

UV DURABILITY OF TENCATE™ GEOSYNTHETICS

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When we think of geosynthetics, we usually have materials in mind whose end-use keeps them buried underground, away from exposure to ultraviolet (UV) light and its damaging effects on the synthetic polymers from which they are manufactured. Obvious exceptions would be erosion and sediment control products such as silt fencing and turf reinforcement mats, which are manufactured to withstand a certain amount of UV exposure before their material properties are degraded to a point that their intended functions can no longer be maintained or are no longer needed. Geosynthetic manufacturers typically add stabilizing components to their synthetic resins or coatings used to manufacture geosynthetics, but these additives are very expensive and can also reduce material strength and other desirable geosynthetic properties, so they are generally used in moderation.

The damage to geosynthetics from UV exposure can be evidenced through changes in both the physical appearance and material performance of a product. Some of the most easily observed changes are partial strength loss and loss in material density over time. The UV spectrum wavelength between 300 nm and 400 nm appear to be the most aggressive in damaging geosynthetic polymers which occurs on a molecular structure level.

In light of the known effects of UV degradation of geosynthetics, most specification agencies recommend that these materials not be exposed to the elements for an extended period of time. One example of this train of thought is the American Association of State Highway and Transportation Officials (AASHTO) "Geotextile Specification for Highway Applications," Designation: "M288," which recommends that "*Atmospheric exposure of geotextiles to the elements following lay down shall be a maximum of 14 days to minimize damage potential.*" Other examples include specifying minimum percentage of strength retention after a set number of hours of exposure to simulated UV degradation testing, such as seventy percent (70%) strength retained after five-hundred (500) hours of exposure in Xenon arc testing (ASTM D4355).

In order to evaluate the stability of geosynthetics to simulated UV exposure and weathering effects, the industry has developed or adopted several new and existing testing methods that use either real-time or accelerated exposure schemes. ASTM International test method D4355 mentioned above uses a xenon arc light source to provide UV spectrum wavelengths and also uses cycles of heat and moisture to simulate natural weathering cycles. Another current ASTM test standard, D7238, or QUV, utilizes condensation and a fluorescent UV light source to simulate weathering cycles for geomembranes and similar products. While these test methods are accepted within the geosynthetics industry to be useful measures of UV durability, correlating them to real-world exposure degradation rates is awkward and has been hit-or-miss at best.

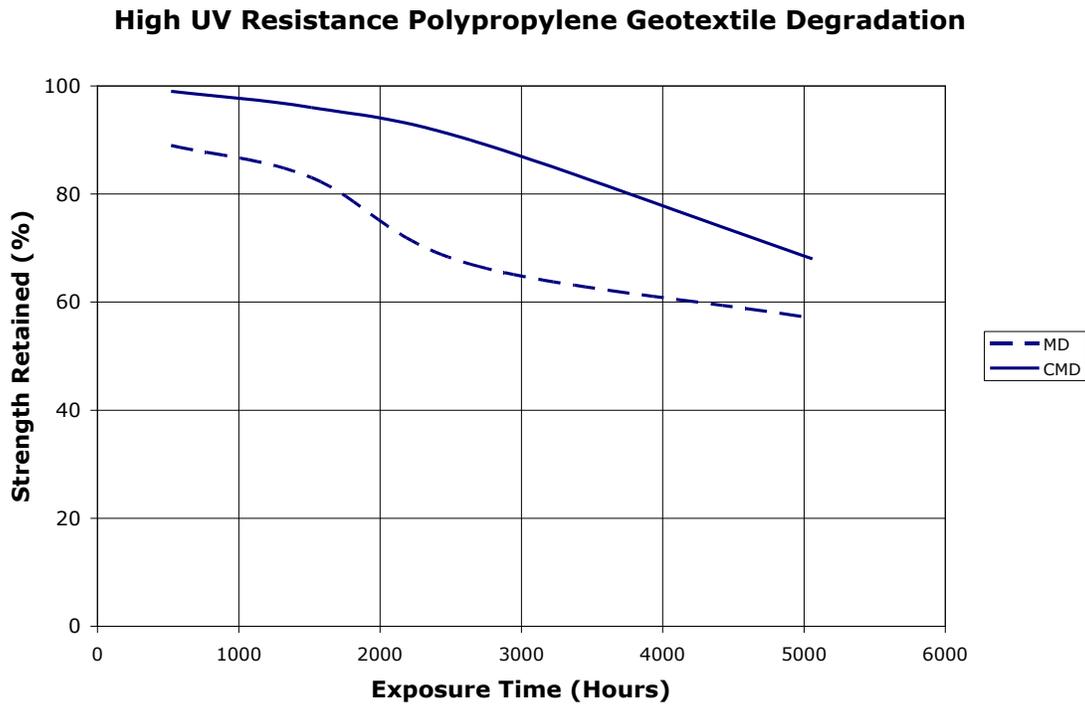


Figure 1: Example UV Degradation Strength Loss over Time for a Woven Polypropylene Geotextile with Added UV Inhibitors.

The central problem in developing correlations between laboratory UV degradation test results to real-world field application is that UV intensity and degradation rates are not constant across the globe as they are in the lab. If we use the 500 hour benchmark for UV degradation from ASTM D4355 as a datum and try to correlate it to field measured values in North America, similar degradation might be expected after six months to one year in Tampa, Florida, or seven to ten years in Seattle, Washington or five to seven years in Toronto, Ontario. It is important to note that there are other environmental effects to take into account that go beyond UV degradation when considering the potential deterioration mechanisms of geosynthetics when they are left exposed to the elements, but they are beyond the scope of this technical note.

It is possible to assess the level of UV exposure over time in any given location in the world with some accuracy. To do this, one must have both “erythemal UV irradiance” data for that location and information relating diurnal and seasonal variations in UV intensity. More specifically, irradiance information is gathered by both satellite and ground sources and gives a representation of ultraviolet light spectrum radiation at ground surface levels. While this type of information is extremely useful in nailing-down the levels and spectrums of UV light hitting an exposed geosynthetic, it must still be correlated to laboratory test results to be useful in determining the specifiable deterioration level of a geosynthetic that can be related to outdoor exposure rates.

Figure 2 shows an example of erythemal UV irradiance levels across the globe measured on a single day at 1200 hours (12:00pm, noon).

Earth Probe TOMS Version 8 Local Noon Erythemal UV Irradiance on July 01, 2005

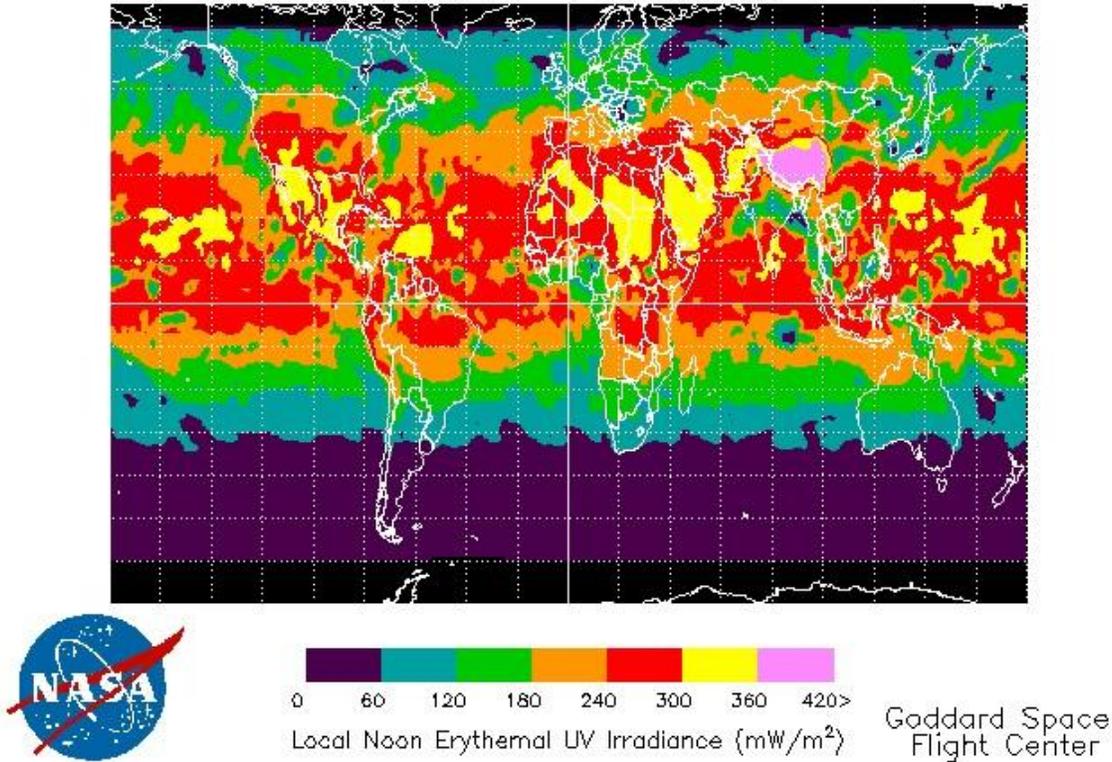


Figure 2: Courtesy of the U.S.A. National Aeronautics and Space Administration.

Since the intent of this technical note is to provide some guidance for the user to be able estimate the durability of our TenCate products when degraded by UV light, we will make some estimated correlations between the laboratory test methods and field exposure rates. The calibrated output of the Xenon arc light source used in ASTM International test method D4355 is 350 mW/m², and the output for the fluorescent UV light source used in D7238 is 710 mW/m². Thus, the intensity of the QUV (D7238) source is about twice that of the Xenon arc (D4355) source, or twice as intense. If we look at a closer view of the erythemal UV irradiance over the United States for one day in July, 2005, as shown in Figure 3, we can see that the intensity across the southwestern US (New Mexico, Arizona, Colorado) is similar to the intensity of the light source used in D4355. Similarly, the erythemal UV irradiance across the northeastern (New England) and northwestern (Washington, Oregon, Montana, Idaho) US is about two-thirds the D4355 intensity. The corresponding ratios to D7238 would be one-half in the southwest and one-third in the northeast and northwest.

Earth Probe TOMS Version 8 Local Noon Erythral UV Irradiance
on July 01, 2005

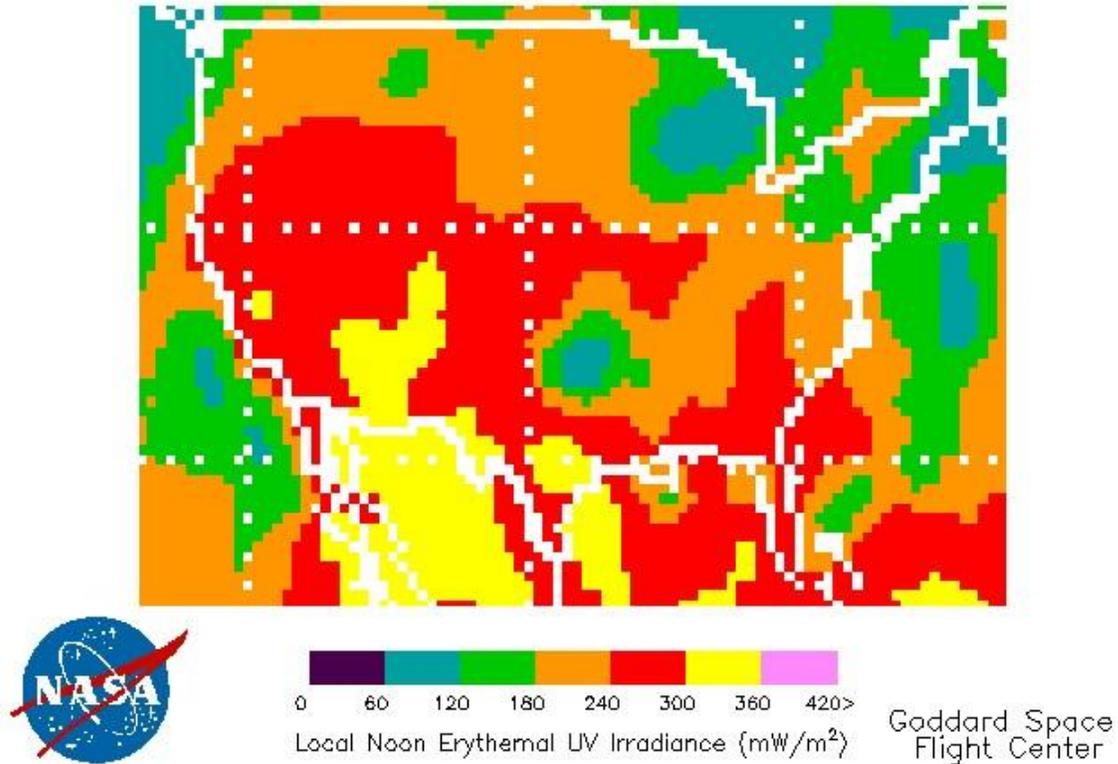


Figure 3: Close-up of Figure 2 of the Continental United States, Courtesy of the U.S.A. National Aeronautics and Space Administration.

Continuing the correlation between laboratory UV degradation testing and actual field UV exposure rates, we must also look at the duration of natural sunlight over a 24 hour period. The natural variation in sunlight intensity due to the earth’s rotation about its axis is termed “diurnal” and refers to this 24 hour cycle that is repeated daily. Figure 4 shows an example of the diurnal peak solar intensity variation one would expect to observe throughout any given day, discounting environmental variables such as cloud or smoke cover, rainfall, solar eclipse, etc. If the solar irradiance level is averaged over a 24 hour period, the average is approximately 24% (of peak solar intensity). This ratio will be used to further correlate field UV exposure rates to the laboratory tests.

We can also look further into some of the other variables that will impact erythral UV irradiance levels, such as cloud cover and/or rainfall. For example, Seattle, Washington, USA, experiences about 225 cloudy days per year, which is about 61% of the time. We can assume from the lower regional UV irradiance levels shown over isolated areas in Figure 3, that cloud cover and/or rainfall can reduce the irradiance level to about 50% of the peak irradiance level. Mean or average total sunshine information for the continental

US is available from the National Oceanic and Atmospheric Agency as shown in Figure 5, and can be used to further refine this percentage for specific regions of the US. This ratio will also be used to further correlate field UV exposure rates to the laboratory tests.

Typical Diurnal Sunlight Irradiance Variation

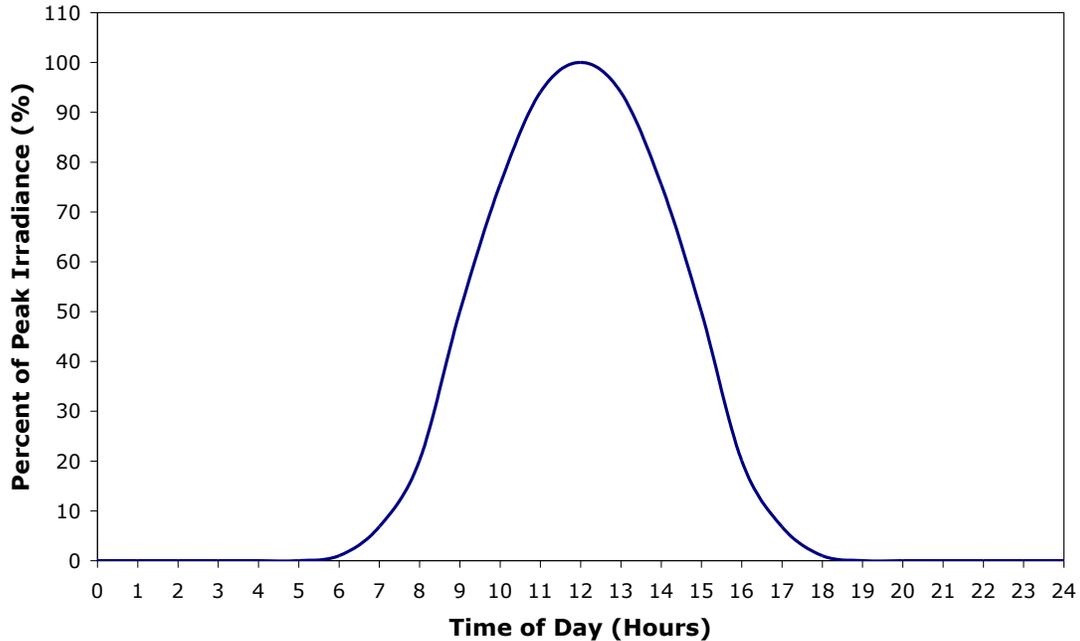


Figure 4: Example of a Diurnal Peak Sunlight Irradiance Curve.

The next step in the correlation process is to take into account the specific environmental factors we have discussed to this point and relate the field observations to the laboratory test methods. We have to keep in-mind that the industry standard is to report the MARV (minimum average roll value) percentage of strength retained for geosynthetic products. For geosynthetics, this is typically reported at a 500 hour bench mark. The UV irradiance level calculated for 500 hours of exposure in the ASTM D4355 laboratory test method works out to 175,000 mW*hr/m², while ASTM D7238 yields 355,000 mW*hr/m².

We then must combine the regional environmental factors, which are approximate, to come to a similar irradiance exposure level for geosynthetics left exposed in an outdoor environment. These locale-specific factors are again, are erythemal UV irradiance; diurnal sunlight variations; and mean sunshine percentage. Table 1 show this combined data for eleven (11) selected US cities, and summarizes the approximated exposure time span that correlates to the 500 hour laboratory test results. The results of the tabulated approximations show that the 500 hour Xenon arc UV test correlates to roughly one-half to two years of field exposure, while it takes roughly twice as long, or one to four years in the field, to get to the same UV irradiance levels achieved in QUV testing.

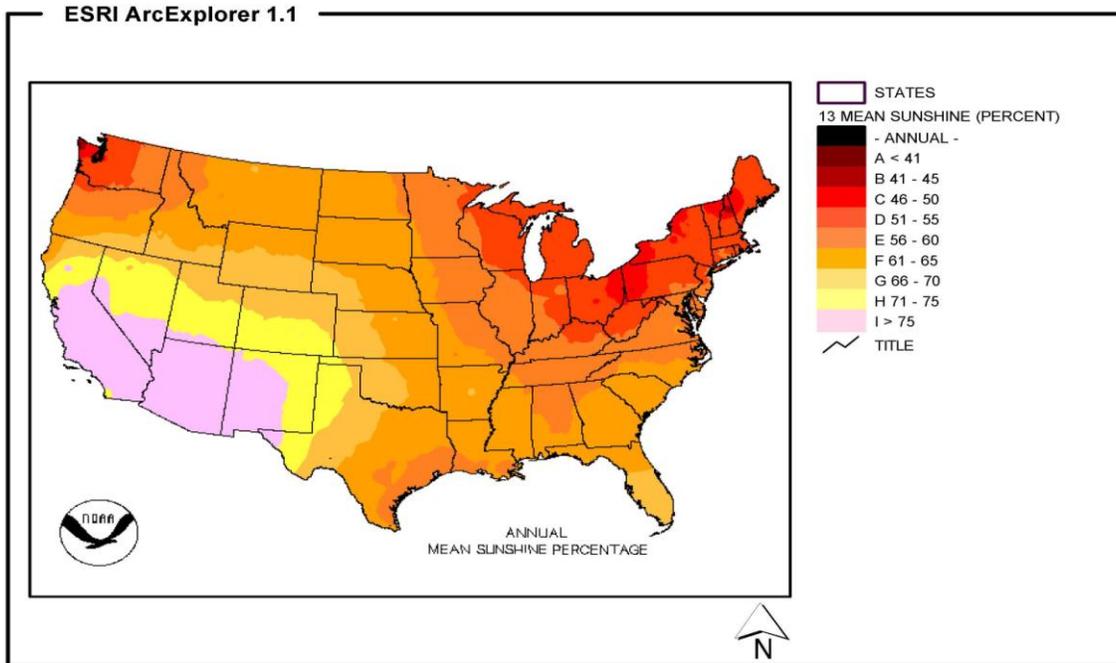


Figure 5: Courtesy of the U.S.A. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service.

Table 1: Equivalent Outdoor UV Irradiance Exposure for 500 Hour Laboratory Testing for ASTM D4355 and D7238.

Continental US City	Peak Erythral UV Irradiance (mW/m ²)	Annual Mean Sunshine Normalized to 24 Hour Day (decimal)	Daily Average Solar Irradiance Level (decimal)	Annual Average Erythral UV Irradiance (mW/m ²)	Equivalent Time of Exposure: 500 Hour ASTM D4355 (Years)	Equivalent Time of Exposure: 500 Hour ASTM D7238 (Years)
Atlanta, GA	300	0.34	0.24	213,701	0.8	1.7
Billings, MT	180	0.34	0.24	128,220	1.4	2.8
Chicago, IL	240	0.28	0.24	143,607	1.2	2.5
Hartford, CT	240	0.28	0.24	143,607	1.2	2.5
Orlando, FL	300	0.37	0.24	230,797	0.8	1.5
Phoenix, AZ	360	0.42	0.24	317,986	0.6	1.1
San Antonio, TX	360	0.34	0.24	256,441	0.7	1.4
San Diego, CA	300	0.39	0.24	247,893	0.7	1.4
Seattle, WA	180	0.20	0.24	76,932	2.3	4.6
Washington, D.C.	240	0.31	0.24	157,284	1.1	2.3
Wichita, KS	300	0.34	0.24	213,701	0.8	1.7

We can surmise from this 500 hour exposure comparison that geosynthetics with added UV inhibitors are fairly resistant to the degradation effects of UV irradiance relative to geosynthetics that contain no inhibitors (i.e. virgin HDPE, PP, PET, etc). Something else we take for granted is that woven geotextiles are more resistant to UV degradation than nonwoven geotextiles due to the larger cross sectional area of their yarns, all else being equal. Stabilized PP yarns and filaments are also more resistant to UV irradiance than uncoated PET yarns as is evidenced in their MARV strength retention at 500 hours of UV irradiance exposure: 70% - 90% for PP; 50% for PET. Based on the best industry recommendations, we recommend that our TenCate geosynthetic products not be left exposed to the elements for more than 14 days, as specified in AASHTO M288, unless their specific application requires continued outdoor exposure like silt-fence, sediment control, erosion control, wrap-face MSE wall or RSS facing, or the like.

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ASTM D 4355-07 "Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus," American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA.

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