SAE INTERNATIONAL

April 8, 2022
Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

Re: Docket No. NHTSA–2022–0013; Fed. Reg. Vol. 87, № 35, February 22, 2022

Deputy Administrator Dr. Steven Cliff; National Highway Traffic Safety Administration,

SAE is a technical standards development organization made up of professional engineers and affiliates interested in advancing the state of the art in automotive and aerospace engineering. SAE International (SAE) has a dynamic Lighting Systems Group numbering 60+ active members including international lighting and regulatory experts experienced with Adaptive Driving Beam (ADB) systems. Participation includes members from automakers, manufacturers of lighting assemblies and light sources, test equipment and materials suppliers, universities involved in lighting research, lighting test facilities, regulatory agencies, and other interested parties.

The SAE Lighting Systems Group would like to thank the National Highway Traffic Safety Administration for publishing a ruling on Adaptive Driving Beam (ADB) systems and appreciates the opportunity to provide comments to Docket No. NHTSA-2022-0013 via our Regulatory Cooperation Task Force (RCTF).

While the SAE Lighting Systems Group stands behind SAE J3069™, it is understood that the agency has decided to develop their own methodology for the certification of ADB systems in the United States. In reviewing the ADB final rule, the SAE RCTF recognizes steps NHTSA has taken to simplify and streamline the ADB testing and move towards a window of harmonization with regulations utilized outside the United States. These steps will help enable the deployment of ADB systems on US vehicles.

However, the SAE RCTF has identified two aspects of the ADB final rule that will degrade the effectiveness of ADB systems and limit the benefits for the ADB-equipped driver and other road users. These will cause significant and unnecessary ADB performance restrictions along with placing severe design and manufacturing constraints on lower beams of all ADB-equipped vehicles.

1. The 1-degree transition zone:

S9.4.1.6.4.5 allows "*A transition zone not to exceed 1.0 degree in either the horizontal or vertical … between an area of reduced intensity and an area of unreduced intensity*".

The SAE RCTF appreciates NHTSA's recognition of the necessity for a transition zone in response to industry's comments to the ADB NPRM. However, the 1-degree zone specified in the ADB final rule enables only very high-resolution, pixelated ADB systems to comply with the laboratory requirements. These high-resolution systems are quite costly; currently they represent a relatively small number of ADB systems in use in other markets, and only those found on premium vehicle models.

The vast majority of ADB systems use the technique of staggering overlapping segments of light to create the ADB pattern. This technique provides an affordable method to create the required high upper beam intensities. The staggering of these segments provide increased visibility during opposing and preceding vehicle encounters over a multitude of positions and reduces the appearance of abrupt movement of the areas of reduced intensity within the pattern. Such abrupt movement of the dimmed areas within the beam pattern are less satisfactory to drivers.

With this technique, the area of unreduced intensity does not reach full upper beam levels within the 1 degree specified, especially at the H-V, H-3L, and H-3R upper beam test points. These affordable ADB systems will provide much greater illumination versus standard lower beam in these enhanced roadway visibility areas but cannot transition between lower beam photometric intensities to upper beam photometric intensities in the currently specified 1 degree transition zone.

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An example is shown in Figure 1. This figure illustrates the light output of a 12-segment ADB system projection along with a graph of the intensities for a horizontal slice through the beam pattern at 0 degrees vertical. The area of unreduced intensity would not be able to fulfill the upper beam requirements for approximately 3 degrees. Additional examples are shown in Appendix 1, which represent required transition zones from approximately 1.9 degrees for an 84-pixel system (high resolution) to 7.8 degrees for a 6-pixel system (low resolution).

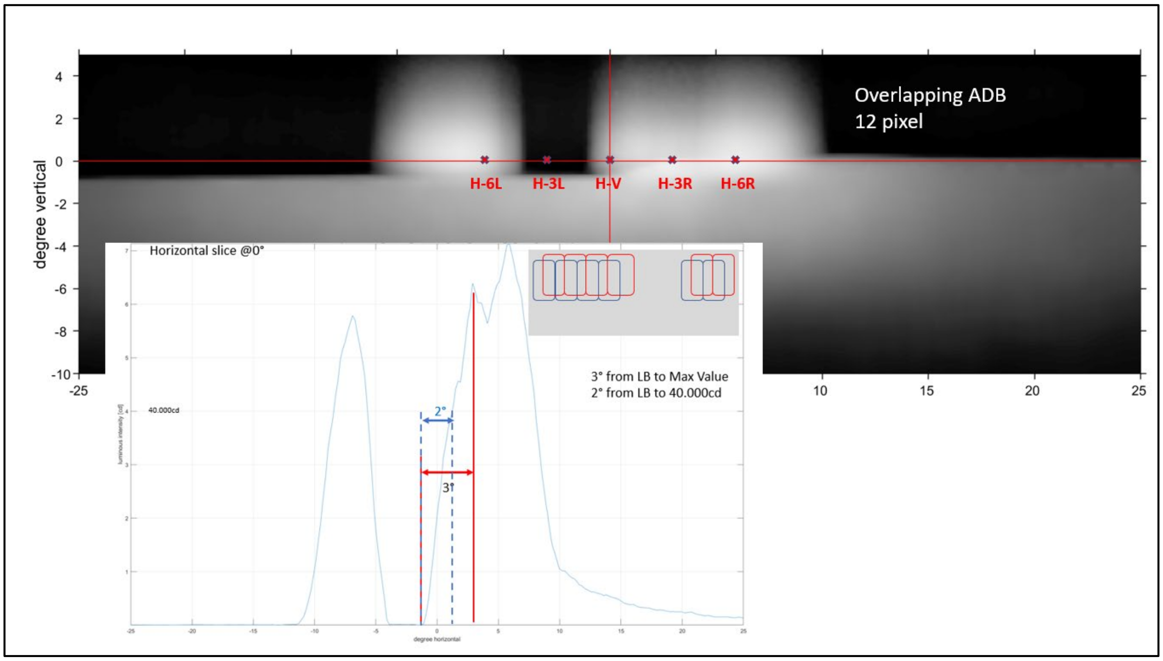

Figure 1 – Typical real-world example of an overlapping/staggered ADB pattern compared to upper beam requirements

The industry's likely solution to fulfill the FMVSS № 108 photometric requirements for these ADB systems will be to enlarge the area of reduced intensity to include one or more of the H-V, H-3L, and H-3R test points. In effect, this diminishes the area of unreduced (upper beam) intensity in the visibility-critical areas around an opposing or preceding vehicle, without providing any glare-reduction benefit for the opposing or preceding driver. Also, additional unreduced light intensity segments would be required to be extinguished in addition to those already extinguished in order to de-glare opposing or preceding drivers with a larger transition zone. This results in a less effective ADB system with less additional roadway visibility for the driver. These examples are shown in Figures 2 and 3.

Figure 2 is a representation of a single headlamp with staggered overlapping ADB segments. Superimposed onto this graphic is a representation of a single opposing vehicle at approximately 100m distance. The resulting ADB locally dimmed pattern is shown for a system functioning to the regulatory requirements of regions outside of the United States. This results in a fully dimmed pattern for the opposing vehicle, but the ADB-equipped driver has the benefit of the additional light (visibility) greater than lower beam levels to each side of that opposing vehicle. While this additional light is less than upper beam photometric levels, the intensity is still far above what is provided by the standard lower beam in that enhanced roadway visibility area. However, this partial upper beam intensity is unlikely to meet all upper beam minimum criteria with the 1-degree transition zone defined in the ADB final rule.

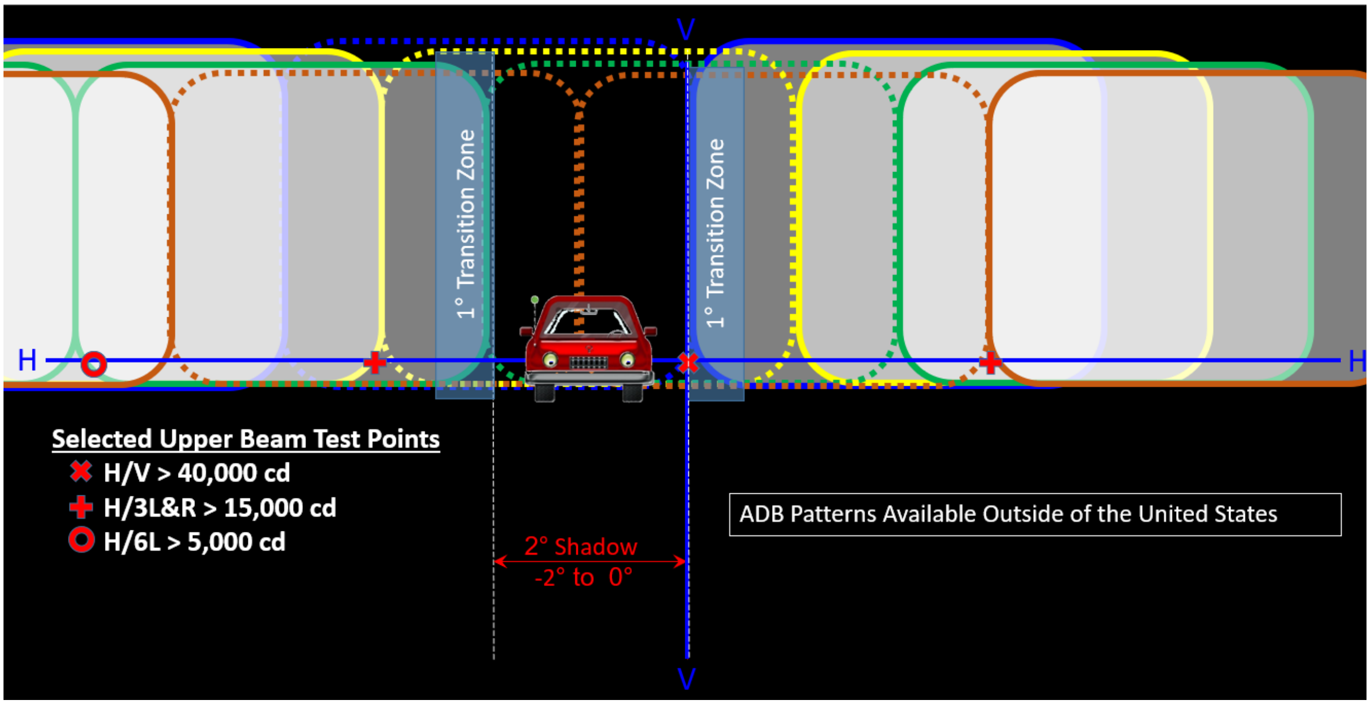

Figure 2 – ADB performance for regions outside of the US following UN regulations or SAE J3069™

However, as Figure 3 illustrates, to comply with the FMVSS № 108 requirement for full upper beam intensity beyond the 1-degree transition zone, the area of reduced intensity would have to extend laterally well beyond the opposing vehicle. In this representation, the width of the reduced area would enlarge from 2 degrees to 6 degrees to include the regulated (laboratory testing) upper beam test points which would not meet the Figure 2 partially dimmed example. Therefore, instead of partial upper beam intensities, this area would only allow standard lower beam intensity levels. The ADB-equipped vehicle driver would lose the visibility benefit of the additional light in these areas of the roadway and/or curbside regions and would be constrained to lower beam light levels in this enhanced roadway visibility region.

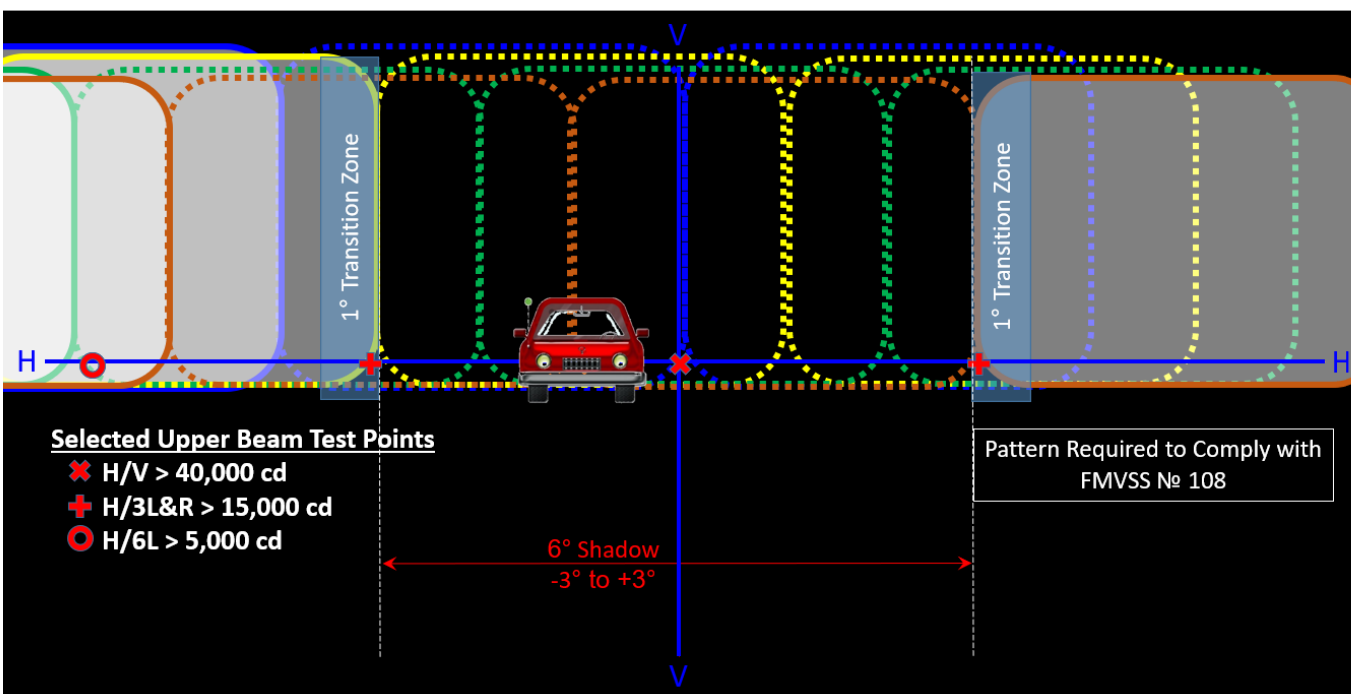

Figure 3 – ADB Performance Required to Comply with FMVSS № 108

These illustrations are for one example system type with a stimulus vehicle at a specific position and orientation relative to the ADB-equipped vehicle. There are many other scenarios and additional ADB systems that will create similar light output degradations resulting in much less road visibility for the driver. ADB systems using very high-resolution segments may be able to meet the 1-degree transition, but these utilize more expensive technologies.

The most straightforward regulatory resolution to this concern is to not explicitly constrain or define the size of the transition zone. However, the ADB final rule preamble explained NHTSA's reluctance to allow this. An alternative proposal would be to enlarge the allowed transition zone to 4-degrees in the horizontal direction. Based on the data collected within the industry, this would allow the deployment on U.S. roads of affordable ADB systems to provide enhanced roadway visibility immediately around opposing or preceding vehicles without affecting their glare exposure.

Appendix 1 contains horizontal photometric scans similar to Figure 1 for additional ADB systems which are currently available or in development in other global markets. These industry examples illustrate the need for a transition zone larger than 1-degree and indicate that a 4-degree transition zone is required for many ADB systems.

2. *Incompatibility of ADB Vehicle Level Glare and the Lower Beam Photometry Requirements*

The SAE RCTF also appreciates the steps taken to lessen impact of the glare restrictions in the right-hand curve test scenarios by reducing the distance at which those glare requirements are to be measured. The Insurance Institute for Highway Safety (IIHS) data provided in the SAE comment to the NPRM (NHTSA-2018-0090-0167, December 11, 2018) supporting this need have now been updated to 2021 model year vehicles and are shown in Figure 4. Unfortunately, this data indicates that this issue still exists despite the improvement with the ADB final rule over the previous NPRM condition.

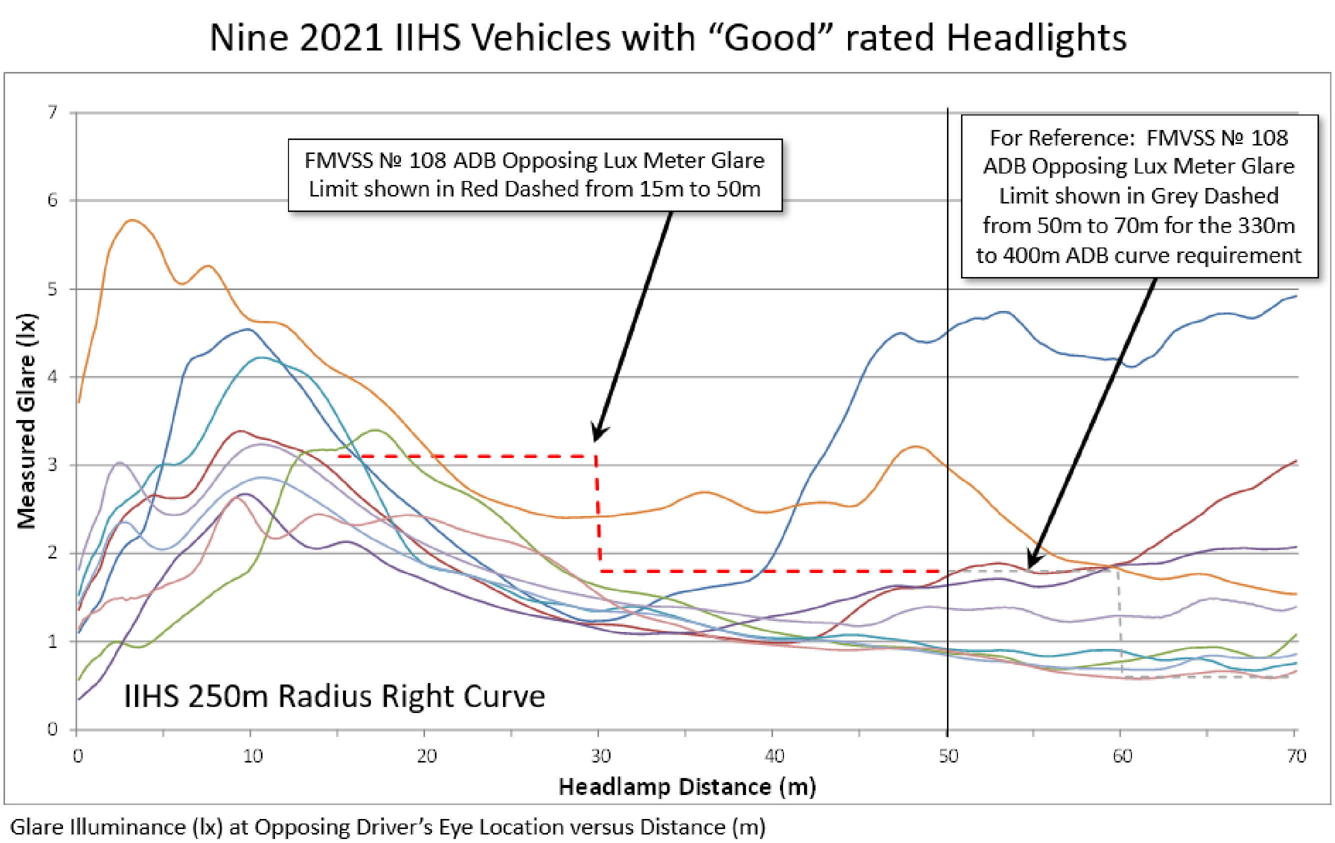

Figure 4 – IIHS glare measurements for a 250m curve radius

Further study of the ADB final rule shows that even the shorter distances will still result in areas of close proximity and/or overlap between the established vehicle test glare limits and the existing lower beam minimum photometric requirements. These intersecting areas result in a very small window to meet both requirements between the photometric minima and maxima test values. As a result, ADB lamp manufacturing will be severely challenging for lower beams or likely require significant downward re-aim of a lower beam incorporated within the ADB system. Such downward re-aim will reduce roadway visibility distances.

To further clarify, one area in which intersecting requirements exist is at the lower beam photometric test line of 0.5U, 1R to 3R. This particular lower beam photometric scan requires a minimum intensity of 500 cd throughout, while allowing a maximum of 2,700 cd anywhere along the line. During the right curve ADB test scenarios, the glare detectors on the test fixture will have a relative travel path which will cross this same test line at some test distance (this distance varies with factors such as curve radius, headlamp mounting height, etc.). Therefore, the dynamic vehicle test is also imposing a glare limit on the same region of the beam pattern which does not match the corresponding laboratory requirement.

An example of this is illustrated in Figure 5, showing a 400m right curve and an ADB headlamp mounting height of 600mm. In this example, the current lower beam maximum of 2,700 cd along that line for a single headlamp would now be limited to 2,160 cd *from the pair of ADB headlamps.* Dividing this value for each of the two headlamps results in approximately 1,080 cd from a single ADB headlamp imposed by the vehicle driving test requirements. However, the laboratory testing minimum of 500 cd is still required for lower beams along that entire photometric scan line. With that conflict, a compliant lower beam providing an intensity not much greater than the minimum intensity required along the 0.5U-1R to 3R line would fail the ADB vehicle testing requirements.

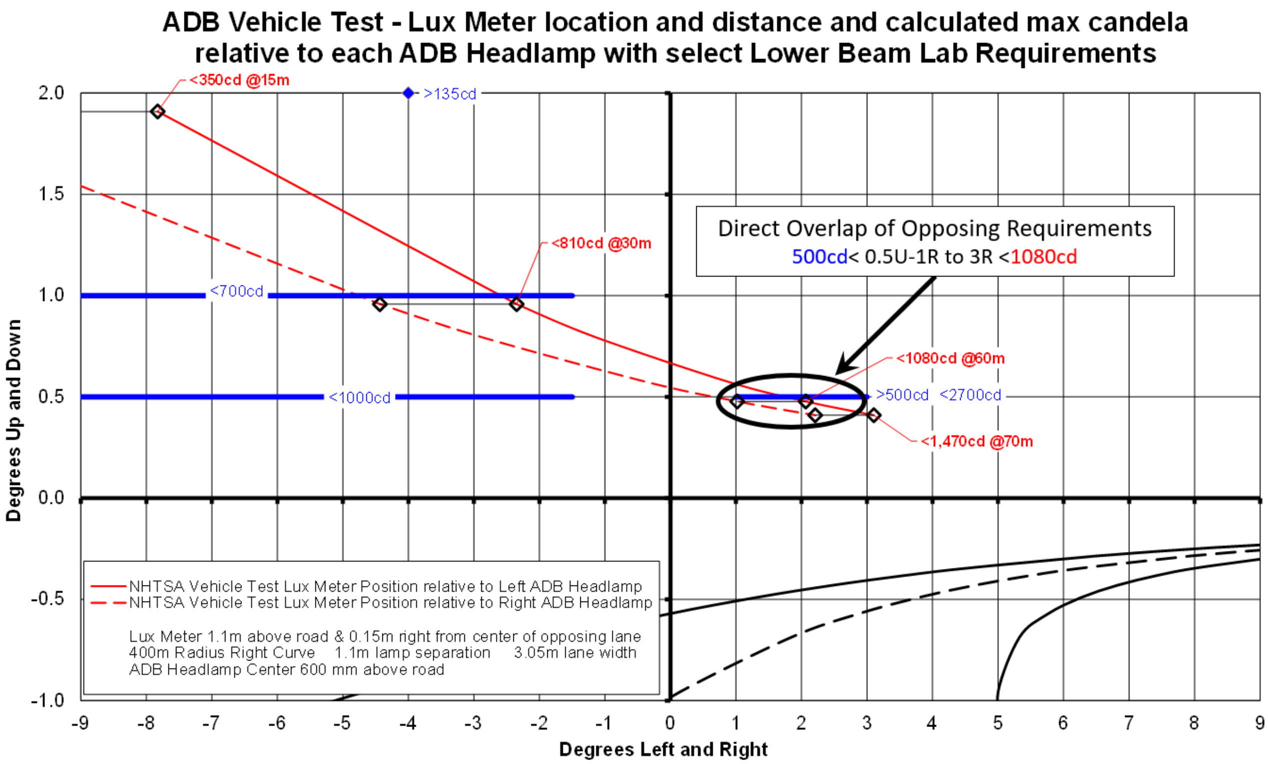

Figure 5 – 400m right radius curve isocandela view of ADB vehicle glare requirements superimposed onto the lower beam photometric requirements showing conflict at 0.5U 1R-3R

A similar conflict exists for the 210m right curve and an ADB lamp mounting height of 800mm where the upper limit would be approximately 1103 cd per ADB headlamp. This is illustrated in Figure 6.

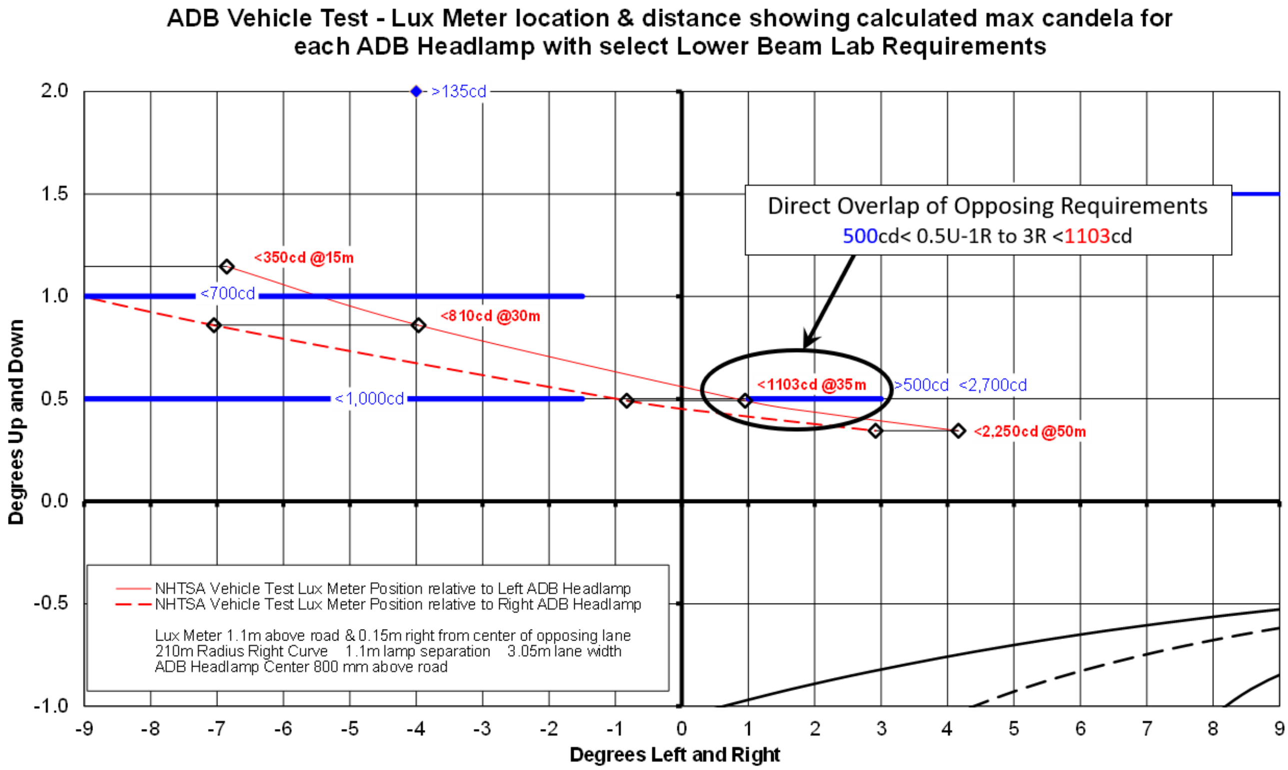

Figure 6 – 210m right radius curve isocandela view of ADB vehicle glare requirements superimposed onto the lower beam photometric requirements showing conflict at 0.5U 1R-3R

Another area of close proximity of opposing requirements is at the lower beam test point of 2U-4L. This test point requires at least 135 cd. For the 210m right curve at an ADB mounting height of 600mm, the lux meter position for the vehicle test requirements would be in very close proximity to this point at 15m distance, requiring no greater than 700 cd from a pair of ADB headlamps, or 350 cd per ADB headlamp. This is illustrated in Figure 7.

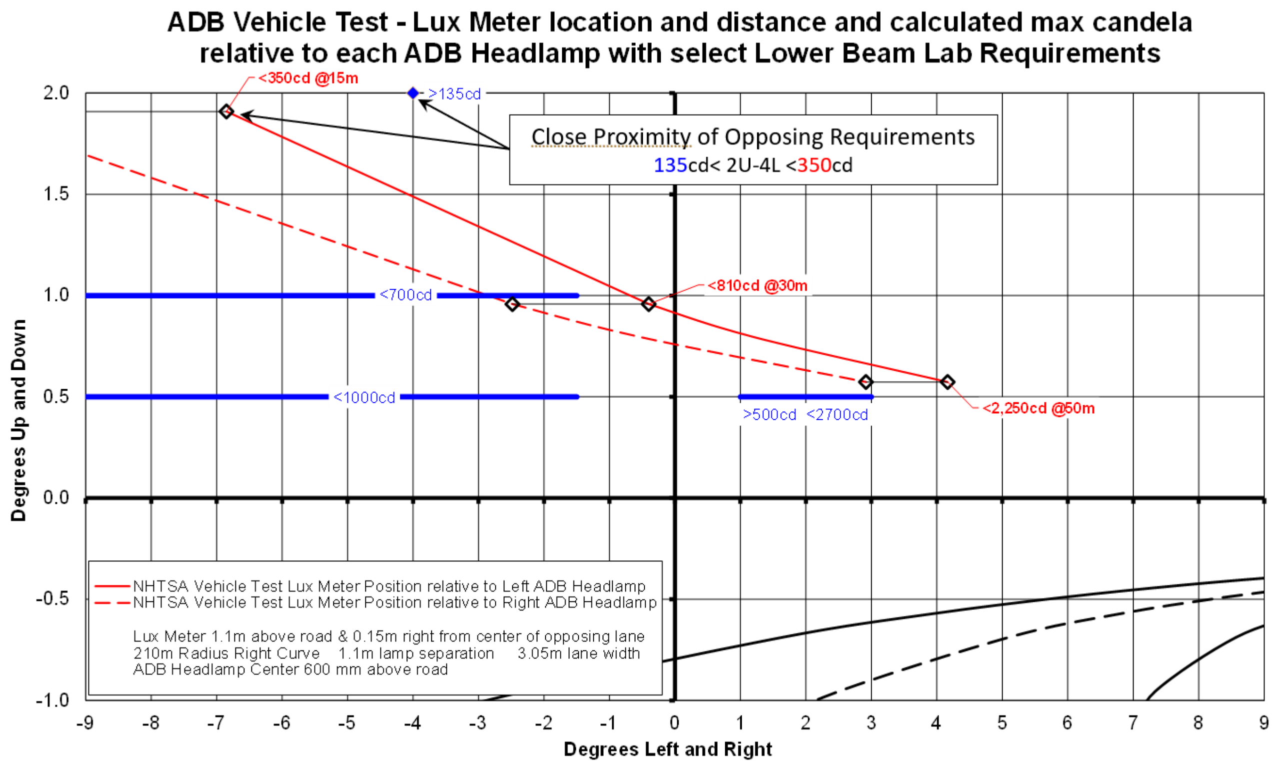

Figure 7 – 210m right radius curve isocandela view of ADB vehicle glare requirements superimposed onto the lower beam photometric requirements showing conflict at 2U-4L

In these examples, the requirements severely restrict the production margins to design and manufacture a headlamp that can robustly comply with all the disparate FMVSS № 108 requirements. These specific examples only illustrate some of the areas where there is a clear conflict. There are many other configurations which exist where the conflicts are not as obvious but will nonetheless reduce the permissible range of light output (i.e., visibility) resulting in requirements that cannot be robustly maintained in production.

Additionally, these concerns are further exacerbated by glare contributions from parking lamps, road reflections, and other light sources. As a result, the vehicle test glare limits are more severe than the values which are mentioned above and/or notated within Figure 5, 6, and 7.

An undesirable method to avoid this conflict is to raise the headlamp mounting height to greater than 1,000mm. Higher mounting heights can be extrapolated from Figures 5, 6, and 7, and will eliminate the overlap of some laboratory test criteria with the lux meter locations during some vehicle test scenarios. This approach has drawbacks in other test scenarios.

Another method is to aim the headlamps downward significantly – likely greater than 4 inches at 25 feet (0.8 degrees downward) – to provide sufficient margin to robustly comply with the regulatory requirements. This would not be desirable since the lower beam would be aimed down continuously thus reducing down road visibility at all times.

Another undesirable method is to install an automatic aim system which lowers the headlamp aim when the vehicle is in ADB mode. This significant downward aim would be a concern during false positive occurrences where the lower beam's down-the-road visibility would be greatly reduced. A similar concern might exist if any hysteresis occurs once an opposing vehicle has passed. We are also unsure how state and local authorities would judge this, as some state regulations limit the downward aim of headlamps to no more than 4 inches at 25 feet (0.8 degrees downward).

Several potential regulatory remedies were also considered to resolve this issue, taking into consideration the dynamic nature of testing, diverse vehicle designs, and the multiple test scenarios which are included in FMVSS No 108. In lieu of modifying the regulatory requirements for lower beam or increasing the permissible illumination detected during the vehicle tests, the suggested regulatory remedy is to relate the vehicle tests' glare requirements using the lower beam comparative method as specified in SAE J3069™ section 6.5.1.2. With this method, the glare measured at the test fixture from an ADB vehicle headlamp cannot exceed the intensity levels of that same ADB vehicle's lower beam by more than 25%. This will ensure the ADB system provides similar performance to the standard lower beam without necessitating large downward re-aim and performance degradation of the lower beam.

For reference, the rationale from SAE J3069™ states:

> *… an allowance was included that if the glare values exceeded these [lower beam] lux levels, they would be acceptable if the levels didn't exceed 125% of the low beam levels measured from the ADB equipped vehicle under the same conditions. The rationale was to require a light level restriction that is no greater than the low beam on the vehicle being tested, while allowing slightly higher light levels than that vehicle's low beam to accommodate test variation and small amounts of increased light due to beam pattern variations. It should be noted that the ADB light level comparison to the low beam is for the particular low beam for that vehicle, not to the regulatory maximum allowed light levels for the low beam. It is expected that low beam light levels for any particular vehicle will be below the maximum allowed, such that the 125% allowance does not represent 125% of the maximum allowed glare.*

While NHTSA expressed concern with this approach in the preamble of the ADB final rule, perhaps this type of criterion should be reevaluated considering the unintentional conflicting limitations discussed above. We note that this concept would also countervail the glare from additional light contributions in the glare zones from parking lamps and road reflections previously mentioned.

The SAE RCTF considers this solution the most practical and most in the spirit of regulatory harmonization.

In conclusion, we appreciate the Agency's consideration of these comments. We are available to discuss our technical recommendations and comments in detail. Please contact Mr. Michael Larsen to arrange a meeting.

Respectfully submitted on behalf of the SAE Lighting Systems Group.

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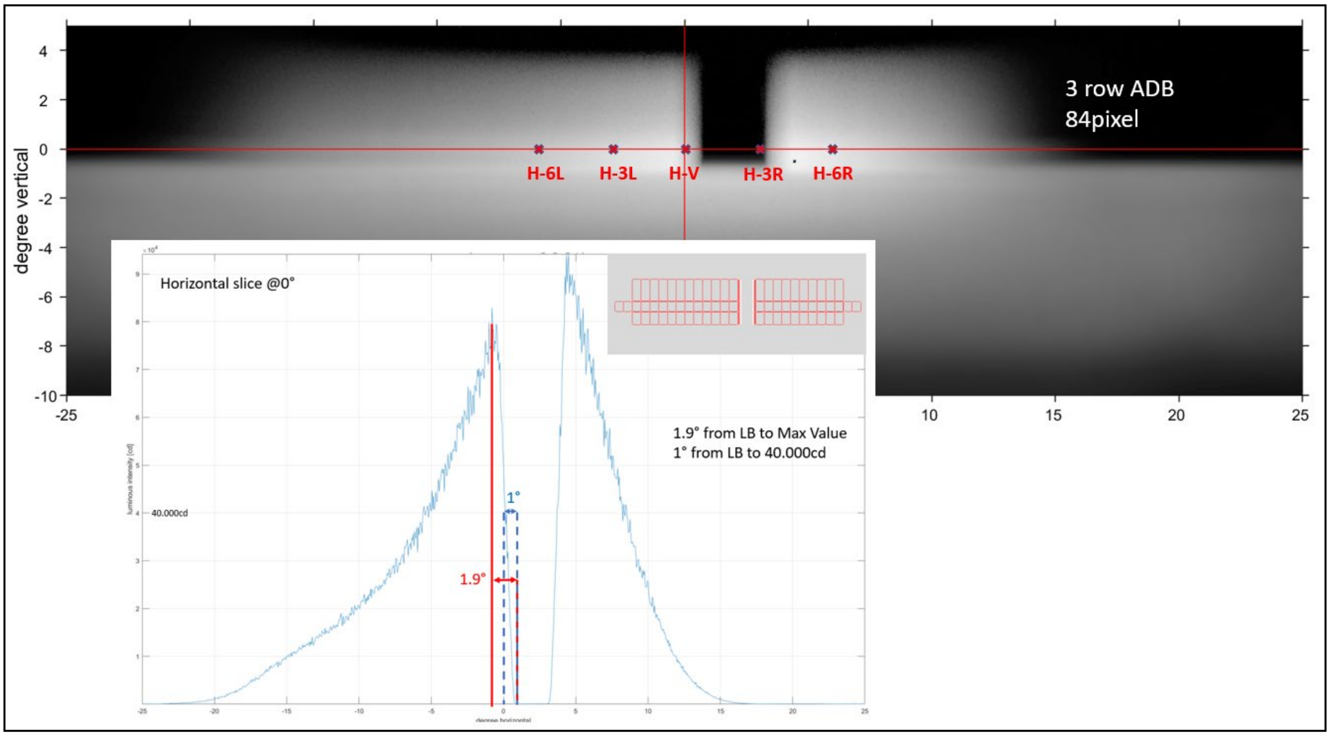
Ms. Ann Carlson, Chief Counsel
Mr. Ryan Posten, Associate Administrator, Rulemaking
Mr. Joseph Jaklic, Chairman, SAE Lighting Systems Group
Mr. Michael Larsen, Chairman, SAE J3069™ ADB and SAE Regulatory Cooperation Task Force

Appendix 1

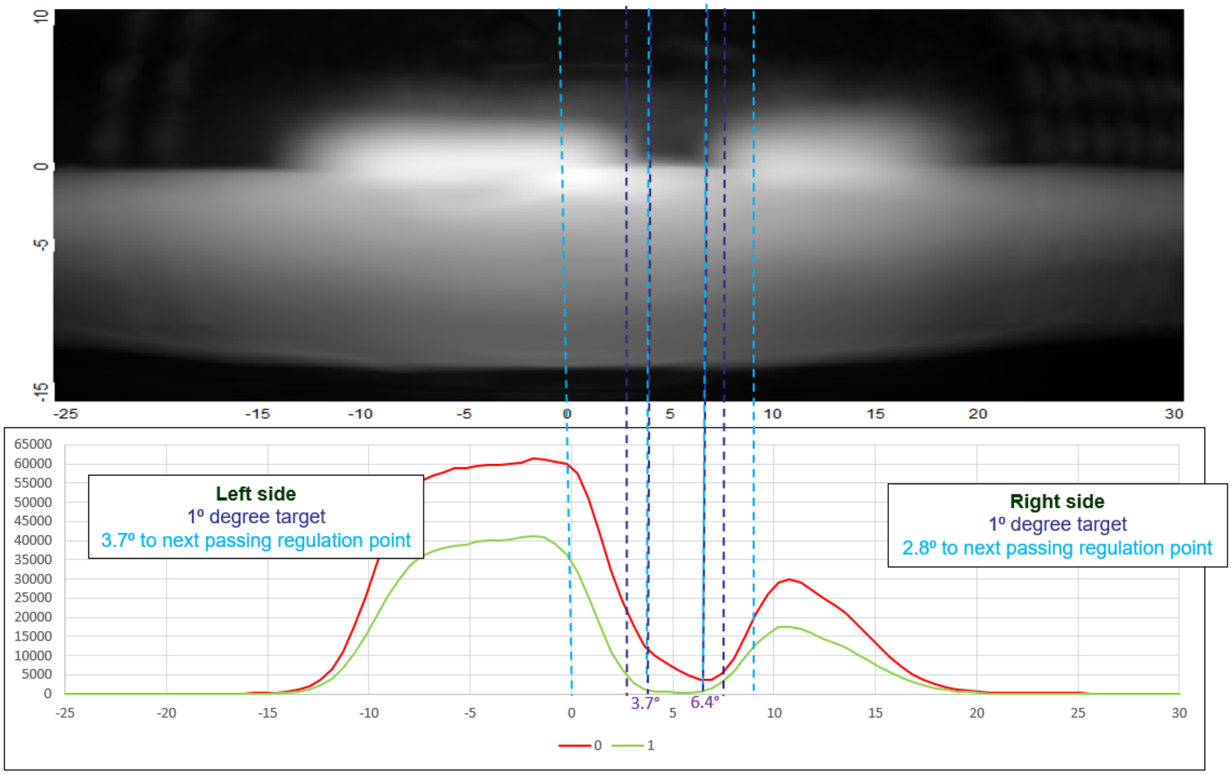
REAL-WORLD EXAMPLES OF STAGGERED OVERLAPPING ADB PATTERNS COMPARED TO UPPER BEAM REQUIREMENTS

The information in this appendix represents various ADB headlamp transition zone measurement results compared to the ADB final rule transition zone requirement. The scaling factor differs from graphic to graphic, therefore, the charts are not directly comparable to one another.

EXAMPLE A1-1



EXAMPLE A1-2



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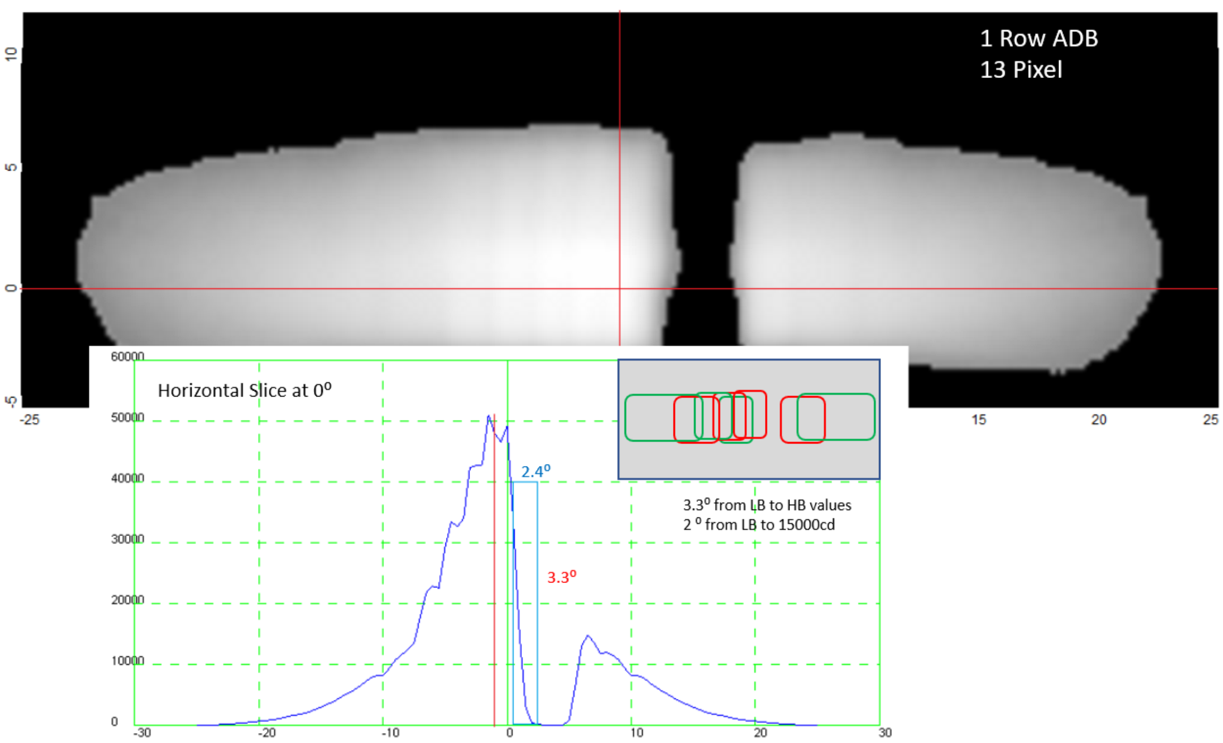
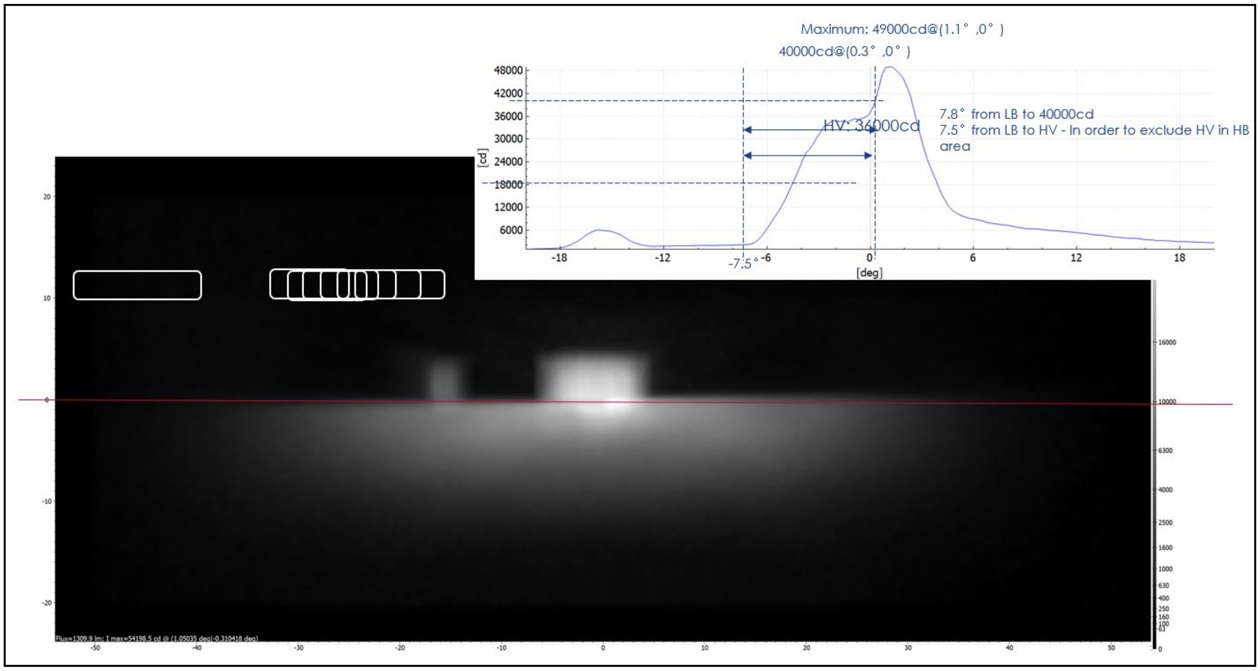
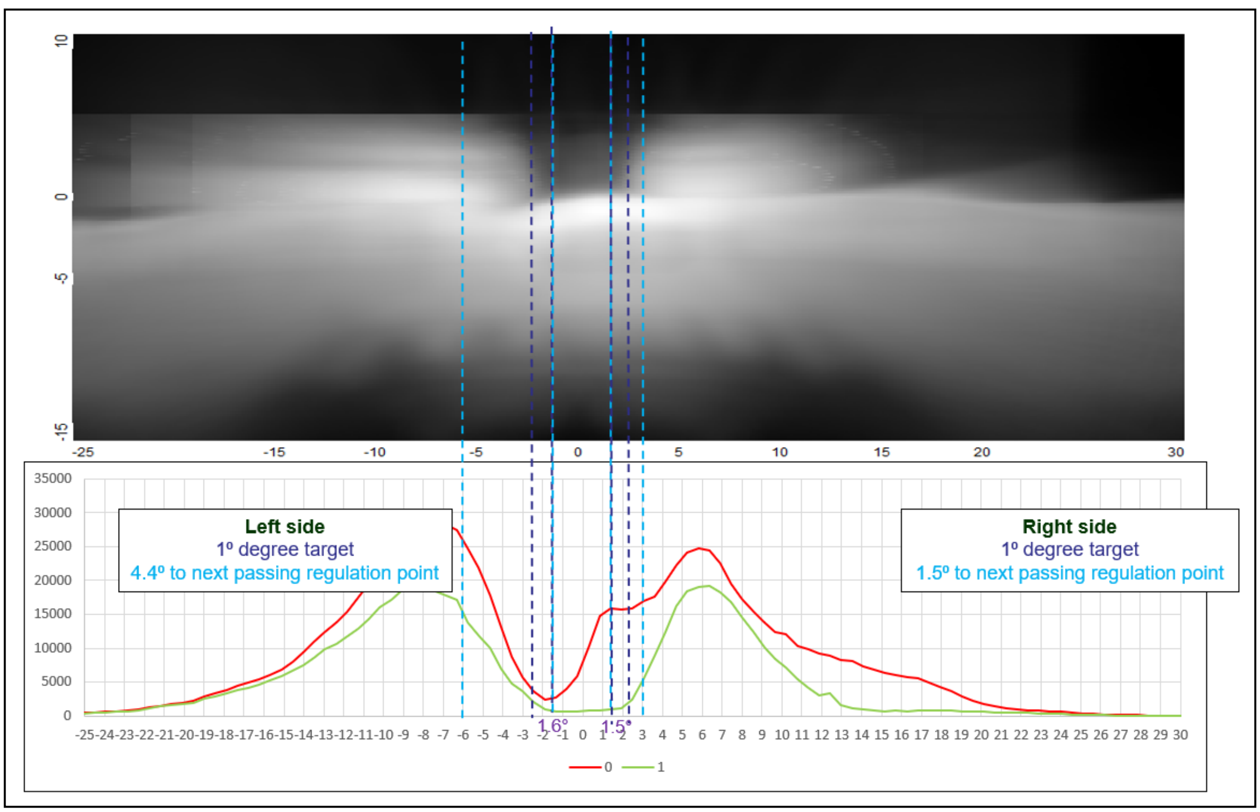


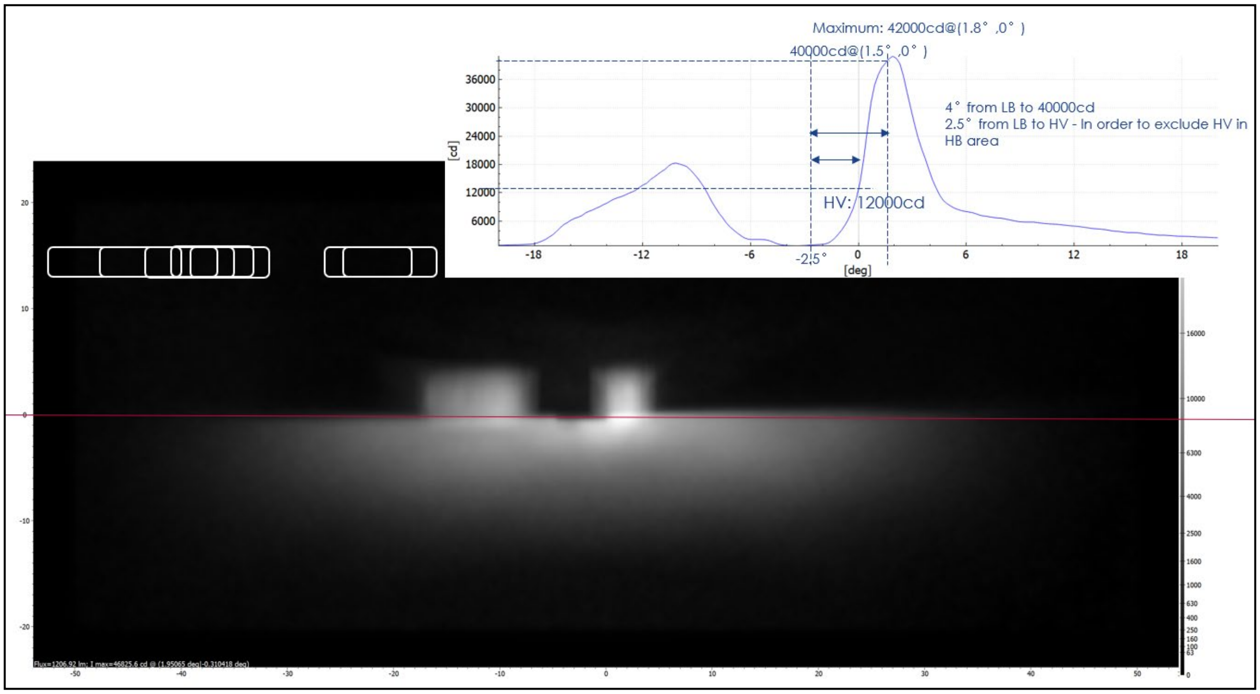
EXAMPLE A1-4



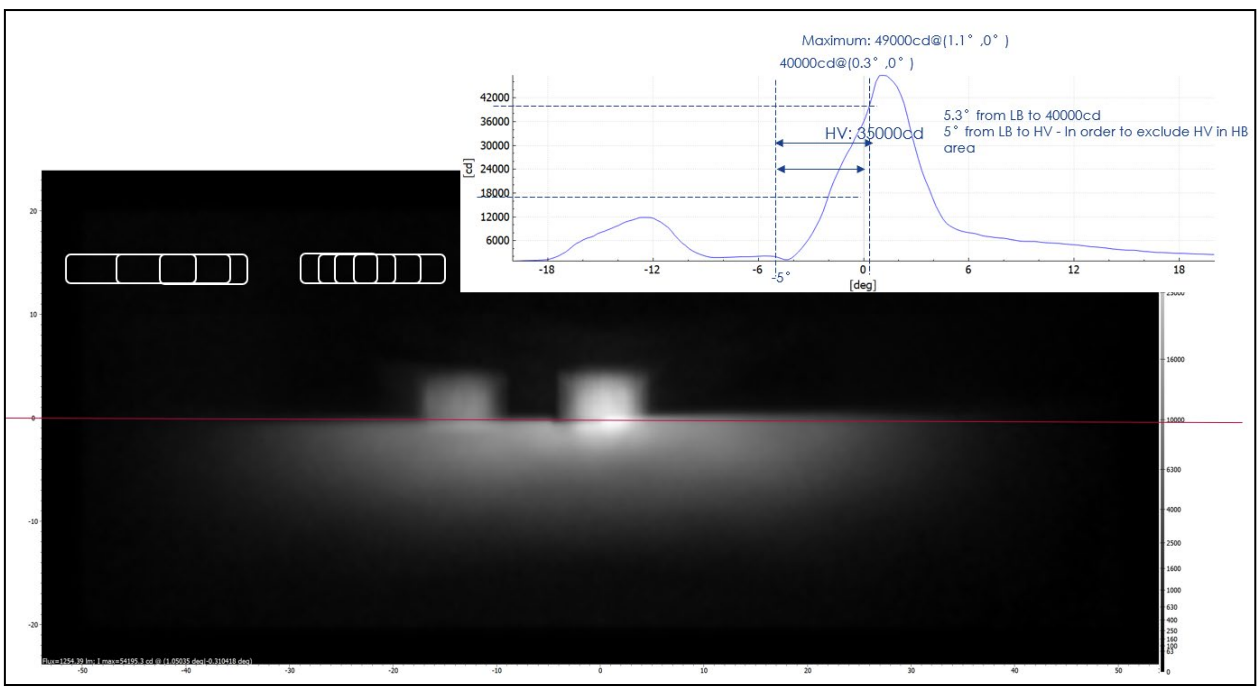
EXAMPLE A1-5



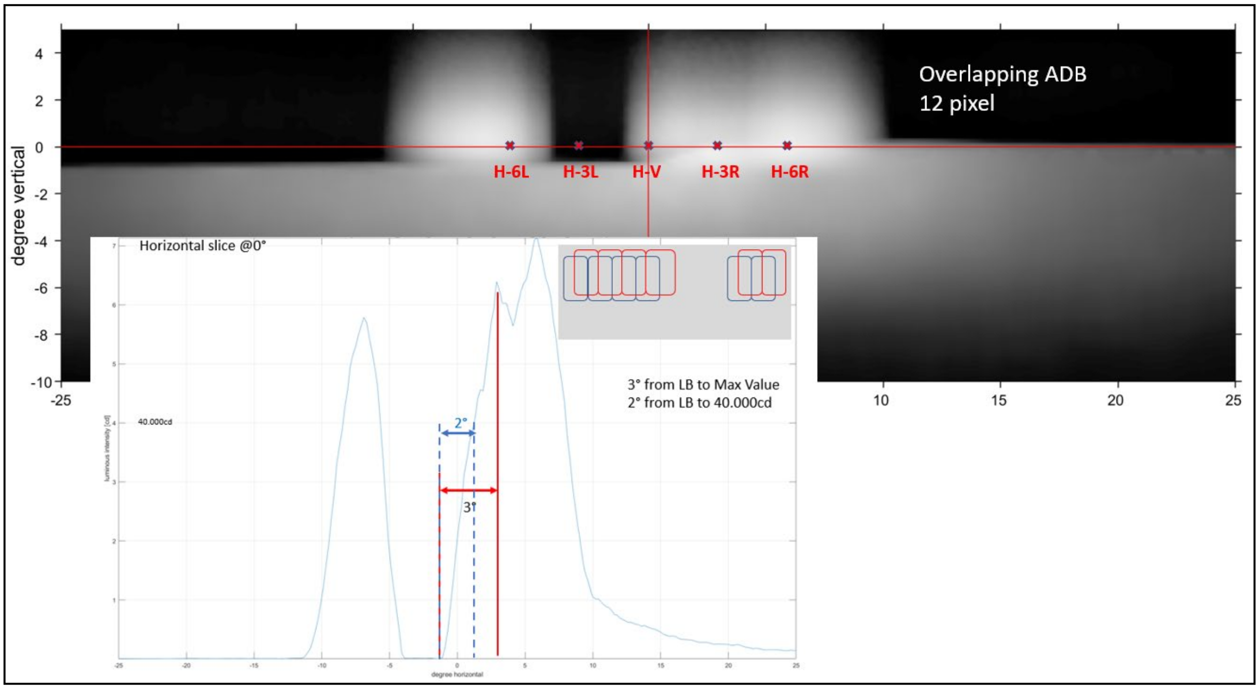
EXAMPLE A1-6



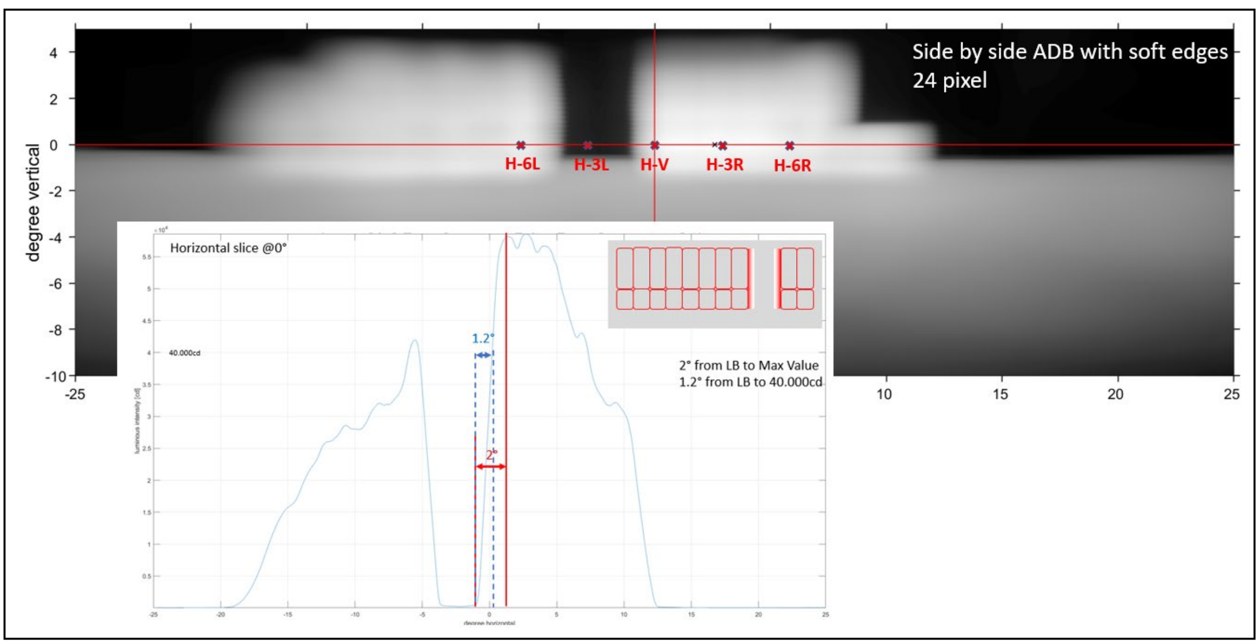
EXAMPLE A1-7



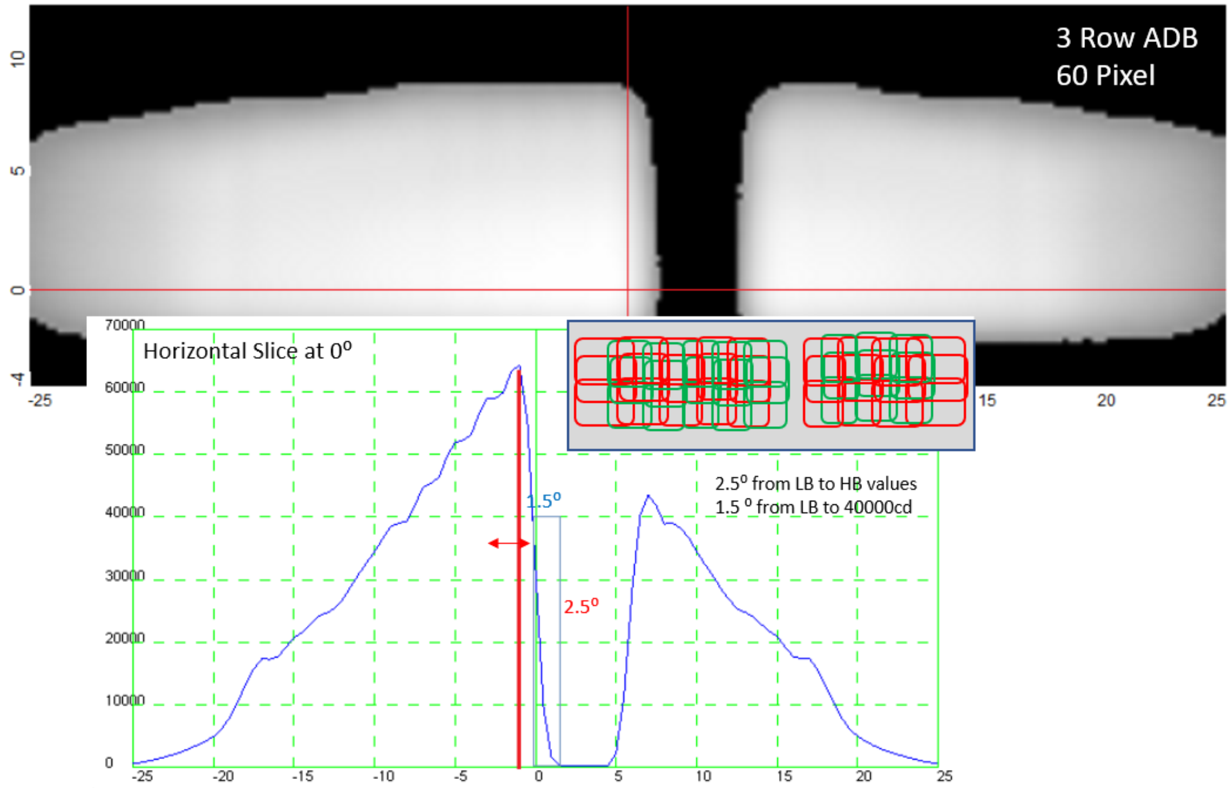
EXAMPLE A1-8



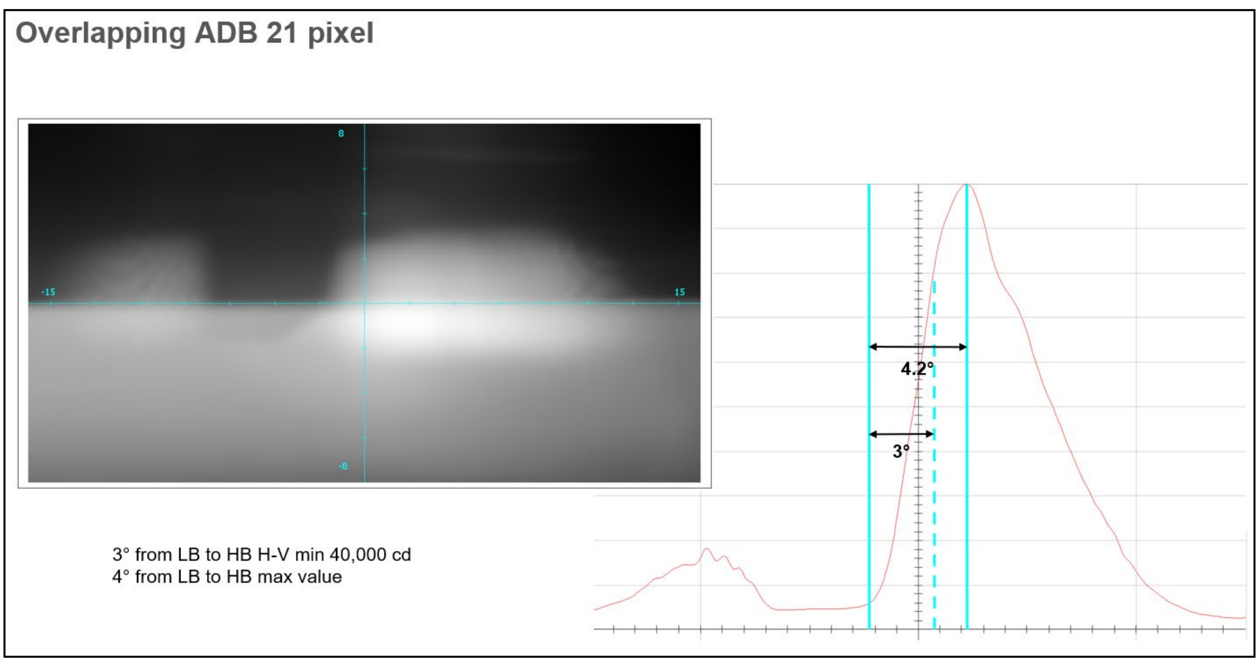
EXAMPLE A1-9



EXAMPLE A1-10



EXAMPLE A1-11



EXAMPLE A1-12