ACRYLITE® Soundstop

Roadway Glare and Reflection

Technical Overview

The purpose of this Technical Brief is to discuss reflective glare relative to ACRYLITE® Soundstop noise barrier sheet panels and offer explanation as to why it has not been a significant deterrent for the driving public.

The Technical Brief will expand on three characteristic facts:

1. Most reflections are above the line of sight.
2. Intensity of light diminishes sharply as distance increases.
3. ACRYLITE® Soundstop sheet reflects only a portion of the light that is projected against its surface.

ACRYLITE® Soundstop sheet is a lightweight sound insulating panel that features outstanding optical clarity, long-term weatherability, and excellent impact resistance. A common misconception associated with transparent ACRYLITE® Soundstop sound walls is the potential for glare due to the headlights of oncoming vehicular traffic. For many years, transparent ACRYLITE® Soundstop sound walls have been installed along highways in Europe, Asia and other parts of the world. To our knowledge, reflected glare from a noise barrier has not created issues with traffic in any of these installations. A close examination of the geometry and optics involved suggests why.

The Reflections are Typically Above the Line-of-Sight

In many sound wall installations, the ACRYLITE® Soundstop sheet only makes up a portion of the sound wall panel material. It is very common for walls to have a concrete, wood or metal base, with the transparent panels mounted above. When the bottom of the transparent sound wall panel is above the sight line of the driver, then all reflections will be above the driver.

The Intensity of Light is Significantly Reduced as Distance Increases

In general, the intensity of the light decreases proportionally to the square of the distance traveled. Hence, the intensity of the light reflected from a sound wall is greatly diminished due to the distance it travels from the headlamp to the ACRYLITE® Soundstop wall and from the ACRYLITE® Soundstop wall to the driver.

Illuminance is the measurement of how bright a point source of light appears to the eye. Figure 1 shows the decrease in illuminance over distance for a typical automotive high beam headlamp directed into a 45° cone. It illustrates how significantly light will diminish in intensity over distance traveled.

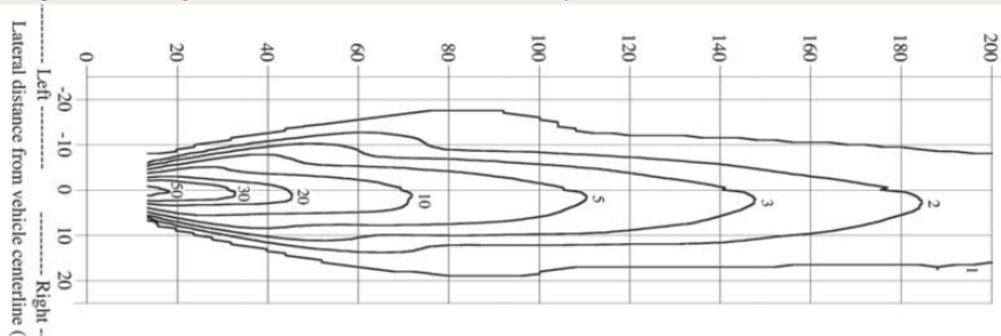
For example at a distance of 20 meters, standard headlamp high beam brightness is measured at 50 vertical lux. At 110 meters distance, that same light source measures 5 vertical lux.

Simply stated, the brightness of a light source will diminish over greater distance in the same manner that objects appear smaller as distance increases.

Since ACRYLITE® Soundstop has a very smooth “high gloss” surface it is assumed that it also has a very high reflectance but this is not necessarily true. When light is projected at an ACRYLITE® Soundstop panel, a portion of the light passes through the sheet and the remainder is reflected.

The percentages of light that are transmitted and reflected will vary according to the angle of projection. At very low angles (see Figure 2) ACRYLITE® Soundstop sheet reflects a majority of the incident light. As angles or reflection increase, the amount of light reflected diminishes sharply. For light projected at angles below 10° the light typically travels a very long distance and this has the effect of reducing the brightness of the light as seen by the oncoming driver.

Figure 1. Longitudinal Distance from Headlamps (m)

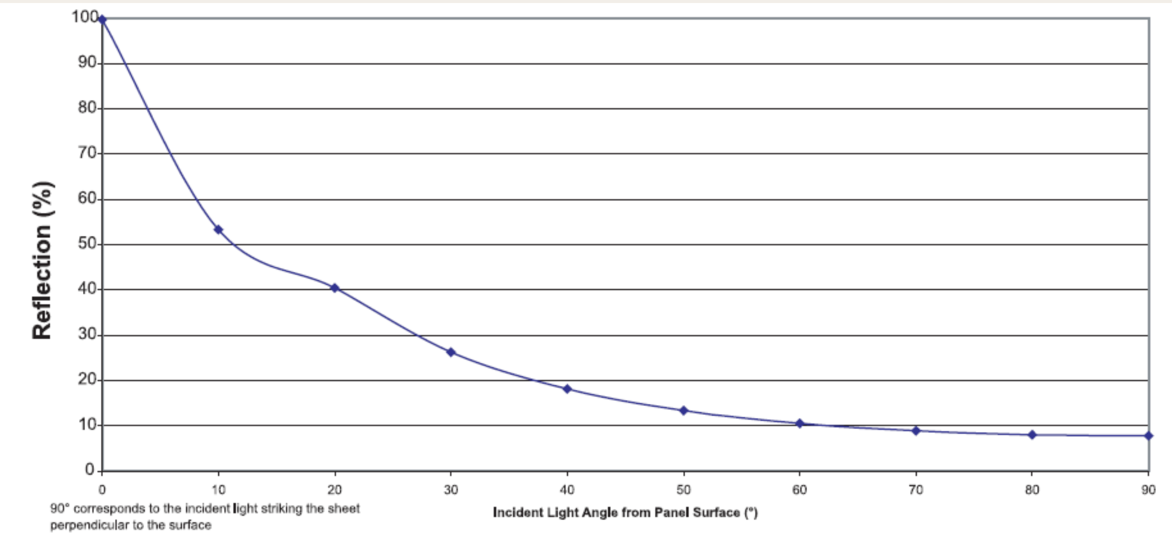


1 Source. The University of Michigan Transportation Research Institute, Report No. UMTRI-2001-19, May 2001

When light is projected against a ACRYLITE® SOUNDSTOP panel, only a portion of that light is reflected. The remainder passes through the panel.

Figure 1. Iso-illuminance diagram (vertical lux) at the road surface from a pair of lamps having the median luminous intensities for the sales-weighted sample representing the high beam headlamps on current passenger vehicles in the U.S.1

Figure 2. Reflection ACRYLITE® SOUNDSTOP Sheet



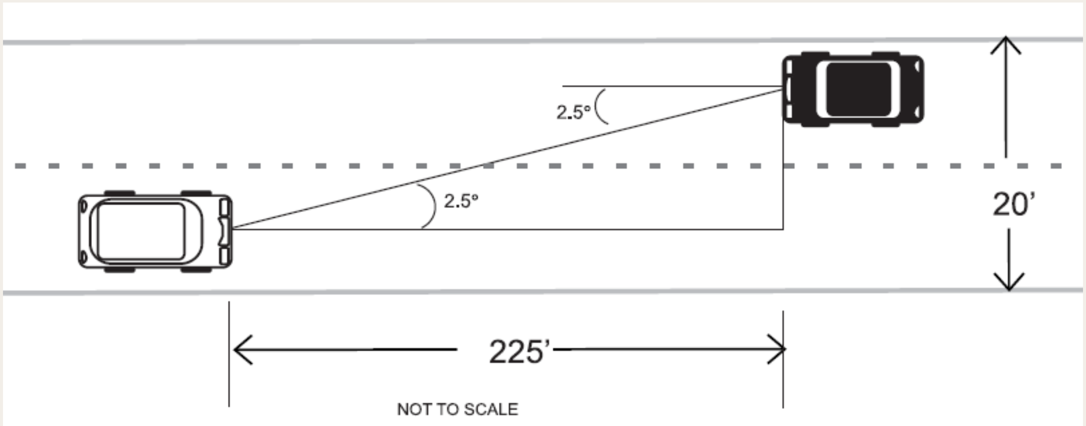
The effects of both distance and angle of reflection combine together to greatly reduce the intensity of reflected light.

The intensity of the light is greatly diminished due to the distance the light has traveled from the headlamp to the ACRYLITE® Soundstop sound wall. It is then reduced in intensity further according to the angle at which it is reflected and then further reduced in intensity due to the distance the reflected light travels from the ACRYLITE® Soundstop sound wall to the driver. In most circumstances, the light projected directly from the headlights of an oncoming vehicle is significantly more intense than the reflected light.

How much glare is too much?

Disability glare is created by a light so bright that its intensity results in a measurable reduction in a driver's ability to perform visual tasks. This reduction in performance is a direct result of the effects of stray light within the eye, which in turn are dependent on the age of the driver. At night, vehicle headlights produce direct glare by shining into the eyes of drivers in approaching cars and indirect glare such as reflections from rearview mirrors. Typically, the effects of glare on drivers are much greater at night than during the day, because at night drivers are adapted to lower light levels. For example, lights that are barely noticeable by day can be uncomfortably glaring at night.

The following are two examples to help illustrate the difference between direct glare from oncoming vehicle's headlamp and indirect glare from a sound wall constructed from ACRYLITE® SOUNDSTOP Sheet.

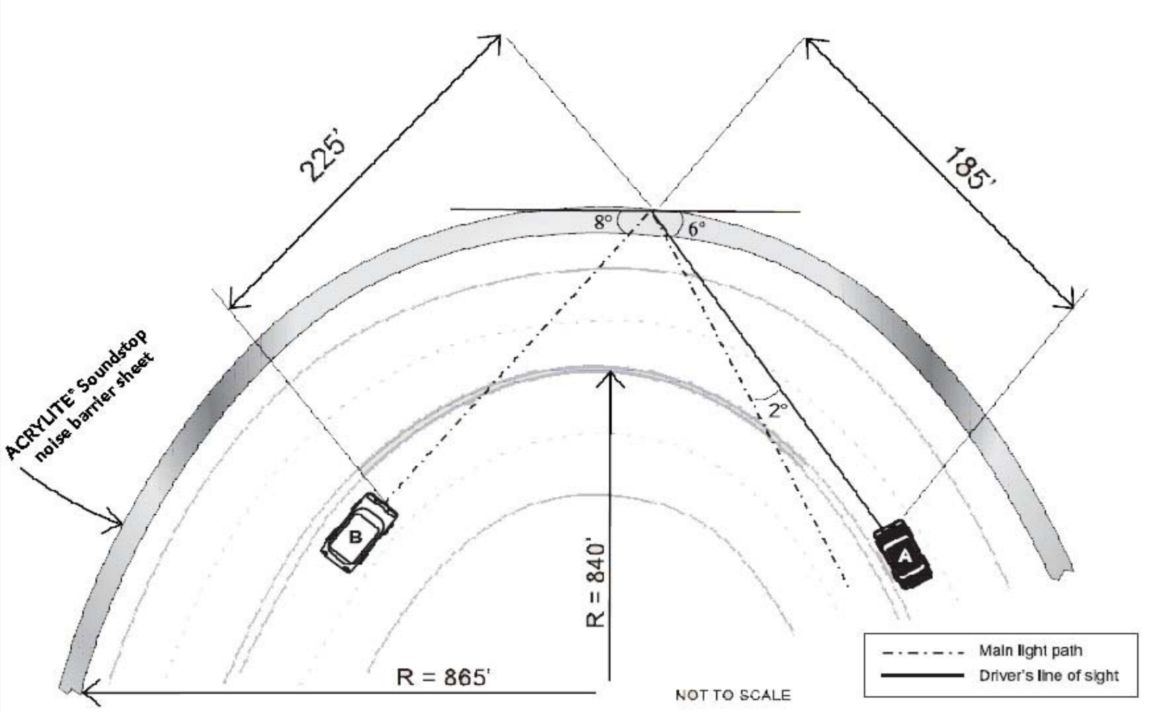


Example 1

First, consider the glare from an oncoming vehicle with the following assumptions:

- One lane of traffic in each direction
- Each lane is 10-ft wide
- The driver is 50 years old and looking straight ahead along the middle of the lane
- The cars are separated by a distance of 225-ft
- A background luminance of 0.026-cd/ft2 (an unlighted roadway at night)
- A headlamp luminous intensity of 42,500-cd and 25,431-cd at 2.5° left of center.

In this example, the luminance of the glare reaching the drivers eyes is calculated to be .50-fc. Thus, an object in the roadway will have to have its luminance compared to the background luminance increased over 40-fold to be detected. In other words an object in the roadway will have to be about 40 times brighter to be seen when there is glare from an oncoming high beam headlight at 225 feet away.



Example 2

Consider a highway curve with the following geometry:

- Two lanes of traffic in each direction
- The cars moving in opposite directions approach each other, they are in the inside lanes
- Each lane is 10ft wide
- The radius of curvature is 840 feet (very tight for a highway)
- The driver is 50 years old and looking straight ahead along the middle of the lane
- A background luminance of 0.026-cd/ft2 (an unlighted roadway at night)
- A headlamp luminous intensity of 42,500-cd and 29,440-cd at 2° left of center

The cars on the outside of the curve (represented by vehicle A) will cross paths with both reflected light (indirect glare) from the ACRYLITE® Soundstop sound wall panels coming from the cars on the inside of the curve (represented by vehicle B in Example 2) and then, afterwards, direct light (direct glare) coming from the same cars (vehicle B). The light from vehicle B's headlamps will strike the ACRYLITE® Soundstop sound wall after traveling a distance of 225 feet. The incident light will be reduced in intensity by 40% when it strikes the ACRYLITE® Soundstop panel at an angle of 8°. The reflected light will then travel a distance of approximately 185 feet and will cross the path of vehicle A at an angle of 2°. The illuminance of the glare reaching the drivers eyes is .10-fc and therefore, an object in the roadway will need to have its luminance increased 13-fold in order to be seen.

If we compare the 13-fold increase in contrast threshold for reflected light from a ACRYLITE® Soundstop sound wall with the over 40-fold increase for direct glare from an oncoming headlight it is easy to understand why indirect glare from a ACRYLITE® Soundstop sound wall has not created any known complaints.

Definitions

Glare occurs when the intensity of a light is greater than that to which the eyes are accustomed. It is usually defined as a bright light or a brilliant reflection.

Direct glare is caused by light sources in the field of view and reflected glare is a bright reflection from a polished or glassy surface (for example, the vehicles side view mirror). Disability glare is caused by light scattered within the eye, causing a haze of veiling luminance that decreases contrast and reduces visibility.

Reflectance is a measure of the reflected incident light (illuminance) that is reflected away from a surface. Reflectance will depend on the surface properties of the material as well as the angle from which it is illuminated.

Luminous intensity is the light-producing power of a source, measured as the luminous flux per unit solid angle in a given direction. It is a measure of the strength of the visible light given off by a source of light in a specific direction. In this brief luminous intensity is expressed in terms of candelas (cd).

Luminance is the amount of luminous flux reflected or transmitted by a surface into a solid angle per unit of area perpendicular to a given direction. It is a physical measure of the amount of light reflected or emitted from a surface and roughly corresponds to the subjective impression of "brightness". Luminance does not vary with distance. It may be computed by dividing the luminous intensity by the source area, or by multiplying illuminance and reflectance.

Illuminance is the amount of light incident per unit area of a surface at any given point on the surface. The illuminance E at a surface is related to the luminous intensity I of a source by the inverse square law E = I/d2, where d is the distance between the source and the surface. In this brief illuminance is expressed in terms of foot-candles (fc).

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