top portion containing the UV additives and biocides, reducing the thickness of the wear layer compared to a more traditional configuration.

[ASTM D4434 references two test methods that are acceptable for accelerated weathering: ASTM G154 Standard Practice for Operating Fluorescent Ultraviolet \(UV\) Lamp Apparatus for Exposure of Nonmetallic Materials](#) and [G155 Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials](#). The two test methods are not comparable because they use different parts of the UV spectrum and have different moisture or condensation cycles. Additionally, ASTM D4434 calls out two different irradiance set points for the different test methods. Third party testing has shown that most ASTM D4434 membranes exceed the minimum 5000 hours for both test methods, although by an amount that can vary significantly among manufacturers. In order to understand the robustness of a membrane to this aging, it is important to ask manufacturers not just if they pass this test at the ASTM D4434 minimum, but when the membrane actually fails the test method and at what amount of total energy exposure. This information will allow the designer to compare results and determine which membrane best suits the expected lifespan of the roof.

Thickness Over Scrim

The minimum thickness over scrim per ASTM D4434 is 16 mils for all three membrane types. However, most membranes in the market today are well over that; most membranes have thickness over scrim closer to half the thickness of the sheet. Manufacturers work to claim the greatest thickness over scrim possible and have been known to turn this into a specification requirement in order to block out competition. This is done with little clarity on how the data point has been determined. While it is important to have a high amount of cap over the scrim, since that is what contains the UV additives and biocides to extend the longevity of the membrane, the specific number in itself may not be the most critical. Information on heat aging, accelerated weathering, outdoor aging and formulation longevity will likely provide more insights into durability of the membrane than a small difference in thickness over scrim (e.g., 2 mils). Additionally, ASTM D6754

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compliant KEE membranes, mentioned previously, have a minimum requirement of 7 mills over scrim, which may provide a much thinner wearing layer than ASTM D4434 compliant membranes.

Physical Properties Not Referenced in D4434

ASTM D4434 does not contain testing requirements for all properties that are important for high performing PVC roof membranes. Two additional properties that are commonly discussed are moisture wicking properties of the scrim and chemical resistance.

Moisture Wicking Scrim

The need for low moisture wicking properties of the cut edge of a membrane is often a concern of specifiers and designers. Fiberglass is a naturally more hydrophobic material than polyester. This means the fiberglass scrim in a Type II membrane should not absorb moisture when exposed at cut edges of the membrane. However, most manufacturers of Type III and Type IV membranes use polyester reinforcement that has a low-wicking or

non-wicking coating. The reinforcement is tested by the reinforcement manufacturers to not absorb moisture when exposed, such that cut-edge sealant is not required on the membranes. This is different from the requirements for cut edges for many TPO membranes where a cut edge sealant may be required to prevent moisture wicking into the membrane.

Chemical Resistance

Chemical resistance is one of the main reasons for specifying PVC membranes on projects such as restaurants and airports. The most effective testing standard for chemical resistance of PVC membranes is ASTM D5260 Standard Classification for Chemical Resistance of Poly(Vinyl Chloride) (PVC) Homopolymer and Copolymer Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds. This test method requires samples of the membrane to be completely submerged in the tested chemical for 30 days, followed by the membrane being weighed to record weight loss from the test. It is a very stringent test, as the cut edges and core of the material would not typically be exposed to

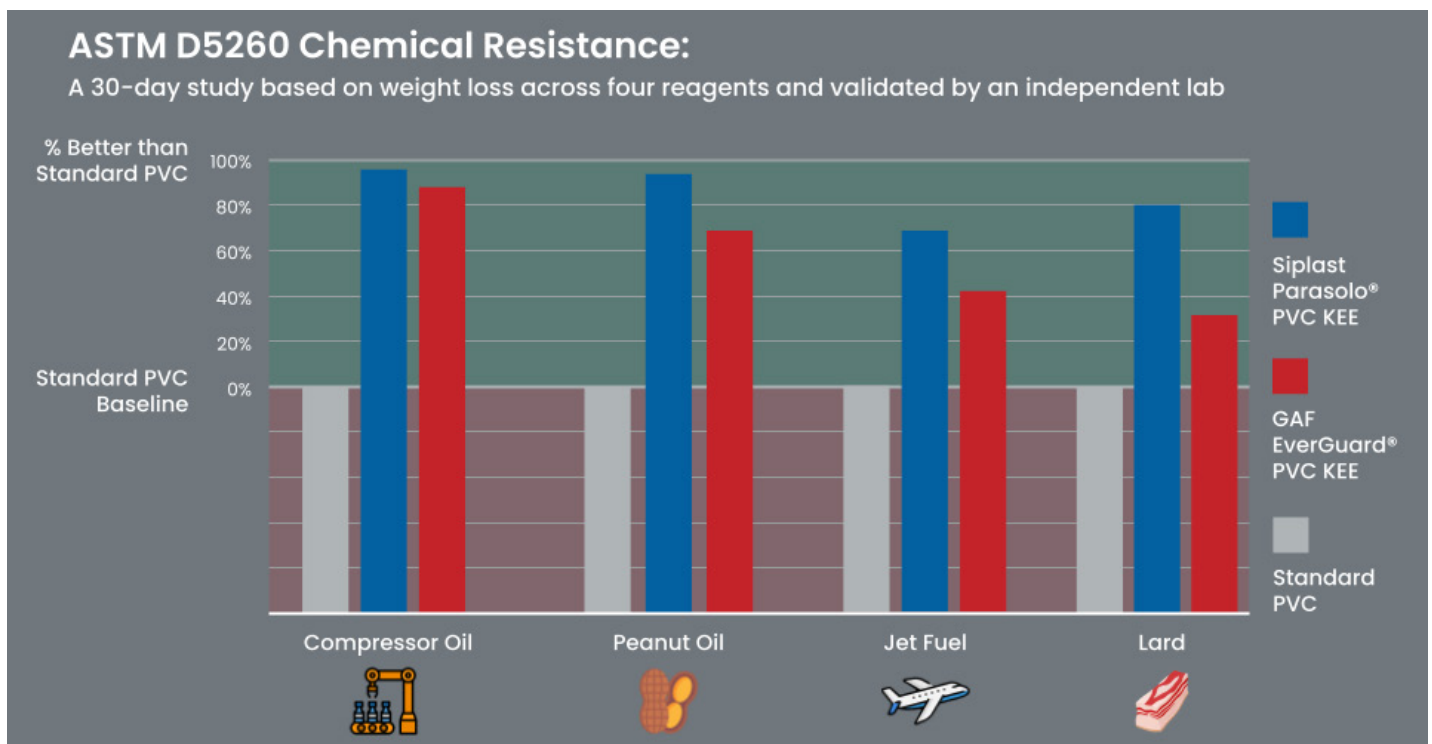


Table 2. Source: GAF R&D

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the reagent. However, it is a clear method for comparing relative performance between different membranes under consideration. The same test method can be used on all types of PVC, regardless of Type or ASTM specification it is designed to meet. For example, this test method has shown that PVC KEE has improved chemical resistance compared to PVC as shown in Table 2.

Specifying the Best Membrane For Your Project

Specifying PVC membranes can be confusing due to multiple types and specifications classifying the membranes. It is important to understand the different expectations of the products in each category to best understand what is needed to meet the project needs.

ASTM D4434 Type III and Type IV membranes are expected to have higher breaking strength, higher tear resistance and higher puncture resistance than Type II membranes. These properties are especially important for mechanically attached membranes and to provide resistance to damage from foot traffic and dropped tools. Impact resistance may also have a role in hail resistance, though that testing is completed on full assemblies, including coverboard, insulation and attachment method.

ASTM D4434 also contains requirements for accelerated weathering and elongation of the membrane. Accelerated weathering can be based on two different methods, with most membranes performing higher than the specification minimum. **The number of KJ/nm/m² or number of hours should be made available by manufacturers to allow for comparison by specifiers to understand long term performance.** The difference between the Type II and Type III/IV elongation requirements within ASTM D4434 is a key differentiator stemming from the Type definitions within the specification, resulting in the elongation requirements being significantly greater for Type II membranes.

For more information on the impacts of these properties and what is best for your project, reach out to the [Building and Roofing Science Team](#).

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