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Earthmoving Equipment - An Operator's Field of View (S.A.E. Standard J1091)

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Purpose of Standard

S.A.E. J1091 states that the "Purpose of this document is to establish a test method to determine the maskings that are caused by various parts of the machine on a visibility circle around the machine..." for the operator.

Test Method and Evaluation Zones

A series of well defined lights and mounting hardware ("Light Source"[1]) is positioned at a location in the operator's seat relative to the "Seat Index Point." The light radiating from these lights effectively simulate the lines-of-sight for the average, or fifty percentile, operator.

[1] Terms that are capitalized and in quote marks (e.g. "Light Source") have specific meanings within the text of the standard.

The lights are positioned on a horizontal bar that is allowed for some tests to rotate fifteen degrees, as a person's head may rotate, and for some tests are spread outward on the bar to simulate some left and right head movement. This rotational and lateral movement effectively simulates a restricted range of head movement of an operator sitting in the operator's seat. Actual head movement could be substantially greater and in different directions than that simulated by this standard.

Visibility, or blockages to visibility ("Masking"), is determined by establishing a 12 meter diameter "Visibility Test Circle" around the equipment (using the "Seat Index Point" as its center) and determining if the light from the "Light Source" impinges on this test circle. Determination of whether or not the light impinges on the test circle can be visually verified by observing shadows generated by the lights and equipment obstructions if the test is conducted in a darkened location. An alternative method, when performed in a lighted area, is to use a mirror positioned at ground level positioned in the direction of the light source. An observer looks into the mirror and the point where the light source just becomes hidden determines masking outlines. The result of either test is a 12 meter diameter circle with various sections noted as non-visible or "Masked" and other portions noted as visible.

The "Visibility Circle" is divided into six (6) pie-shaped sections for evaluation of the resulting visibility masking. The forward pie-shaped piece is called the "Sector of Vision," and could be described as a component of forward visibility with a left-to-right width of 9.5 meters. This could be

considered the width of a path that the equipment might traverse if it were to move directly forward.

A comparable rearward visibility pie-shaped section is called the "Visual Field," and is an approximately 90 degree segment that traverses a potential rearward path of travel. There are two other forward and to the sides visibility segments that are called the "Field of Vision" and two rearward and to the sides visibility segments called the "Field of View." See Figure 1 for examples of the "Visibility Test Circle" for a dumper and a roller.

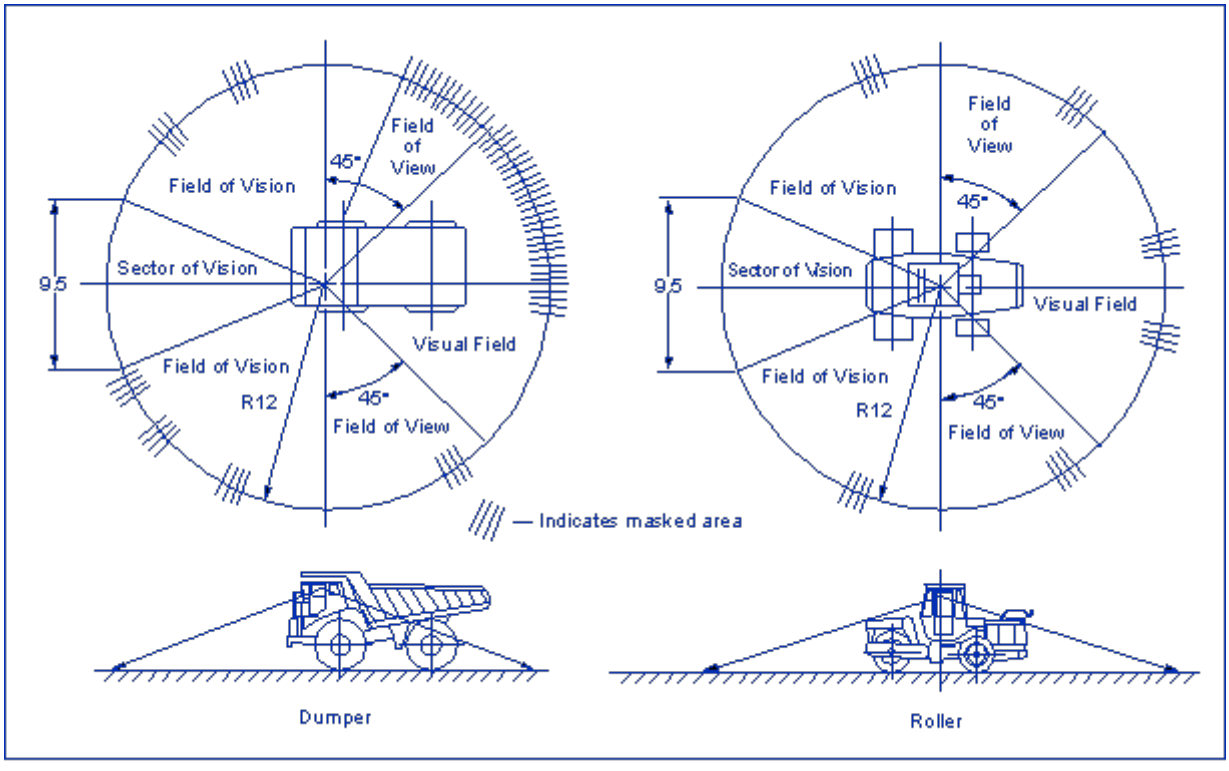

Figure 1

Based on these general light source masking or non-masking conditions on these six pie-shaped segments, a particular piece of equipment is rated as "Category I, II, or III," with the lower number representing fewer masking blockages.

Discussion

It is important to have a standard and repeatable test methodology to evaluate the potential visibility available to an operator in earthmoving or other equipment. Although this method was written around specific categories of equipment, it could be used for other machines to grade or rate the masking effects. Such a test allows comparison among pieces of equipment, and assists in determining the effect of design changes and the addition of ancillary equipment on general visibility in terms of masking.

The test procedures have certain assumptions and constraints that limit its use in evaluating the actual visibility afforded an operator. For example, the range of motion of an operator's eyes can be much greater than that provided by this test method, and hence better views may be achieved by increased head and eye movement. Certainly, the need for repetitive and excessive head movement could be

problematic, but head and eye movement beyond the limits of this test often occur.

For a piece of equipment that is moving forward, objects approach and will pass through potentially masked areas on the 12 meter evaluation circle. This approach and subsequent masking would not necessarily result in the operator not knowing of the presence of the object in the equipment's path. This approach view during forward movement means that ratings of forward masking, in the context of this test, is biased based on a stationary evaluation.

On some pieces of equipment, it is critical to see certain roadway or pathway landmarks. For example, the view of the left-side road edge can be critical for large haulage vehicles during travel on haulage roads. This test procedure does not address that left-side visibility need in the evaluation.

The use of various visibility aids are not really addressed by this standard. While the body of an outside rear view mirror itself might result in a masking condition based on this test, the added visual access to the rear provided by such a mirror may result in an overall improvement in operator visibility. This test method may result in a poorer rated category by the presence of certain size and location mirrors.

The U. S. Bureau of Mines developed and tested blind area viewers and video camera devices for the larger earthmovers often found at mine sites as a means to provide improved forward and rearward views. These devices had limited utility under maneuvering and travel conditions, and were deemed most useful for start-up conditions. Again, when tested under this S.A.E procedure, their utility may be questionable.

This S.A.E. test evaluation has a variety of assumptions in assigning categories I, II, and III to a product's test results. Higher rated categories are generally considered to have more masking, and that is assumed to be inferior to designs with lower category ratings. Blockages, or masking, may interfere with the complete view of several adjacent areas on the 12 meter circle; but if the visibility need is to see a structure like a long curb (as might be important for a grader), then seeing several intermittent sections of that curb may be sufficient to judge the distance to the smaller masked portions of the curb. Blockages on the visibility circle of the base of a streetlight pole may have little importance if the upper portion of the pole is visible. And sideways visibility into the pie-shaped "Field of Vision" and "Field of View" segments of the test circle may have no meaning for maneuvering large vehicles which do not have tight turning radius and cannot directly maneuver into those areas.

Most earthmoving equipment maneuver at relatively low speeds, with a wide turning radius. Their power and suspension systems often provide operators with little tactile feedback about contact with many objects they may potentially encounter while operating. Operators are not only responsible for the equipment's movement, but often are involved with equipment work tasks like grading, material movement, and compaction. These unique parameters mean that the general public's appreciation of the normal visibility needs for over-the-road trucks and cars do not necessarily apply to this category of equipment.

Closing Comments

What an operator of earthmoving equipment can see and needs to see can be of critical importance and may be evaluated by using this test method and variations of this test method. The procedures and results of this method are very useful if properly used and interpreted. Light bars used to simulate

lines-of-sight, the resulting light and dark shadow profiles, and the lights detection by hand-held mirrors are useful tools in evaluating visibility from an operator's station. Being able to rate maskings, especially when specific tools are added onto base equipment configurations is important for both comparison purposes and to evaluate visibility effects.

Due to the unique operations and user environments of earthmoving equipment, equipment operators and those involved in these evaluations must realize the limitations and utility of results of this test method.

Dr. Gary M. Hutter, P.E., joined the S.A.E. Human Factors subcommittee #3 responsible for this standard in 1984, and has been a past chairman of that subcommittee and contributor to that standard. Dr. Hutter is President of Meridian Engineering and Technology, Inc., Glenview, IL. Dr. Hutter also is a faculty member at the Illinois Institute of Technology, Chicago, IL where he teaches graduate classes in industrial health and safety, and OSHA compliance.