AD-A038 197 NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCI--ETC F/G 6/17
OPTICAL PROPERTIES AND VISUAL EFFECTS OF FACE MASKS. (U)
1977 N00014-75-C-0406

UNCLASSIFIED NL

1 OF 1
AD
A038197

END
DATE
FILMED
5-77

Optical Properties and Visual Effects of Face Masks

Committee on Vision

Assembly of Behavioral and Social Sciences

(6)

OPTICAL PROPERTIES AND VISUAL EFFECTS OF FACE MASKS,

Report of Working Group 48

(11) 1977

(12) 10p.

Committee on Vision
Assembly of Behavioral and Social Sciences
National Research Council

(15) N00014-75-C-0406

National Academy of Sciences
Washington, D.C.

1977

407040

Office of Naval Research
Contract No. N00014-75-C-0406

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

NRC COMMITTEE ON VISION

Working Group 48 - Optical Properties and Visual Effects of Face Masks

Members

F. Dow Smith, Chairman
Newton Centre, Massachusetts

William Benson
Executive Secretary
Committee on Vision

Glenn A. Fry
School of Optometry
Ohio State University

J.W. Gebhard
Applied Physics Laboratory
Johns Hopkins University

Richard F. Haines
NASA, Ames Research Center

Randall M. Hanes
Applied Physics Laboratory
Johns Hopkins University

Gordon G. Heath
Division of Optometry
Indiana University

Saul M. Luria
Naval Submarine Medical Research Lab.
New Groton, Connecticut

Edward F. MacNichol
Marine Biology Laboratory
Woods Hole, Massachusetts

Kenneth Welsh
FAA, Aeronautical Center
Oklahoma City, Oklahoma

REPORT OF WORKING GROUP 48

INTRODUCTION

The working group was specifically asked to suggest procedures for studying the optical properties and visual effects of the XM-29 mask, and this report is based on material presented and discussed at Ft. Rucker on July 14-15, 1976. However, the techniques of field and laboratory testing described in the report may be generally used to study a variety of face masks.

XM-29 Mask:

The XM-29 field protective mask is designed for military use to provide respiratory protection against field concentrations ~~of all~~ chemical and biological agents in vapor or aerosol form. The mask covers the face and is suspended by a flexible six-point harness attachment such that a continuous peripheral seal is made against the face of the wearer. The facepiece consists of the peripheral sealing area, the harness-attachment area, the lens area, the component-mounting area, and the nosecup area.

The component-mounting area of the mask covers the forward region below the lens, the chin region, and the mandible region of the face. It contains the following components:

1. Forward-mounted acoustically transparent speech diaphram,

2. Side-mounted adaptors for canisters, an outlet valve and resuscitation tube assembly located at the low point of the mask, and a water intake and valve assembly with internal and external portions.

The nosecup is an integrally mounted, flexible assembly that accommodates the oral-nasal configuration of the mask wearer and that contains one or more inlet valves.

Principal Recommendations

1. There is an urgent requirement for field testing the XM-29 mask to determine its compatibility for use in conjunction with specialized optical viewing instruments. The tests should encompass all instruments in the current or anticipated inventory. Planning and execution of the tests should include the participation of the U. S. Army Aeromedical Research Laboratory (USAARL) and U. S. Army optical engineering personnel familiar with the equipment and its application.

Performance under test conditions using the XM-29 mask in these field tests should be compared with performance using appropriate current masks, such as the M-17, M-24, and M-25, and compared with performance when no mask is used. The results of these tests will provide both a basis for evaluating the degree to which the XM-29 universal design provides improved capability and a data base for determining whether special designs may be needed for specialized applications.

2. It is recommended that high priority be given to developing a spectacle frame that can be used with the mask without significantly degrading the seal. The frame should accept lenses of standard shape. We believe that there is a high probability of developing a successful frame, given adequate funding and the use of a sound systems approach.

The alternate approach, which uses lens inserts in the mask for spectacle wearers, presents serious problems. There will be major technical difficulties in achieving and maintaining proper positioning of the lenses as well as logistical problems in delivering the necessary optometric services.

3. It is recommended that an evaluation be made to determine the possibility of reducing the thickness of the mask, either overall or locally in the area close to the eyes when the mask is collapsed for instrument use. We recognize a number of potential problems associated with this concept, but the major optical benefits to be gained from reduction of aberration and from improved access to the exit pupils of the viewing devices warrant this reconsideration. Even the presence of some kind of stiffening ribs molded into a mask that is otherwise thin would probably not negate these benefits as far as overall performance is concerned.

Discussion and Secondary Recommendations

The design of the XM29 mask from an optical point of view offers the important advantage of a wide unobstructed field of view but with the associated disadvantage of an inescapable loss of visual acuity for almost all directions of view. This loss (to be discussed later in the report) will occur even for an optimally centered position of the mask. It is inherent in the geometry of the system, quite separate from additional visual loss that might arise because of imperfections in the molding or in the uniformity of the coatings, because of haze in the mask material, or because of flexure of the mask away from the nominal position.

For some applications, such as use by mobile infantrymen not using optical instruments, we expect that this loss of acuity will be within acceptable limits and, with regard to total visual performance, may be more than compensated by the gain in peripheral field of view. There is, however, a potentially serious problem of the disruption of normal space perception caused by the optical aberrations. This could lead to erroneous judgment of distance, or to wearer discomfort. Field tests and/or laboratory tests should be carried out by USAARL to resolve this issue.

The loss of visual acuity can be quantified through optical measurements of a prototype mask and by optical computation. We recommend that these measurements and computations be given a high priority; the optical measurements are within the capability of USAARL, but it would be more appropriate for the computations to be carried out by the mask developer. The measurements will, of course, reflect defects in the fabrication and material of the sample tested as well as errors due to the geometry. A suggested procedure for making these tests using a precision focimeter is given in Figure 1.

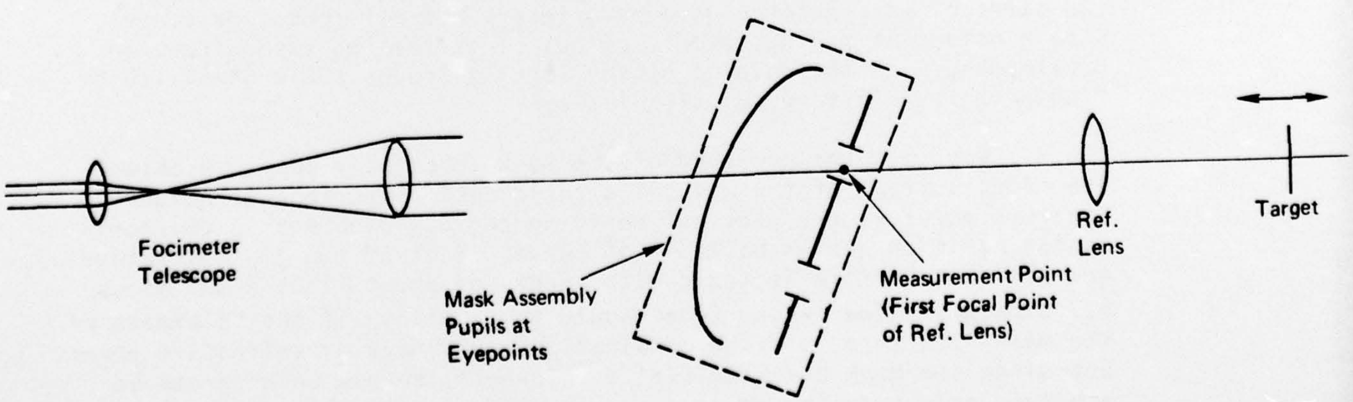

FIGURE 1 Use of Focimeter for Test of Mask

For applications requiring vision through telescopes, sighting devices, and the like, we think it likely that there will be a degradation in visual performance compared to that achievable in the absence of the mask. The field tests recommended above should determine the magnitude of this degradation and whether it is within acceptable limits. If the performance is unacceptable for a task or for a class of tasks, then it may be necessary to design specialized versions of the mask for such specialized requirements.

It is possible that it may be necessary to incorporate flat or plano meniscus windows of good optical material (comparable to glass). The exit pupil requirements of typical binocular instruments rule out the possibility of using a single extended flat window and would require the use of separate, probably circular,windows, one for each eye.

As we shall see in a following discussion, the mask also presents potentially serious problems by affecting the wearer's space perception. This may lead to discomfort, even nausea, and may affect his ability to perform tasks requiring depth perception. The field testing recommended previously (Principal Recommendation 1) should include an evaluation of these effects. Laboratory testing of personnel wearing the mask would also be useful.

The above comments are valid whether or not the user is wearing spectacles, provided that the lenses used by the spectacle wearer give the proper correction and are properly positioned before his eyes. The positioning of the lenses with respect to the eyes is often highly critical. The proposed inserts will not achieve this result, and we doubt that any insert system will do so in a practical way. We have, on the other hand, seen no convincing evidence to rule out the use of mask-compatible spectacles, and we therefore feel strongly that high priority should be given to finding an optometrically satisfactory yet compatible spectacle frame. This effort should go beyond modification of existing frames and should include the evaluation of wide, thin temples of a soft plastic tapered, if needed, to a feather edge. It is current policy to provide all combat troops with a spare pair of spectacles. The mask-compatible spectacle could be suitable as a spare. There would thus be a substantial saving over a system requiring two pairs of spectacles plus a mask insert for all combat personnel. Such a potential saving, alone, clearly justifies an expenditure on development. In the opinion of the Working Group, the probability of finding a satisfactory solution is high.

Why does the geometry of the mask inherently pose a problem? The front surface of the mask is a toric optical surface of about 4 diopters power in the vertical meridian and 6.7 diopters in the horizontal meridian (assuming radii of curvature of 5" and 3", respectively), and the rear surface is toric with powers of about minus 4 and minus 6.7 diopters. The two surfaces would thus balance if the thickness of the mask were zero, and the combination would have no refractive power. But since the mask has some finite thickness, such a balance can be achieved only by using an inner power that is slightly stronger than the outer power -- and then only for a line of sight perpendicular to the mask. If the line of sight is oblique, these conditions for neutralization no longer exist. There will be an astigmatic power error and a deviation of the central ray of the bundle. The deviation will be different for each eye, unlike the case with spectacles where the analogous deviation is usually similar for both eyes (see Figure 2). The difference in deviation can lead to problems in spatial perception. These problems would be reduced by either making the mask thinner or by reducing its curvature, but they would not be completely eliminated because of the separation of the eyes. If the face plate flexes, the angular error will fluctuate. This will make the scene swim and could lead to nausea.

The job of the optical designer is to pick curves for the mask that minimize these effects, except for those attributable to flexure, over which he has little control. It is also important that the designer report his design data in visually useful terms that can be used to predict binocular visual performance.

The design results should therefore be presented in terms of optical power error in diopters at the spectacle position for both eyes, for both the horizontal and vertical meridians, and for a number of lines of sight. The deviation of the chief ray of the bundle should also be given in prism diopters. Thus the results will be stated in established visual terms and therefore will be accessible for comparison with the substantial empirical data base on the visual effects that occur in patients having anisometropic corrections or other defects similar to those imposed by the mask.

A laboratory optical evaluation should be carried out to measure visual errors as seen from the spectacle position for each eye. The measurement made by simply placing the mask in a focimeter in the plane where one would test a spectacle lens will not reveal the errors described above, although it would help evaluate monocular performance of the mask when pushed into the pupil of a telescope.

To make the required measurement, stops should be placed in the mask approximately at the center-of-rotation point for each eye. The stop should then be placed at the measurement point in a focimeter and the mask rotated about this point so that the measurement can be made for various directions of view for both eyes. This will require a focimeter modified in length so as to provide increased working distance. This implies no optical modification beyond an increased mechanical separation of the telescope from the target assembly and some way of providing space to accommodate the mask as implied by Figure 1, which shows how the measurement can be made.

Figure 2 shows why the mask will inherently affect space perception in a different way than encountered with glasses. An

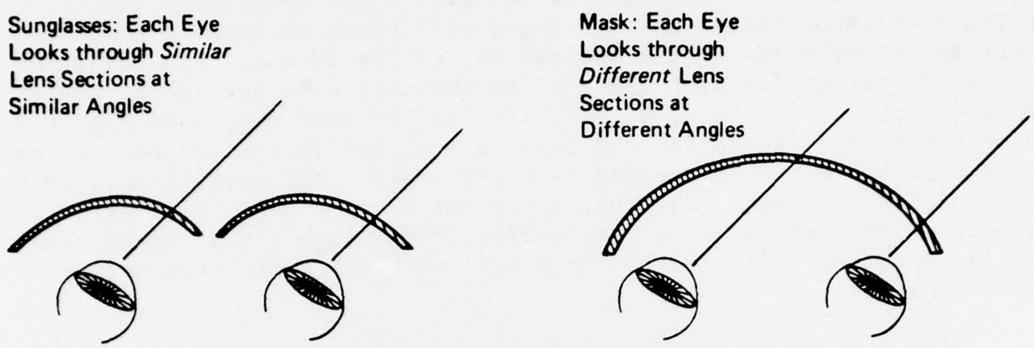

FIGURE 2 Illustration to Show Fundamental Difference between Binocular Vision through Mask and through Sunglasses

individual sunglass lens, for example, will cause a deviation of the line of sight, even with no prescription. This, again, is related to the thickness and curvature of the lens, as with the mask. For the glasses, however, each eye is similarly affected and the difference between the ray deviations will be relatively small. It is the difference that matters. In the case of the mask the situation is further worsened by the fact that this difference fluctuates as the wearer scans the field of view.