Evaluation of the Federal Vision Standard for Commercial Motor Vehicle Operators

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A reassessment was made of the adequacy of the current federal interstate vision standards for commercial motor vehicle operators. The technical approach included a critical review of existing literature, development of draft recommendations, delphi-approach surveys, a workshop to review draft recommendations with expert truck industry and vision panelists, and a report with final recommendations. No compelling evidence was found in the research literature on the vision performance of passenger and commercial drivers to warrant substantial change to the current standard. However, a number of problems in the current standard were identified during the literature review and at the workshop. The requirements for distant visual acuity remain at least 20/40 in each eye without corrective lenses or visual acuity separately corrected to 20/40 or better with corrective lenses and distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses. The requirement for field of vision was revised to at least 120 degrees in each eye measured separately in the horizontal meridian. The standard also now states that a driver should have the ability to respond safely and effectively to the color of traffic signals and devices showing standard red, green, and amber, although no test for color vision is required. The instructions to perform and record the visual examination were extensively revised as were the identification of the type of equipment, specification of stimuli needed to conduct testing, and instructions on how to perform tests. In addition, revisions were made to the list of visual disorders and impairments to be noted on the exam form.

There is widespread agreement that vision plays an essential role in the driving task. However, the level of vision that is necessary for safe driving continues to be a contentious issue. The reason for this is the continuing unavailability of definitive empirical evidence upon which to base a clearly defensible visual performance standard. The purpose of setting vision standards for drivers of commercial motor vehicles (CMVs) is to identify individuals who will represent an unreasonable and avoidable safety risk if allowed to drive CMVs. The research objective in support of a vision standard has been to identify the level of seeing, based on empirical evidence in place of a consensus, that has to be met so that CMV drivers will not be a safety risk to themselves or to the motoring public.

Driving safety is maintained through a constant stream of small decisions and less frequent larger decisions that require a high rate of accurate visual information about the driving environment. The level of vision required to support success in the decision-making process and driving safety depends on the level of complexity of the projected driving task (i.e., high-speed, wide-open highway compared with congested urban or suburban roadway environments). It also depends on the consequence of encountering an error, or series of errors, in the decision stream that will lead to a catastrophic outcome for the driver and others in the driving environment. For drivers of CMVs, the consequence of error is likely to be much greater in terms of loss of life and property than the result of a similar error made by the driver of a private motor vehicle. This fact is supported by the statistics accumulated from 1979 to 1986 on the disproportionately high rate of heavy-vehicle involvement in fatal crashes. For all types of accidents (adjusted for exposure mileage), combination trucks (tractor-trailer combinations) have slightly less than 50 percent of the accident involvement rate of passenger cars but have a fatality involvement rate that is nearly twice that of passenger cars (*1*). In fact, in 1990, 4,061 people died in tractor-trailer crashes. However, only 12 percent were truck occupants; the majority of these fatalities were passenger vehicle occupants (*2*).

Driving errors that might not produce a crash in a smaller motor vehicle may well lead to a crash in a heavy vehicle because of its more limited maneuverability. The appreciation of this fact motivates the effort to define visual standards for driving that are most likely to lead to safer driving. In addition, the apparently greater difficulty of the CMV driver's vehicle control task and the obviously greater adverse consequences of heavy-vehicle crashes lead to the presumption that the visual requirements for the driver of a CMV should be more stringent than those thought to be appropriate for smaller vehicles. This view is reflected in the existing federal interstate vision standard for CMV operators.

The current need to reassess the bases for the federal vision standard for CMV operators was motivated by a number of factors, including inaccuracies in the current standard, claims that current standards unfairly discriminate against some drivers, and emerging trends in vision assessment technology and vision-driver performance evaluation methods. The initiative for this research was set by the Federal Highway Administration's Office of Motor Carriers.

The technical objectives for the reassessment of the federal vision standard for CMV operators were

- Critical review and evaluation of the current federal vision standard (*3*) scientific information and data sources pertaining to driver vision testing requirements for operating CMVs that weigh more than 10,000 lb,
- Development of preliminary recommendations for revising vision test and testing requirements and testing procedures,

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- Conducting a delphi-approach opinion survey with vision and industry experts to assess the most important visual functions for critical CMV driving tasks,
- Conducting a workshop to review draft recommendations with panelists representing industry and the visual science community, and
- Summarizing project findings, including final recommendations for the vision test requirements and testing procedures.

LITERATURE REVIEW

The literature review covered a comprehensive analysis of the history of the standard, published research, and selected unpublished project data on the relationship between driving and vision performance, identification of state and international standards, and published recommendations from the medical community.

History of Standard

The federal government began regulating vision standards for motor carriers in interstate commerce during the late 1930s. At that time, the standard was based on a consensus of experts in the fields of vision and driver safety. The vision standard has been changed steadily in the direction of requiring more stringent visual capability (Table 1). The standard (*3*) as currently stated calls for "distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses, field of vision of at least 70 degrees in the horizontal meridian in each eye, and the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber." Along with the lack of an empirical base for the visual measures used for the standard, there were problems with major inaccuracies of the visual field requirement. The current standard states that a 70-degree field of view is the minimum requirement for each eye. This is obviously erroneous since the field of view in a normal healthy adult is closer to 140 degrees for each eye. In addition, problems were found with the color vision requirement, which on a practical basis is probably unenforceable. The color requirement as now stated would not exclude red-green color-defective drivers since the standard does not provide adequate instruction on requirements for color vision testing. It is also doubtful that the standard intended to exclude typical red-green color-defective drivers since these drivers are currently on the road and there is a lack of evidence that their driver safety record is worse than the record of those without such color vision defect. In addition, one of the major problems with the standard is the lack of an adequate description of the specificity of testing stimuli, lighting conditions, equipment, or uniformity of testing procedures. The standard also does not provide any direction on uniformity of testing procedures.

Empirical Evidence: Driving and Vision Performance

A comprehensive literature review was undertaken to identify research that reported measurements of the relationship between many aspects of visual performance and accessible indicators of driving safety. The studies identified were primarily *post hoc* analyses of data already accumulated through routine driver registration testing and record keeping. However, some studies introduced into the driver testing routine novel controlled vision testing methods designed to obtain data on a broad scale that could then be correlated with the driving record over time. The literature search found numerous research projects that examined the relationship between vision test results for operators of motor vehicles and their driving performance record (i.e., accidents and violations), dating back to the mid-1950s. Most of these studies were initiated to determine what visual skills best correlate with driving performance. The results were used to recommend to state licensing agencies the most practical vision tests to administer to license applicants and renewals. Many of the studies focused on vision tests that were easily accessible through commercial vision screening devices. However, some of the

TABLE 1 History of the Visual Standard for CMV Operators

	Visual Acuity			Visual Fields		Color Vision			
Year	One Eye	Other Eye	Binocular	All Meridians	Horizontal Meridians	Red, Green	Yellow	Amber	Other Notes
1937 (*4*)	"Good eyesight in both eyes (either without glasses or by correction with glasses) including adequate perception of red and green colors"								
1939 (*5*)	20/40	20/100	--	45 degrees	--	Yes	Yes	--	--
1944 (*6*)	20/40	20/100	--	45 degrees	--	Yes	Yes	--	--
1964 (*7*)	20/40	20/40	--	--	140 degrees (Binocular)	Yes	Yes	--	Drivers requiring correction by glasses are required to wear them while driving.
1970 (*8*)	20/40	20/40	20/40	--	70 degrees (each eye)	Yes	---	Yes	
1985 (*3*)	20/40	20/40	20/40	--	70 degrees (each eye)	Yes	---	Yes	If driver wears contacts, evidence to indicate good tolerance.

studies involved developing customized vision testing apparatus, and some used clinical testing equipment known to be impractical for mass vision screening in a licensing bureau environment. Most of the research identified and reviewed focused on the passenger vehicle operator and only a few studies investigated the visual and driving performance of the CMV operator.

Passenger Vehicle Operators

One of the earliest, most comprehensive studies on the relationship between vision and the driving performance record was conducted by Burg (*9–12*) on more than 17,500 drivers over a 3-year period in the 1960s. Driving habits (annual mileage reported), age, and gender were reported in addition to information on their vision test performance for dynamic visual acuity, static visual acuity, lateral visual field, low-light recognition thresholds, glare recovery, and sighting dominance. Of the vision tests analyzed in relation to traffic convictions and accidents (reported), very weak statistically significant correlations were found between vision and the driving performance record. Like other researchers from the 1960s (*13,14*), Burg reported that mileage and age were the most powerful predictors of traffic accidents and convictions. Further analysis of the Burg data by Hills and Burg in 1977 (*15*) revealed a small but significant correlation between static and dynamic visual tests and glare recovery tests and accident rates for drivers over age 54.

In the early 1970s, the U.S. Department of Transportation (DOT) was interested in the results of the Burg studies. DOT initiated a series of investigations designed to develop a battery of vision tests that were more functionally related to driver performance and safety and that could lead to the development of a vision testing device for use in screening driver's license applicants or renewals. In this study, Henderson and Burg (*16*), after reviewing prior literature and analyzing earlier data, provided a systematic analysis of the visual requirements for driving. The initial phase of the study identified important visual functions: static visual acuity (normal illumination), central angular movement, central movement-in-depth, useful peripheral vision, static acuity (low-level illumination), field of view, eye movement and fixation, dynamic visual acuity, accommodation faculty, and glare sensitivity. These visual functions were incorporated into a prototype vision testing device (the MARK I Vision Tester). Over 600 license renewal operators were screened on the device. Accident statistics were collected for the preceding 3 years for each operator. Results showed a moderate, consistent, age-related decline for all the visual functions. Significant age-related loss in visual ability was reported for static acuity under normal and low illumination, glare, and dynamic acuity. However, the correlational analyses conducted to assess the potential predictive validity of the MARK I showed many significant correlations in the direction of poor visual performance statistically related to a good driving record.

DOT, encouraged by some of the results of the MARK I study, decided to continue this research in an effort to establish a generally valid vision screening device for motor vehicle department use. Further testing by Shinar (*17–19*) on 890 licensed operators revealed very low correlations between accident rate measures and visual performance. In fact, no significant correlation existed between vision and driving records for the 25 to 54 age group. Additional testing indicated that poor dynamic and static visual acuity under low levels of illumination was most consistently related to accidents; poor static acuity under low levels of illumination was related to nighttime accidents. There was also a relationship between central angular movement and accident involvement. In addition, none of the single vision tests was significantly associated with accident involvement for all age groups, but each test was significantly associated with accident involvement for one or more of the age groups. Results for the battery of vision tests and the driving statistics did not establish a clear-cut relationship between specific visual tests and the driving record.

Another important effort conducted around the same period by Hofstetter (*20*) correlated the visual acuity test scores of 13,700 drivers with self-reported accidents during the previous 12-month period. Data were collected nationally over a period of 10 years by means of a survey form given out in a variety of settings and populations, with support from the Auxiliary to the American Optometric Association, using commercial vision screeners. Accident rates for persons with acuity in the lower quartile of the measurements were compared with rates for persons with acuity above the median measurement. Drivers in the lower visual acuity group were found to be twice as likely to have had three accidents in the previous year as those with acuity above the median, and 50 percent were more likely to have had two accidents. No significant differences were found between the lower-acuity and higher-acuity drivers when only one accident was used as the criterion of comparison. This study provided some evidence for the connection between poor visual acuity and increased accident frequency. However, these results applied only to the very poor visual performers compared with the best in the driver cohort.

Studies on visual fields and glare were also conducted in the 1970s. Council and Allen (*21*) compared horizontal visual field measurements with accident rates for more than 52,000 drivers and found that only 1 percent of the drivers recorded a horizontal field of 120 degrees or less and that the accident rate for these drivers was no higher than the rate for those whose fields were greater than 120 degrees. Studies on glare sensitivity incorporated into other vision testing using the MARK I and MARK II (*17*) devices were also unable to show any significant relationship. Wolbarsht (*22*) conducted a study of glare sensitivity using a modified commercial vision screener with a customized overlying glare source of controllable intensity. He tested 1,500 driver's license applicants and renewals for glare sensitivity at three veiling glare ratios (background:target) of 2:1 (high glare), 4:1 (medium glare), and 8:1 (low glare). The results showed no significant correlation between glare sources and driving performance, although the average glare sensitivity scores did increase with age.

Research on assessing visual and driving performance continued in the 1980s. Keltner and Johnson (*23*) used automated static perimetry to screen more than 500 drivers for any evidence of visual field loss in 1980. With this technique it was found that approximately 5 percent of the motorists had significant visual field loss compared with only 1 percent found

to have a noticeable deficit in the study by Council and Allen (*21*), who tested only in the horizontal meridian. In addition, Keltner and Johnson reported that subjects over age 65 had four to five times the incidence of visual field deficits of younger persons. For the Keltner and Johnson study, field loss was defined as substantial depression of all or part of the peripheral visual field or an inability to detect two or more adjacent visual field points (scotoma), or both. This project was extended (*24*) to compare the visual field loss of 10,000 volunteer drivers with accident and conviction histories. For this larger study, it was found that drivers with visual field loss in both eyes had accident and conviction rates that were twice as high as those for drivers with normal visual fields. The results were statistically significant. It was suggested that decreased performance on a visual field test probably results from age-related decreases in retinal illumination and other acquired vision impairments (such as glaucoma, degenerative myopia, diabetic retinopathy, and retinal detachment) that are more common in older age groups.

Another study, conducted by Davison (*25*) in 1985, examined 1,000 motorists who were randomly stopped in and around a town in England and asked to volunteer for a vision test and provide information on driving record, vision examination history, and other demographic information. Significant positive associations were found between accidents and right-eye or left-eye visual acuity and binocular acuity for all drivers, and a relationship was found between accidents and heterophoria for drivers who were over 55. Decina et al. (*26*) recently completed a study for the Pennsylvania Department of Transportation to determine the value and feasibility of periodic vision screening during license renewal. The study examined the relationship of three vision measures (static visual acuity, horizontal visual fields, and contrast sensitivity) to accident and violation records for over 12,400 licensed operators, who were unaware that they would be tested. It was found that drivers who failed the Pennsylvania Department of Transportation visual standard or scored below "normal" on the contrast sensitivity test were at a significantly higher risk for accidents in only the two oldest age groups (66 to 76 and 76+). However, the researchers found no significant relationship between poor vision performance on each of the vision tests analyzed separately with accident and violation records.

For the most part, significant statistical relationships between specific vision test scores and driver performance records (for passenger vehicles) were not clearly established in the literature. Many researchers found it difficult to relate driving performance to visual capabilities; some of the more important difficulties were as follows:

- Vision is only one of many factors influencing driving performance,
- Some vision tests may not relate closely to visual requirements of driving,
- Reliability of criteria used to measure driving performance may be low,
- Samples of the driving population may be unrepresentative, and
- Individuals with visual difficulties often place self-imposed limits on their driving, reducing their exposure to the risk of an accident and biasing statistical sampling.

CMV Operators

In 1973, Henderson and Burg attempted to relate CMV driving skills to the visual tests included in the MARK I Vision Tester (*16*). Their goal was to establish a sound scientific basis for minimum visual standards for the Office of Motor Carriers. The relative importance of different aspects of the driving task was established by examining literature, interviewing truck drivers, observing truck drivers in action, and conducting a systematic examination of the driving task. The researchers established a hierarchy of importance for the visual functions selected as most important. Weights were assigned to various driving behaviors and to each visual function according to its judged importance to driving behavior. Those visual functions judged to be most important to the truck driving task and necessary to an analysis comparing visual performance and accidents and violations were static visual acuity; dynamic visual acuity; perception of angular movement; perception of movement-in-depth, visual field, movement-in-depth and steady, saccadic, and pursuit fixations; glare sensitivity; and angular movement. Significant relationships between accidents and poor visual performance were found only with measures of perception of movement and dynamic visual acuity. No correlation was found between static visual acuity or field of view and accident frequency for commercial drivers.

In a more recent attempt to correlate visual performance with accident record, Rogers et al. in 1987 (*27*) compared the driving records of visually impaired heavy-vehicle operators with the records of a sample of visually nonimpaired heavy-vehicle drivers. The purpose of the project was to determine whether the federal vision standard could be justified on the basis of the traffic safety record of these drivers. The records of more than 16,000 heavy-vehicle operators registered by the California Department of Motor Vehicles were examined. Measures of driving performance consisted of 2-year total accidents and convictions associated with incidents involving commercially registered vehicles. Visually impaired operators were categorized into two subgroups of substandard static acuity: (*a*) moderately visually impaired (corrected acuity between 20/40 and 20/200 in the worse eye and 20/40 or better in the other), and (*b*) severely visually impaired (corrected acuity worse than 20/200 Snellen in the worse eye and 20/40 or better in the other). Nonimpaired drivers met current federal acuity standards (corrected acuity of 20/40 or better in both eyes). Analysis results, adjusted for age, showed the following:

- Visually impaired drivers had a significantly higher incidence of total accidents and convictions and commercial-plate accidents and convictions than did nonimpaired drivers.
- Moderately impaired drivers had a significantly higher incidence of commercial-plate accidents than did nonimpaired drivers.
- The incidence of total accidents did not significantly differ between the nonimpaired and moderately impaired drivers.
- Severely impaired drivers had a significantly higher incidence of commercial-plate convictions than did nonimpaired drivers.
- Nonimpaired and moderately impaired drivers did not significantly differ on commercial-plate convictions.

- Drivers licensed to operate any combination of heavy vehicles had a higher incidence of total accidents and convictions and commercial-plate accidents and convictions than did those licensed to operate single vehicles having three or more axles.

These findings led to qualified support for the current federal visual acuity standard, particularly regarding exclusion from driving of the severely impaired (visual acuity below 20/200 in the worse eye and 20/40 or better in the other). Less support is offered regarding the restriction of the moderately visually impaired heavy-vehicle operator (visual acuity between 20/40 and 20/200 in the worse eye and 20/40 or better in the other).

Another recent study identified in the literature assessing the relationship between vision and truck operator performance was conducted by McKnight et al. (*28*), who examined monocular and binocular visual and driving performance of tractor-trailer drivers. On the visual measures, the monocular drivers were significantly deficient in contrast sensitivity, visual acuity under low illumination and glare, and binocular depth. However, monocular drivers were not significantly deficient in static or dynamic visual acuity, visual field of individual eyes, or glare recovery. In addition, no differences were shown between monocular and binocular drivers on driving measures of visual search, lane keeping, clearance judgment, gap judgment, hazard detection, and information recognition. The one exception was sign-reading distance, which was defined as the distance at which signs could be read during both day and night driving in a controlled road test. The binocular drivers were first able to read road signs at significantly greater distances than were the monocular drivers in both daytime and nighttime driving, and this decrement correlated significantly with the binocular depth perception measure. McKnight also reported a large variation in visual and driving measures among monocular drivers and several significant differences between them and binocular drivers, suggesting the need to assess the monocular drivers' visual functioning capabilities more closely and to continue research in identifying visual performance measures that significantly correlate with measures of safe driving skills.

Summary of Literature Results

The studies reviewed represent a substantial accumulation of data on the relationship of vision to driver (passenger and heavy vehicle) performance. No single study provided support for definitive changes to the current federal commercial motor vehicle vision standard. Nevertheless, it was equally apparent that changes in terms of both more and less stringent requirements in several performance areas should be evaluated at this time with the minimum aim of encouraging further empirical work. In addition, it is apparent that a large gap exists between the current standard and its uniform and effective implementation at the level of routine practical testing. Even though little evidence appears to exist to support a substantial and direct relationship between vision and driver safety, much evidence has been accumulated to support the hypothesis that vision, in interaction with other factors, contributes in a critical way to influence highway safety.

State and International Visual Standards

State CMV vision standards applying only to intrastate driving were reviewed. The requirements for each state are generally less stringent than the current federal CMV standard. The binocular visual acuity requirement in almost 80 percent of the states is 20/40, but less than 10 percent of the states deny a license for monocularity. Less than 40 percent of the states have visual field standards comparable with the federal standard, and only 24 percent have a color standard (*29*). Review of vision standards for CMVs in other industrialized countries revealed wide variances. Most countries require a visual acuity level for each eye separately that is more stringent than the current U.S. standard of 20/40 in each eye. Only a few countries have a binocular acuity requirement, and when specified, it is more stringent than the U.S. requirement. For visual fields, most other countries state that the driver must have "normal" or "full" fields. Most other countries do not have a requirement for color vision. In addition, the driving privilege in many countries may be denied because of stereopsis, aphakia, diplopia, high myopia, night blindness, and nystagmus. Many countries also require periodic vision checks.

Medical and Government Recommendations

The American Medical Association (AMA) has participated in setting vision standards for CMV operators and has provided guidelines (*30*) for vision testing to its members. The guidelines published in 1986 differ from the federal vision standard in excluding high-power spectacle lenses (10 diopters or greater) and in requiring visual acuity in each eye of 20/25 or better compared with 20/40 for the CMV standard. In addition, other visual disorders are discussed, including stereopsis, nighttime vision, diplopia, and oscillopsia, but specific recommendations for excluding drivers with these conditions are avoided.

The National Highway Traffic Safety Administration of the U.S. Department of Transportation, in cooperation with the American Association of Motor Vehicle Administrators, published a booklet in 1980 (*31*) that presented a set of recommendations for all drivers otherwise medically capable of operating commercial vehicles, including heavy trucks. The recommendation for visual acuity differs from the federal vision standard but is the same as that proposed by the AMA (i.e., 20/25 or better is required in each eye, not 20/40 as specified in the federal standard). The recommendation for visual fields is specified as 140 degrees for each eye in the horizontal meridian. The recommendation for color vision is the same as the federal vision standard and AMA recommendations (i.e., ability to distinguish red, green, and yellow/amber). The booklet provides recommendations for visual acuity, visual field, ocular motility, color discrimination, depth perception, dark adaptation, refractive states, and strabismus (crossed eyes).

EXPERT OPINION SURVEY

An expert opinion survey was conducted because of the dearth of reliable data relating visual assessmenteither clinical ex-

amination or screening by a Department of Motor Vehicles protocolto the driving record. Accordingly, using a delphi-type approach with a panel of visual and truck industry experts, specific visual functions deemed most important for safely performing each of seven critical CMV driving tasks were initially identified. This information established minimum acceptable performance levels for each visual function for each driving task.

The approach used an iterative process in which the most frequent response for visual functions ranked by order position (most important, second most important, third most important, etc.) was tabulated for each driving task; this information was then made available to each panel member, and further responses from each person were requested as needed to resolve ties and achieve consensus for all rankings. Three iterations of this process were required, resulting in the collective judgments. Panelists also provided subjective (rating scale) evaluation of the relative safety of matched monocular and binocular drivers with respect to the seven critical CMV driving task response capabilities. Table 2 presents the results of these two surveys. Finally, panelists were able to express their opinion on visual disorders and ocular conditions that should be noted on a physical examination form and that should require a follow-up exam by a vision specialist.

WORKSHOP CONSENSUS

A workshop was conducted to review and provide a consensus on preliminary draft recommendations. The panel represented the truck industry and the visual science community and consisted of licensed doctors of medicine, ophthalmologists, optometrists, professors of ophthalmology, and traffic and safety professionals in private industry. Focused discussion was held on the most vital points at issue, including the need to exclude monocular drivers or those with substantial visual loss in one eye only, the statement of the visual field requirement, the need for more complete and accurate testing of visual field (more in accord with the medical diagnostic procedure), the benefit of including newer tests of vision, the intent and effectiveness of the current color vision standard, and the basis of a risk analysis model that could be used to evaluate changes to the standard. The workshop panelists concluded that there were no compelling reasons to change the current binocular visual acuity standard of 20/40, that there was a need to measure horizontal visual fields using a more rigorous method than that currently employed in commercial vision screening equipment, and that the current color vision requirements are unenforceable and do not meet the intent of not excluding red-green color-defective individuals from the driving privilege. Most panelists agreed that the testing procedures for measuring acuity and visual field needed to be more comprehensive. Visual acuity optotypes, background illumination, and target luminance should follow the procedures recommended by the National Academy of Sciences (*32*). Specifying visual field target size and luminance was recommended, and the need for a test procedure that would provide a repeatable and accurate measure of field limits in the horizontal meridian was discussed. In addition, doubt was expressed about risk, if any, presented by drivers who are color blind, since traffic signing has been standardized and drivers have many other cues for the operation of a vehicle in a safe and effective manner. Panelists generally believed that it was important to note visual disorders and ocular conditions and that individuals with specific conditions should be referred to ophthalmologists.

Panelists participated in post-workshop evaluation of visual acuity, visual field, and color vision standards. Panelists were asked to select specific alternative wording for each requirement of the standard. The wording of the final recommended standard conforms to the majority choice for each requirement.

FINAL RECOMMENDATIONS

On the basis of the review of the literature, delphi exercise, and workshop views of the panelists, the recommended changes to the CMV standard were amended as follows. The statement of the visual acuity standard was found to be adequate. More specific wording to rule out below-standard performance in one eye was added to the Instructions for Performing and Recording Physical Examinations. Extensive revisions were made to this section to specify more completely the testing conditions and procedures to be used when measuring acuity, including light level, stimulus type, and specific test procedures. The statement of the visual field standard was changed to require at least a 120-degree field of view in each eye measured separately in the horizontal meridian. Extensive revisions were also made to the Instructions section to specify minimum stimulus conditions and an acceptable procedure

TABLE 2 Visual Functions Judged Most Important for Safely Performing Seven Critical CMV Driving Tasks

Driving Task	Visual Function by Order of Importance 1	2	3	Binocularity Critical
Maintaining safe speed for conditions	Visual fields	Motion Perception	Contrast Sensitivity	Yes
Maintaining safe following distance	Depth perception	Motion Perception	Visual Fields	No
Staying in lane/steering control	Visual fields	Static acuity	Contrast Sensitivity	No
Merging/Yielding in traffic conflict situations	Visual fields	Visual search/Attention	Motion Perception	Yes
Changing lanes and passing	Visual fields	Depth perception	Motion Perception	Yes
Complying with traffic control devices	Static acuity	Visual fields	Contrast Sensitivity	Yes
Backing up/Parking operation	Depth perception	Visual fields	Contrast Sensitivity	Yes

for testing in the horizontal meridian. The statement of color vision was changed to require only a "safe and effective response" to colored traffic signals and devices, without a specific test of color vision. Under this statement, red-green color-deficient individuals who can otherwise respond safely and effectively (virtually all) will be allowed the driving privilege.

PROPOSED STANDARD

If all recommendations are accepted as visual standards for CMV operators, they could be incorporated into the Code of Federal Regulations as follows (proposed changes in bold type):

391.41 Physical qualifications for drivers.

(b) A person is physically qualified to drive a motor vehicle if that person . . . (10) Has distant visual acuity of at least 20/40 in each eye without corrective lenses or visual acuity separately corrected to 20/40 or better with corrective lenses, distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses, **field of vision of at least 120 degrees in each eye measured separately in the horizontal meridian, and the ability to respond safely and effectively to colors of traffic signals and devices showing standard red, green, and amber. No test for color vision is required.**

391.43 Medical examination; certificate of physical examination.

(a) Except as provided in paragraph (b) of this section, the medical examination shall be performed by a licensed doctor of medicine or osteopathy.

(b) A licensed optometrist may perform as much of the medical examination as pertains to visual acuity, field of vision and the ability to respond appropriately to traffic signals and devices as specified in paragraph (10) of 391.41(b).

(c) The medical examination shall be performed, and its results shall be recorded, substantially in accordance with the following instructions and examination form.

INSTRUCTIONS FOR PERFORMING AND RECORDING PHYSICAL EXAMINATIONS

Head-Eyes

The recommended procedure for testing visual acuity is based on the standard procedures recommended for clinical measurement as reported by the Committee on Vision of the National Academy of Sciences (1980). The standard optotype is the Landolt ring. However, other equivalent optotypes, such as the Sloan letters as a group, are acceptable. Logarithmic sizing should be used (i.e., successively larger sizes should be 1.26 times larger than the preceding size). Optotype letters should be black on a white background of 85 to 120 cd/m². Under these conditions, acuity should be defined as the smallest size at which 7 out of 10 (or 6 out of 8) letters are correctly identified at a given distance. Effective viewing distance should not be less than 4 meters. Regardless of viewing distance, acuity should be specified in terms of a fraction with 20 as the numerator and the smallest type that could be read at 20 feet as the denominator (i.e., 20/20 or 20/40). Although the Snellen chart departs from the standard in several ways, it is acceptable if no practical means of following the recommended procedure is available. If the applicant wears corrective lenses, these should be worn while applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, "Qualified only when wearing corrective lenses." **The recommended procedure for testing visual fields requires equipment that is able to present a round, luminous stimulus of 0.15 to 0.25 degrees in angular extent on a low photopic background of 1 to 10 cd/m². Stimulus luminance should be 50 to 100 cd/m² and duration should be in the range of 100 to 200 msec. Subject fixation should be verifiable. Multiple presentation in random sequence under monocular test conditions must be possible. This will normally require separate test stimulus positions for determining temporal and nasal field limits. Testing must be monocular with one eye blocked. The test procedure should present the nasal and temporal limits (70 degrees to 80 degrees temporal and 50 degrees to 40 degrees nasal) a minimum of 3 times each in a random alternating sequence. Responses are best recorded automatically. If the applicant wears corrective lenses, these are not required to be worn while applicant's visual fields are being checked.**

Note **aphakia**, **cataract**, corneal scar, exophthalmos, **glaucoma**, **macular degeneration**, ocular muscle imbalance, ptosis, **retinopathy**, strabismus uncorrected by corrective lenses, and **any other conditions deemed important. Individuals with no vision in one eye or vision below standards in one eye as specified in paragraph (1) of 391.41(b) are disqualified to operate commercial motor vehicles under existing federal Motor Carrier Safety Regulations**. If the driver habitually wears contact lenses, or intends to do so while driving, there should be sufficient evidence to indicate that the individual has good tolerance and is well adapted to their use. The use of contact lenses should be noted on the record.

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