EXTENDED LIFE PLASTIC™

It's -50°C outside! Is your Plastic Scintillation Portal Monitor still working?

What limits the lifetime of plastic scintillator?

Plastic scintillator is subject to aging that is evidenced by a pulse height loss of about 2% per year. Normally the pulse height loss has little effect on detector sensitivity, and plastic scintillators in a laboratory environment have lifetimes of 20 years or more. For plastic deployed outdoors such as in portal monitors, the situation is different. Recently it has been shown that plastic scintillator exposed to humid summers and cold winters can fog when cold.[1] Hermetically packaged plastic remedies this situation and keeps your portal functioning at the coldest temperatures.

Why does plastic scintillator haze?

Plastic scintillators will absorb moisture when stored in warm humid conditions. When the weather turns cold, the plastic contracts and the water vapor may coalesce to form a haze inside the material. Initially the haze will vanish when the plastic warms, but repeated warm-cold cycles will lead to permanent fog in the scintillator. Depending on the environment this effect may take several years to appear.

How does haze effect performance?

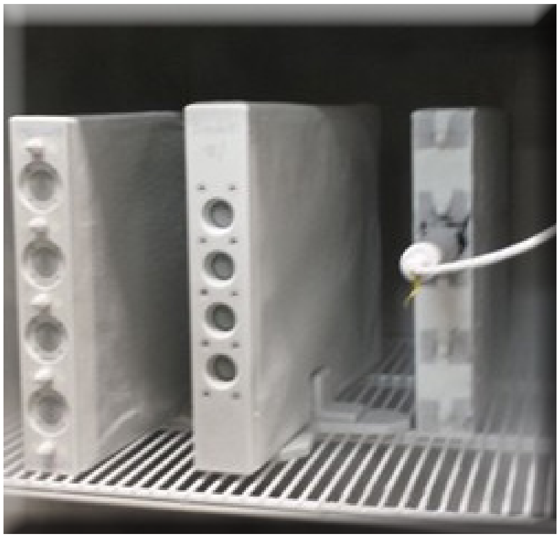
Internal haze introduces scattering sites in the bulk of the plastic that prevent scintillation photons from reaching the photo sensor. This effect decreases the pulse height and increases pulse height variation with position. Essentially the effective area of the detector is reduced along with the system's sensitivity. The effect is most pronounced in large area plastic and the sensitivity to low energy events is the most affected.

How to prevent haze and extend the life of plastic scintillator?

The problem of hazing and subsequent efficiency loss can be avoided by preventing water vapor from being absorbed by the plastic. A hermetically sealed package is a solution that has years of proven reliability with hygroscopic scintillators such as NaI(Tl). In practice the volume of a plastic scintillator used in a portal monitor may be 10 to 20 times greater than a NaI detector and packaging becomes an expensive proposition.

The Solution -

While maintaining constant low energy performance, Saint-Gobain has incorporated a revolutionary barrier film along with the standard wrapping to provide an effective seal against vapor penetration. Prolonged testing in hot, humid conditions followed by a cold temperature soak shows that detectors packaged with the barrier film do not suffer the degradation seen in detectors with only standard wrapping. Several 2" x 4" x 16" plastic scintillators with PMTs were packaged in different configurations and stored for 60 days at 55°C and 85% Relative Humidity (RH) and then taken to -30°C. Tested configurations included standard wrapping i.e. reflective foil and black vinyl, welded aluminum housing, and the standard wrapping with a barrier film layer.



Plastic with accumulated total 90 days @ +55°C and 90% relative humidity with multiple exposure cycles @ -30°C

EXTENDED LIFE PLASTIC

Figure 1 shows the light collection uniformity as a function of temperature. The uniformity is measured as the ratio of the position of the Compton edge for the source placed 2" from the far end of the detector to the position recorded when the source is placed 2" from the PMT. The temperature was cycled from 25°C down to -30° and then to 55°C before returning to 25°. The detector in the aluminum housing show uniform light collection across the temperature range as does the detector with the barrier wrap. The detector with the standard wrapping shows increased non-uniformity as the temperature decreases and recovery as the temperature warms. A look at the individual spectra (figures 2 & 3) as a function of temperature gives an indication of the changes to the scintillator. The spectra below are recorded at -30°C for the source positioned at 2", 8" and 14" from the PMT. On the left are spectra from the detector with standard wrapping. A significant loss of pulse height is apparent as the excitation point is moved further from the PMT. On the right, the detector with the barrier wrap shows virtually no change in pulse height over its length.

The effect of light collection on detection efficiency is evident in the relative net counting rates plots (figures 4 & 5). For these measurements different sources were placed 500mm from the center of the detector and the net count rate was recorded for a Low Level Discriminator of 30 keV as a function of temperature. As the temperature decreases, the relative count rate of the detector with only the standard wrapping falls off due to increased light loss caused by haze induced scattering. For the detector with the barrier wrap, the count rate changes inversely with temperature which is follows thermally induced gain changes of the PMT.[2]

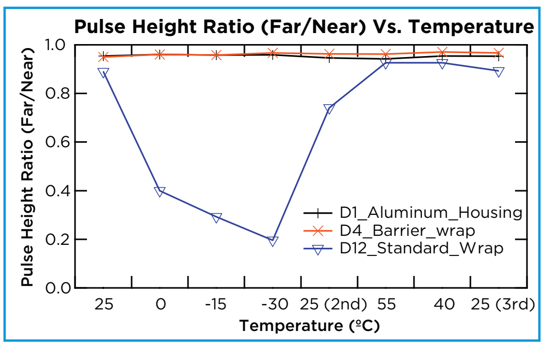


Figure 1

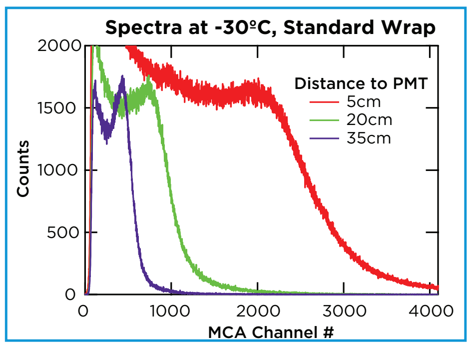


Figure 2

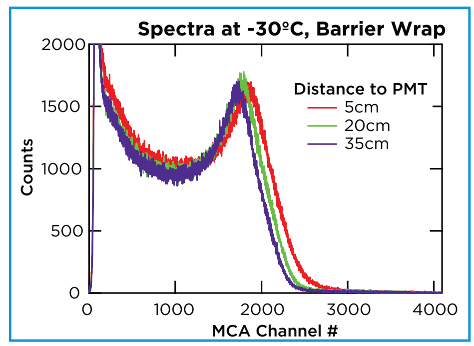


Figure 3

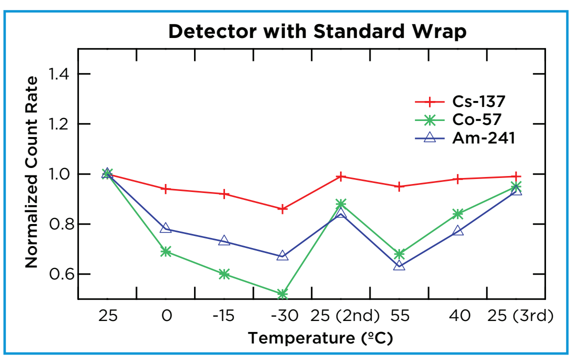


Figure 4

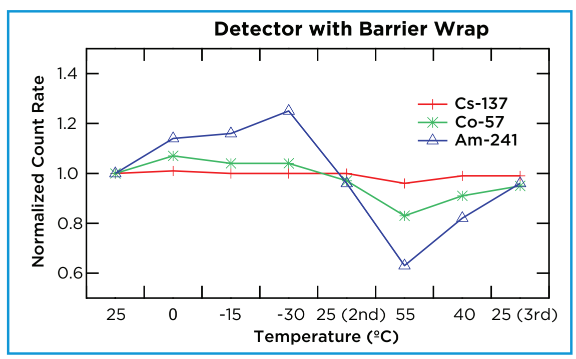


Figure 5

SAINT-GOBAIN

Saint-Gobain Crystals

www.crystals.saint-gobain.com

REFERENCES:
1) R. J. Cameron, B. G. Fritz, C. Hurlbut, R. T. Kouzes, A. Ramey, and R.Smola, "Fogging in Polyvinyl Toluene Scintillators', IEEE Trans, Nuc. Sci. 62 (1), 2015
2) M. R. Kusner and P. R. Menge, "A Cost Effective Means of Extending the Lifetime of Plastic Scintillators in Portal Monitors", IEEE NSS, MIC, & RTSD Conf Proceedings, 2015