

Visual Acuity through Emergency Breathing Masks

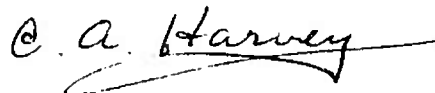
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SUMMARY PAGE

PROBLEM

To evaluate the effectiveness of attaching monocular refractive corrections to the front of the faceplate of emergency breathing masks.

FINDINGS

The configurations of the three emergency masks carried aboard submarines are quite different. Corrective lenses specified for one mask will not necessarily provide optimal acuity when used on another mask. Moreover, monocular corrections were disturbing to some subjects. Binocular corrections are feasible but a binocular holder would further interfere with the visual field of those individuals who do not require a correction. Binocular corrections are also technically much more complex owing to the problem of aligning the optical centers of the lenses on the visual axes of the eyes.

APPLICATION

Monocular corrections do not appear to be a desirable method of correcting refractive errors, even though it does not introduce leaks into the masks. A binocular optical insert is preferable, but a more efficient method of putting it in place than is available with current models is needed.

ADMINISTRATIVE INFORMATION

This research was conducted as part of the Naval Medical Research and Development Command Work Unit M0100.001-1023- "Enhanced visual performance on submarines." It was submitted for review on 7 February 1986, approved for publication on 10 March 1986, and designated as NSMRL Report No. 1071.

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ABSTRACT

The feasibility of attaching monocular corrective lenses to the outside of the three faceplates of the three types of emergency breathing masks carried on submarines was investigated and found to be unacceptable. The configurations of the masks were so different that a refractive correction tailored to one mask was often unacceptable for use with another mask. Many subjects were disturbed by monocular corrections. Finally, the field of view was considerably reduced even with the large lenses used in this study.

INTRODUCTION

Three types of emergency breathing masks are carried on submarines, the Mark-V, the Emergency Air Breathing (EAB) mask, and the Oxygen Breathing Apparatus (OBA). The sharp increase during the past generation in the percentage of young men who wear eyeglasses (Rengstorff, 1972; Kinney et al, 1979) has posed two problems for the use of these masks. The first is that leakage into the masks is increased by the eyeglass frames. The second is that it is often quite uncomfortable to wear a mask over the glasses.

The latter is probably tolerable for the relatively short periods of emergencies, but the former is not, particularly when the degree of leakage is very substantial, as it often is. Kish et al (1980) and Luria and Dougherty (1983, 1984) found that wearing eyeglasses significantly increased the leakage into these masks, and some eyeglass frames made it impossible to wear some of the masks.

There have been attempts to overcome the problem. An innovative pair of frames has been designed which is referred to as the "mask-compatible" or "combat" frame. This replaces the usual solid temples of the frames with elastic rubber straps. As was hoped, this generally reduces the leakage. However, the size of the lens frames makes it uncomfortable for some wearers with certain masks, and the physiognomy of some individuals makes it difficult to get a good seal over the frames with some masks.

The OBA was designed for use in the most dangerous situations, and the problem of leakage is critical. For this reason, a special frame which had no temples was designed for that mask; the entire holder fits inside the mask. This should, in principle, eliminate leaking. However, the lens holder has a hard rubber cushion which rests against the bridge of the nose. This, unfortunately, does not leave enough room for the lens holder in the case of some individuals whose bridge is not sufficiently indented from the forehead. This makes it too uncomfortable to tighten the mask securely against the face and eliminate all leaks. Another problem with this lens holder is that it is difficult and time-consuming to insert in the mask. If an individual does not have his own OBA with his insert permanently in place, there might well be occasions when it would take an unacceptably long time to put it in place. Indeed, Rengstorff (1980) has reported a variety of problems with such optical inserts in gas-masks. He noted that "most of the soldiers who wore inserts reported problems." They

complained about both the quality of vision and the difficulty of putting them in place.

Yet there are many duty stations which require 20/20 vision (Connors and Kinney, 1963), and some individuals would not be able to carry out their duties without their glasses. The problem of the compatibility of eyeglasses with these masks is thus troublesome and becoming more serious as the number of eyeglass wearers increases.

Two possible solutions are to incorporate the corrective lenses into the faceplate of the mask (as is commonly done with diving masks) or to wear the lenses outside the mask. The former cannot be done unless, of course, each man has his own mask. This is not the case on submarines now. It appears more feasible, therefore, to consider the latter procedure. As is the case with the insert for the OBA, each man would carry his own corrective lens, and provision would be made with all the masks for the attachment of a lens.

The fact that the three masks are very different in configuration, however, poses a problem. The distance of the faceplate from the eye varies greatly from one mask to another. This means that a given corrective lens may be satisfactory with one mask but not with another. In this study, we supplied each subject with the proper refractive correction to be worn on the outside of the faceplate of the most widely used mask on submarines, the EAB, and we then measured their acuity with this correction attached to the faceplates of the Mark V and the OBA.

METHOD

Subjects

Twelve staff members who wore corrective lenses served as subjects. They ranged in age from 30 to 61. Their refractive corrections are given in Table 1.

Table 1. NORMAL REFRACTIVE CORRECTIONS OF THE SUBJECTS AND WITH THE EAB

Subject	Eyeglasses	EAB
A	+1.50 -0.50 x 90	same
B	-3.00	same
C	-2.75 -0.75 x 30	same
D	-1.75 -0.50 x 95	same
E	-3.75 -1.75 x 10	-3.50 - 1.75 x 10
F	-3.00	same
G	-3.75 -2.25 x 178	-3.25 -2.00 x 182
H	-2.25 -0.75 x 12	-1.75 - 0.75 x 12
I	+5.25 -1.25 x 75	+4.00 - 1.25 x 75
J	+1.25	same
K	-5.25	-6.00
L	-4.75 -1.50 x 180	-4.75 -1.75 x 180

The Masks

The differences in the configurations of the masks are shown in Figure 1. The faceplates vary significantly in three ways: their angle from the vertical when the wearer is holding his head normally and looking straight ahead, the degree of curvature, and the distance from the eye. Figure 1 shows that the faceplate of the EAB is most nearly vertical, whereas that of the Mark V is considerably tilted. Moreover, the faceplate of the Mark V is quite curved, indicating that it would be difficult to attach a lens in a frontal plane. The OBA is somewhat less curved, and the EAB is the least curved.

Table 2 gives the position of the faceplate relative to the position of the corrective lenses normally worn by the subjects. For example, for SL, the faceplate of the Mark V was 0.75 cm farther from his eye than his eyeglass; the faceplate of the EAB is 4 cm farther. This means, of course, that any lens attached to the faceplates of the masks will lie at quite different positions relative to the eye. This should change the effective power. As can be seen in Table 1, the change in power did not always occur in the expected direction. The differences in the degree of tilt and curvature may be a reason. Both spherical and cylindrical powers are affected by lens tilt (Borish, 1975, p. 1109).

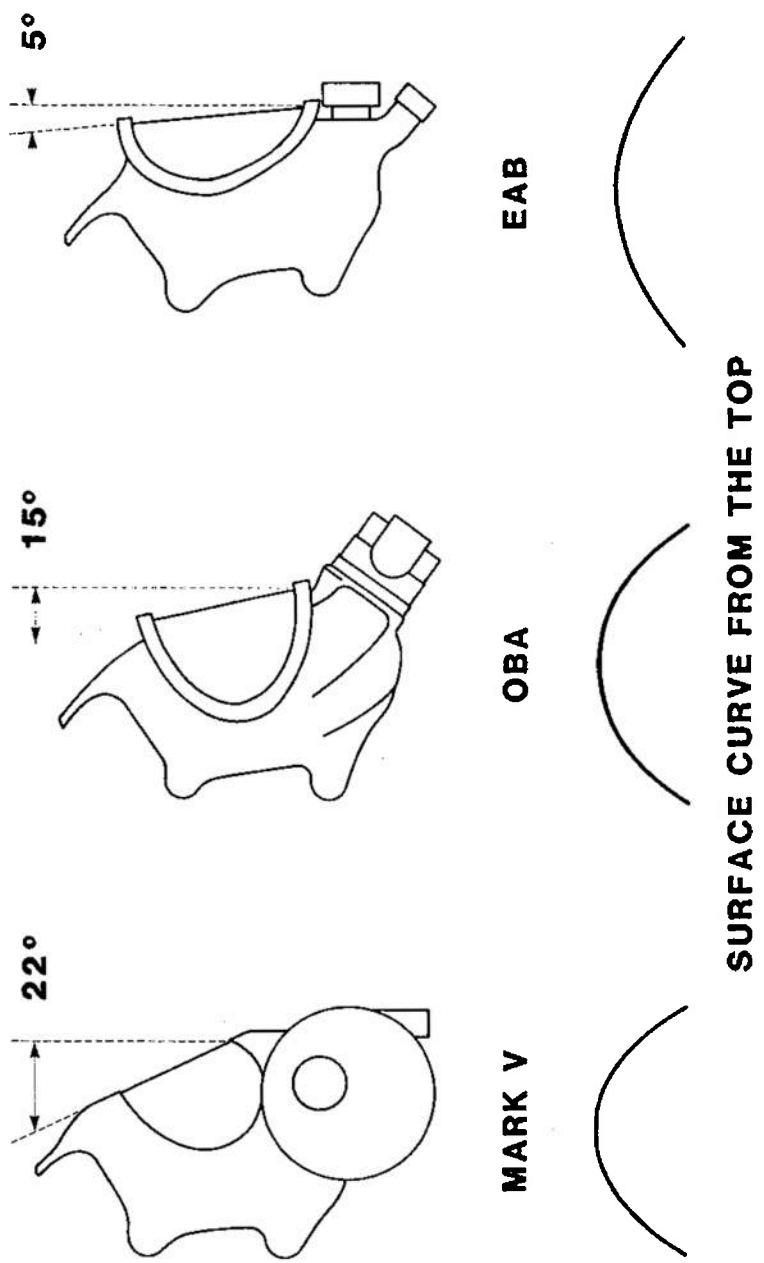


Figure 1. Configurations of three emergency breathing masks.

Table 2. THE POSITIONS OF THE FACEPLATES (CM)
RELATIVE TO THE POSITION OF THE CORRECTIVE LENSES
NORMALLY WORN BY EACH SUBJECT

SUBJECT	MARK V	OBA	EBA
A	.75	2	4
B	0	2	3.5
C	.25	1	3
D	.50	2.5	3.5
E	1.0	2.5	4
F	0	2.5	4
G	2.0	4	5
H	0	2.5	3
I	.50	2.5	5
J	2.0	3.5	5
K	1.0	3.5	5
L	1.5	3.5	4.5
Mean	0.71	2.66	4.12

Procedure

Standard optometric refractions were carried out on the subjects to determine their refractive errors. A lens holder was then attached to the faceplate of the EAB, and the subjects were refracted again using trial lenses placed on the faceplate in front of the subject's preferred eye. Both sets of refractions are in Table 1.

The corrections required with the EAB were obtained in 65 mm lenses. A holder was attached to each of the masks allowing a lens to be put in place (Figure 2).

Each subject wore the three masks in counterbalanced order with the EAB correction attached to the faceplates, and their Snellen acuity was measured.

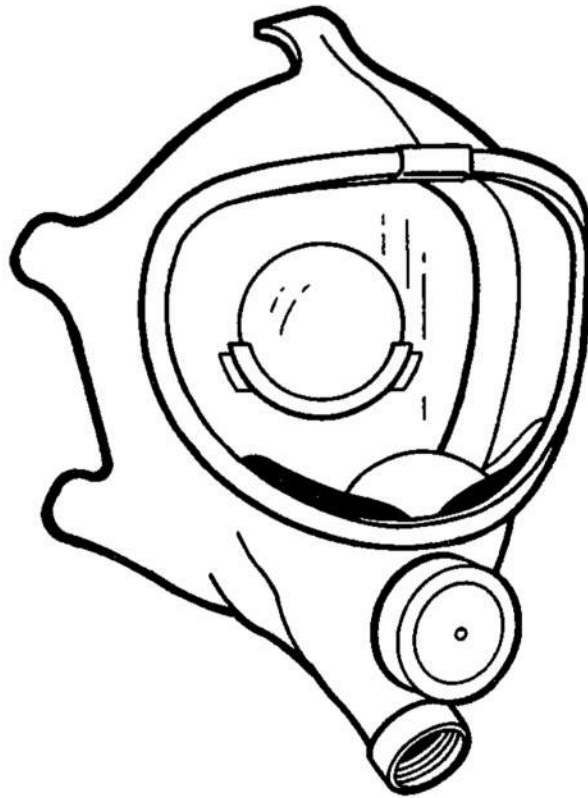


Figure 2. The Emergency Air Breathing (EAB) mask showing the attachment of the corrective lens.

RESULTS

Table 3 gives the Snellen acuities through each of the masks. Although the subjects had been refracted to 20/20 using trial lenses, mean acuity was now appreciably worse. The reason appears to be that the original refractions were carried out with small 35 mm corrected curve trial lenses. The experimental lenses, 65 mm in diameter, were both larger in area (which was desired) and much thicker (which was not). The result was that these lenses rested much farther from the subjects' eyes than the trial lenses. With the EAB, mean acuity was 20/34; unexpectedly, acuity was better through the other masks.

Table 3. SNELLEN ACUITY WITH CORRECTIVE LENSES
MOUNTED ON THE FACEPLATES OF THE MASKS

Subject	Mark V	OBA	EAB
A	30*	25	22
B	25	25	20
C	25	25	27
E	20	30	35
G	25	40	30
H	22	20	27
I	55	30	35
J	25	20	20
K	20	30	60
L	30	25	60
Mean	27.7	27.0	33.6

* 20/20 is listed simply as 20

** LL and MS could not complete the testing

A Friedman non-parametric analysis of variance was carried out on the acuities through the three masks. This showed that acuity was not significantly different from one mask to another ($X = 0.35$, $df = 2$, $p < 0.85$).

The Snellen acuity obtained through the OBA and EAB correlated highly with the subjects' degree of refractive error ($r = .69$ and $.91$, respectively), but the acuity obtained through the Mark V did not ($r = -.13$).

DISCUSSION

The faceplates of the emergency masks are quite different from the faceplates of Scuba masks. The latter are completely flat, rigid, and essentially perpendicular to the line of sight. It is a simple matter to add refractive corrections. The faceplates of the emergency masks, on the other hand, are very curved, flexible, and not perpendicular to the line of sight. Although this study showed that it is possible to add a corrective lens to the faceplates, the same correction will not be completely satisfactory for all three masks.

In choosing to attach a very large lens, we were, of course, trying to keep the field of view as wide as possible, both when the lens was in place and when the lens holder on the faceplate was empty. The thicknesses of the large lenses, however, resulted in differences in their relative position from the eye. As a result, their power was no longer correct. In the future, this mistake could be avoided, but the problem of the flexibility and curvature of the faceplates would remain. The lens holder would have to be rather elaborate.

Even having overcome this problem, another one would remain. It is that only one eye is corrected. With time, individuals suffering from squint, tropia, or some anomaly which results in unequal retinal images or double images learn to suppress one image. However, we found that this situation was uncomfortable for our subjects who were not used to it, and their vision was degraded by the presence of the uncorrected, unsuppressed retinal image. Some were forced to close or cover one eye in order to read the Snellen chart. This is, of course, unacceptable.

We conclude that binocular corrections are desirable, if not necessary, for irregular, short-term occasions. It is possible to manufacture faceplates which would incorporate holders for binocular corrections, but they are technically much more complex owing to the problem of aligning the optical centers of the lenses on the visual axes of the eyes. Moreover, binocular holders would further reduce the field of view through the masks for those who need no correction. What is required is a smaller optical insert and a faster method of putting it in place than is now available.

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