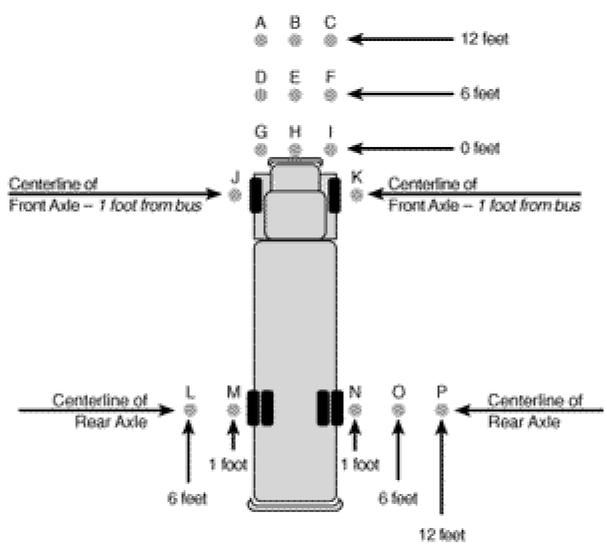
THE SCHOOL BUS

Federal Motor Vehicle Safety Standards (FMVSS) 571.111 Standard 111 provides the requirements for rear view mirror systems for "road vehicles', including the school bus in the US. The Standards are developed and enforced by the National Highway Traffic Safety Administration (NHTSA), the federal agency

> "*** responsible for reducing deaths, injuries and economic losses resulting from motor vehicle crashes. This is accomplished by setting and enforcing safety performance standards for motor vehicles and motor vehicle equipment ***" (Source NHTSA website)

The general requirement for school bus mirrors are found in Section 9 of the Standard and can best be explained using a chart prepared by NHTSA (Figure 1), which illustrates how the mirrors must be adjusted and what view must be provided.

Figure 1



FMVSS 111 – effective for school buses manufactured after December 1993

(Source NHTSA In-Service Training Manual)

The Standard specifies that the school bus will have 2 mirror systems known as

System A (Driving Mirrors) which shall be composed of a 7 x 7 inch flat glass and a second mirror (convex mirror), that together provide a view on the right side of the bus which shows the entire top of cylinder N and the ground 200 feet rearward from cylinder N. The left side pair of driving mirrors must show the top of cylinder M and the ground 200 feet rearward from cylinder M.

and

System B (Pedestrian detection Mirrors) located on the front of the bus and they must show to the operator for all cylinders A-P whose top surface is not visible from the driver's eye location a view of the entire top surface of that cylinder and a view of the ground that overlaps with the view of the ground provided by the System A mirrors.

System B mirrors that have an average rate of curvature of less than 889mm must have a label printed that states conspicuously:

USE CROSS VIEW MIRRORS TO VIEW PEDESTRIANS WHILE THE BUS IS STOPPED. DO NOT USE THESE MIRRORS TO VIEW TRAFFIC WHILE THE BUS IS MOVING. IMAGES IN SUCH MIRRORS DO NOT ACURATELY SHOW ANOTHER VEHICLE'S LOCATION.

Applying these performance standards to Figure 1 would result in a diagram that looks substantially like Figure 2 with the dark shaded area being 1 foot out from the rear wheel

Figure 2

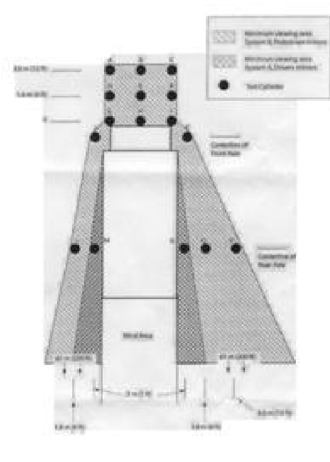


Figure 2, Minimum viewing area, School Bus System A and B Field-Of-View

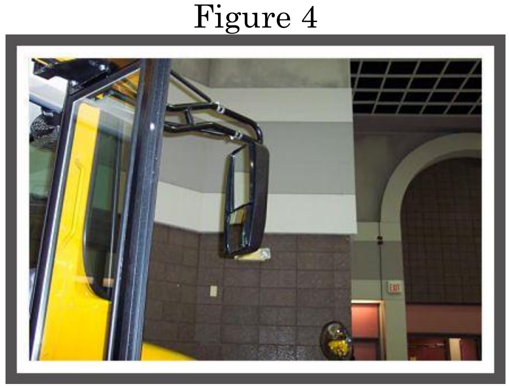
The dark shaded areas are the view of the Driving Mirrors (System A) and the light grey areas are the view of the Pedestrian Detection mirrors (System B) pursuant to the Standard.

No driver would take to the roadway with driving mirrors that only provided a view 1 foot out from the side of the vehicle (the minimum set forth in the standard) so the mirror manufacturers have provided systems of a flat glass and a convex glass that provide 12 feet out on the passenger side, measured at the center of the rear axle, and 6 feet out on the driver's side, measured at the center of the rear axle, for the driving mirrors. The System A mirrors have taken multiple forms over the years with the most common being what is referred to as the double nickel (illustrated in Figure 3) which has a 7 x 10 inch flat glass and a 7 x 10 inch convex mirror mounted on a 1 inch pole mount.

Figure 3

More recent innovations have included a case type mirror where both the flat glass and the convex glass are contained in the same case. (Figure 4 illustrates such a mirror).

Figure 4



In this type of mirror the flat glass portion is usually maintained in at least the size of 7 x 7 inches and the convex portion can be in various sizes. A major difficulty we have found with the case type mirror is that it contains 2 different mirrors designed to each do different things so neither one can achieve its maximum usage when encased is a single case.

Another variation of the case type mirror is sometimes referred to as the "elephant ear mirror" (illustrated in Figure 5) used on transit type school buses or cab over models that have no hood out front of the driver. Here it is meant to include the System A and System B mirrors all in the same case.

Figure 5

If we assume, which is what we found in actual studies, that the operator of the school bus is being provided with exterior mirrors on the passenger side of the bus that provide a view of the area 12 feet out from the center of the rear axle of the bus on the passenger side, we can examine the quality of that view as an aid to successfully operate the bus during the normal school day.
The examination should include a discussion of the view provided on both a horizontal plane level and a vertical plane level, both of which entail a discussion of the field of view provided by the mirrors. The flat glass mirror is excluded from this discussion as it is of no aid in developing a wider angle of view, so the discussion will focus on the convex mirror.

CONVEX MIRROR

From the time mirrors were first placed upon vehicles everyone recognized that it was important for the driver of the vehicle to see areas around the vehicle so driving judgments could be reached and maneuvers on the roadway could be undertaken safely based upon those judgments. By the nature of the vehicle it was obvious that aids were necessary to allow the driver to see all those areas and exterior mirrors were placed upon the vehicle to provide that aid. The mirror technology available at the time was the flat glass mirror and the convex type mirror. To try to show the operator what was necessary the flat glass provided the clearest view but in order to cover the necessary area the flat glass would have to be so large that it would not fit on the vehicle. It was decided that a flat glass, because of the clear image presented, would be used at a size that would fit on the vehicle to allow the operator to have at least a clear view when backing the vehicle and supplementary mirrors would be added to widen or enhance that view. The convex mirror was then selected as a mirror that could enhance the view. When the convex mirror was first invented it was based upon bending the mirror glass so that a wider view would be provided. Bending or curving the mirror is defined by what is called the rate of curvature or amount of the bend. A glass curved a certain amount (rate of curvature) would produce a certain view and if a wider view was desired the glass could be curved even more and we refer to this type of mirror as the single rate of curvature mirror. The problem caused by curving the mirror is that images shown to the operator will always be smaller than the actual size of the object, a natural effect caused by curving the glass. This effect is many times referred to as distortion (which is not technically correct) but it is used to state the effect developed by the mirror. Since the objects seen in the mirror are smaller than actual this interferes with the operator's ability to judge (perception) where the objects are in relation to his/her vehicle and the objects may be closer than they appear to be in the mirror. The operator is then left with making mental calculations as to where the object is and if the proposed maneuver can be successfully and safely made. In their wide angle mirrors offered today by mirror manufacturers this same technology is still used.

BLIND SPOTS

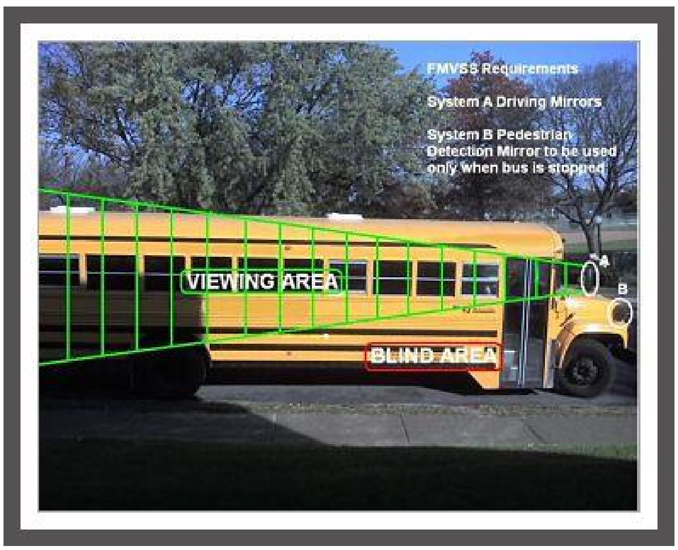
The problem with the use of the single rate of curvature convex mirror is that blind spots (areas not shown to the operator) exist, so the net effect is that operators are provided a wider field of view, that view is "distorted", and the view provided is not all inclusive. Why the view provided by the single rate of curvature mirror does not provide a complete view (leaves blind spots) involves an understanding of the technology itself. The simple fact is that the view provided by the single rate of curvature convex mirror is a cone shaped view, starting at the face of the mirror which widens as distance from the face of the mirror is introduced. On a vehicle this means that from the face of the glass towards the rear of the vehicle the view gradually increases until the mirror actually shows the ground. On the school bus this means that the view shown to the operator starts at the face of the mirror and expands to the rear of the bus to ultimately show the top of the cylinder N as required by the FMVSS Standard.

EXAMINATION OF BLIND SPOTS LEFT BY THE SINGLE RATE OF CURVATURE CONVEX MIRROR

VERTICAL PLANE BLIND SPOT

The cone of view provided by the single rate of curvature convex mirror can be illustrated by the operator sitting in the seat and marking the position where the ground can first be seen. The results are shown by the lines marked on the attached photo (Figure 6).

Figure 6



As illustrated, the vertical plane blind spot starts at the location of the mirror on the bus and decreases towards the rear of the bus and ultimately opens wide enough to show the ground somewhere behind the bus. The mirror is located on the bus 7 feet from the ground and unless the operator turns to look into this area or uses the passenger detection mirrors (not allowed by the FMVSS Standards while the bus is moving) any person or object under 7 feet in height cannot be seen by the operator while the bus is moving in traffic. In 1992 NHTSA was directed to remove this blind spot by requiring that mirrors on the bus to actually show the ground area at the location of the mirrors on the bus and they developed a rule requiring this to be done by the manufacturers. All tried using the single rate of curvature convex mirror and found that to accomplish this feat required a convex mirror of

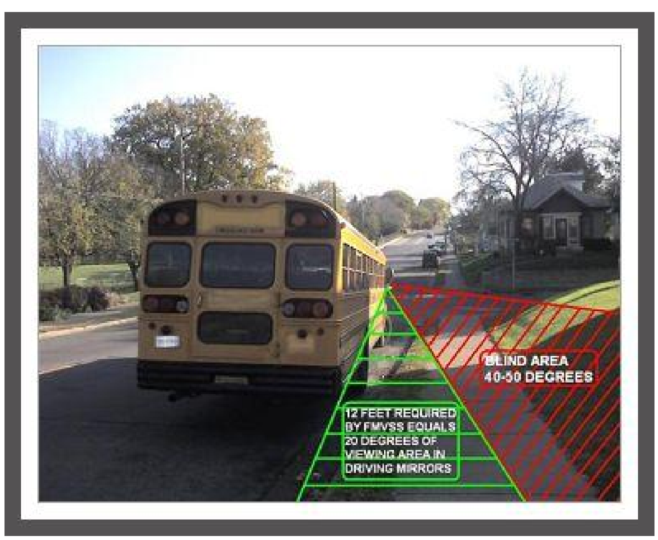
such a severe bend in the glass (rate of curvature) that the images produced were so distorted as to be unusable by the operators and they would not drive the bus with these mirrors.
NHTSA did not solve the problem, they simply changed the rule to require only that the mirrors showed the top of cylinder N leaving the blind spot in place, stating;

> “The intention was to modify the standard’s existing requirements such that school bus manufacturers would no longer have to install either an additional convex mirror, which creates a larger blind spot for the driver, or replace the existing convex mirror with a highly curved convex mirror that produces more distorted images.” (Source Volume 69 Federal Register page 18497)

HORIZONTAL PLANE BLIND SPOT

On the horizontal plane the cone theory provides a view that starts at the face of the mirror which expands (as presently allowed) to show the top of a cylinder 12 feet out from the center of the rear axle of the bus. This is approximately 20 degrees of view along the side of the bus provided by the driving mirrors, and leaves an area along the side of the bus of approximately 40 to 50 degrees factoring in the drivers peripheral view as hindered by the door construction not shown to the operator which can be illustrated by the lines placed on the attached photo Figure 7.

Figure 7



It is submitted that this horizontal plane blind spot requires the operator to turn and look into this area to safely make a lane change or turning maneuver and while doing so is required to take the eyes off the road ahead and possible upcoming obstacles. This blind spot also cannot be corrected except by bending the glass further making the distortion factor a greater problem.

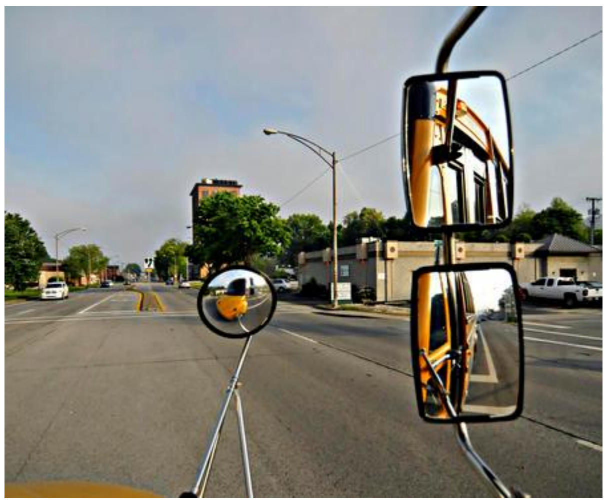
LOCATION OF THE MIRRORS ON THE BUS

At M-C North America we have always maintained that the mirror located on the school bus should be at a 45 degree angle from the driver and located to the front of the windshield so they can be seen by a simple glance of the eyes to that area while maintaining the main eye contact to the front of the bus to watch for upcoming traffic. The following photo shows the operator viewing the mirrors that are presently placed by manufacturers. Figure 8

During this procedure the operator is not viewing the area upcoming and the potential for an accident is greatly enhanced. Further placing the mirrors in front of the driver can reduce the problem of mirror clipping which is becoming more of a problem as operators stick the mirrors out further on the side of the bus to increase the field of view for the operator.

The operator is left with an array of mirrors to look at when operating the bus which can look like the attached photo Figure 9. Picture not taken from operator's seat but is illustrative of the confusing situation.

Figure 9



INTERIOR MIRRORS

In contemporary society it is becoming more and more important that the operator have a clear view of the interior seats of the bus and the area surrounding the operator and door area. The present approach of a 6 inch by 30 inch flat glass mirror (on the larger buses) as the acceptable solution for interior mirrors does not provide the necessary view. In Figure 10 we see the view provided with such a mirror.

Figure 10

The door area and the area surrounding the operator are not visible in the mirror. Here again the location of the mirror should be in the upper left hand corner of the cab area and include a wide angle mirror that shows images with clarity should be used so that it can be positioned to see the door area, the area surrounding the operator's seat and present images that are clear.

NEW TECHNOLOGY

M-C Mirror Technology (US Patent No.8,1723,411) provides a solution to all of the above problems. M-C Mirror Technology uses multiple rates of curvature in the creation of the overall rate of curvature of the mirror. This allows us to provide a wider view while maintaining clarity in the objects viewed. We are also able, using this technology, to fuse different rates of curvature into the same mirror meaning that a greater rate of curvature can be placed on the bottom portion of the mirror than is contained in the top part of the mirror which can allow us to produce a mirror that can be placed on the outside of the bus that shows the ground area closer to the location of the mirror on the bus thus eliminating the vertical plane blind spot and on the side of the mirror facing out to eliminate the horizontal plane blind spot.

If you are ready to discuss how our technology can increase the safety of your school bus fleet contact us for more information. Our goal is to produce solutions and we dislike an operator being placed in the position of " I did not see ***" after an accident has occurred.

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