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EVALUATION OF THE RAF P/Q OXYGEN MASK WITH THE USAF HGU-2A/P FL--ETC(U)
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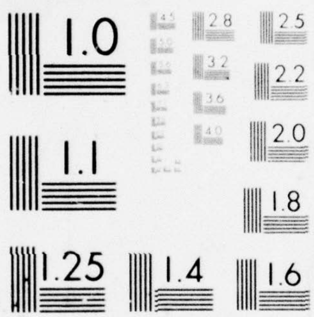

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EVALUATION OF THE RAF P/Q OXYGEN MASK WITH THE USAF HGU-2A/P FLYING HELMET

September 1976

Final Report for Period 1 November 1975-30 April 1976

Approved for public release; distribution unlimited.

USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

NOTICES

This final report was submitted by personnel of the Crew Environments Branch, Environmental Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7164-17-11.

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The voluntary informed consent of the subjects used in this research was obtained in accordance with AFR 80-33.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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The RAF P/Q oxygen mask was evaluated for use in conjunction with the USAF flying helmet. The mask/helmet assembly was tested for comfort, fit, fixed visual fields, and retention during sustained positive acceleration. The mask itself was tested for inspiratory resistance, ease of Valsalva, skin irritation, freeze resistance, and faceseal air leaks. Comparisons were then made with the MBU-5/P mask now operational in the U.S. Air Force. USAFSAM evaluations reveal that the RAF P/Q mask is superior to the MBU-5/P in all the parameters tested, including most importantly retention during high sustained postive acceleration.

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EVALUATION OF THE RAF P/Q OXYGEN MASK WITH THE USAF HGU-2A/P FLYING HELMET

INTRODUCTION

The new generation of fighter aircraft now entering the active duty inventory is placing increased stresses upon our aircrews. These stresses are a direct result of the increased performance of these new weapon systems. Experience gained to date in the operation of these sophisticated, multimillion-dollar fighter aircraft has revealed a pressing need for the development of new personal protective equipment which permits the operator to function at a peak level of performance. The aircrew's ability to operate under sustained levels of high positive acceleration ($+G_z$) requires improved oxygen mask retention. The currently operational MBU-5/P pressure demand oxygen mask tends to slide downward from the face at levels of 4 to 6 $+G_z$, thus impairing both breathing and communications. This study evaluated the Royal Air Force (RAF) aircrew-oxygen mask, commonly referred to as the P/Q mask, to assess its suitability for potential use as a replacement for the MBU-5/P mask in USAF high-performance aircraft.

USAF School of Aerospace Medicine (USAFSAM) efforts to evaluate the RAF P/Q pressure demand oxygen masks for use in conjunction with the USAF flying helmet are described in this report. This work was part of a test project agreement by the USAF and RAF under the auspices of the Air Standardization Coordinating Committee (TPA 685-61) to determine USAF aircrew acceptance of the P/Q mask and to test the P/Q mask's compatibility with the USAF flying helmet. A technical description of the P/Q mask is included as an appendix to this report.

METHODS

Human volunteer subjects were used to evaluate the following mask parameters: comfort, fixed visual field limits, retention under sustained positive acceleration, inspiratory resistance, interference with Valsalva, skin irritation, freeze resistance, and faceseal air leaks.

Fixed visual fields of 20 subjects were measured while the subjects breathed through the MBU-5/P mask and then again while wearing the RAF P/Q mask. The masks were properly fitted to the subjects and attached to the HGU-2A/P helmet; only large and extra-large helmets were used. A Goldman projection perimeter device, model 298, was used to measure the visual fields. The perimeter device consists of a metal hemisphere pivoted on a stand that can revolve throughout 360°. A chin and forehead rest accommodates the subject. With one eye closed the subject focused on the center of the hemisphere on which a fixation mark was made. A 1-mm test object was then brought in from the periphery of the arc toward the center. The arc of the perimeter device is marked off in degrees, and the point at which the test object was seen by the subject was then marked on charts specifically designed for that purpose. While keeping his eye firmly fixed on the center of the perimeter, the subject notified the examiner as soon as he detected the object.

Mask retention under high sustained positive acceleration was evaluated on the USAFSAM human centrifuge by four experienced centrifuge subjects who wore the MBU-5/P and then the RAF P/Q mask. Figure 1 shows the acceleration profile used.

Inspiratory resistance of the mask was measured using a Validyne Model P 24 differential pressure transducer. Sampling ports were inserted into the P/Q mask cavity and into the mask hose. The pressure differential across the inspiratory valve was then recorded on a Mark 280 Brush recorder. Inspiratory resistance was measured at the following altitude/temperature combinations: (a) ambient temperature 72°F (22°C) at ground level, 8,000 ft (2,438 m), and 34,000 ft (10,363 m); (b) 0°F (-18°C) at ground level, 8,000 ft (2,438 m), and 18,000 ft (5,486 m); (c) 122°F (50°C) at ground level, 8,000 ft (2,438 m), and 18,000 ft (5,486 m). Altitudes were simulated in an altitude chamber with high and low temperatures controlled within ±3°F (±1.6°C) at each of the test altitudes. A narrow-panel, CRU-69A pressure demand oxygen regulator was used throughout the study to control the oxygen supply to the mask.

RESULTS

Fit

Earlier attempts to evaluate the P/Q mask in conjunction with the USAF flying helmet were not successful. Most of these trials were efforts to interface the P/Q mask to the helmet using USAF bayonet connectors. The resultant hybrid systems were unsuccessful mainly because the mask/helmet geometry did not allow the P/Q mask to seal against the face properly. In order to equitably evaluate the P/Q mask, an acceptable method for suspending the mask to the USAF helmet was necessary. During the summer of 1975, the RAF Institute of Aviation Medicine (RAF/IAM) designed and tested a set of mounting plates for attaching the RAF mask to the HGU-2A/P helmet that allowed the use of the standard RAF attachment hooks as shown in Figure 2. Figure 3 shows the prototype mask attachment system used in our evaluations. This system permitted the proper interfacing of the P/Q mask to the helmet so that an excellent seal of the mask to the wearer's face was achieved.

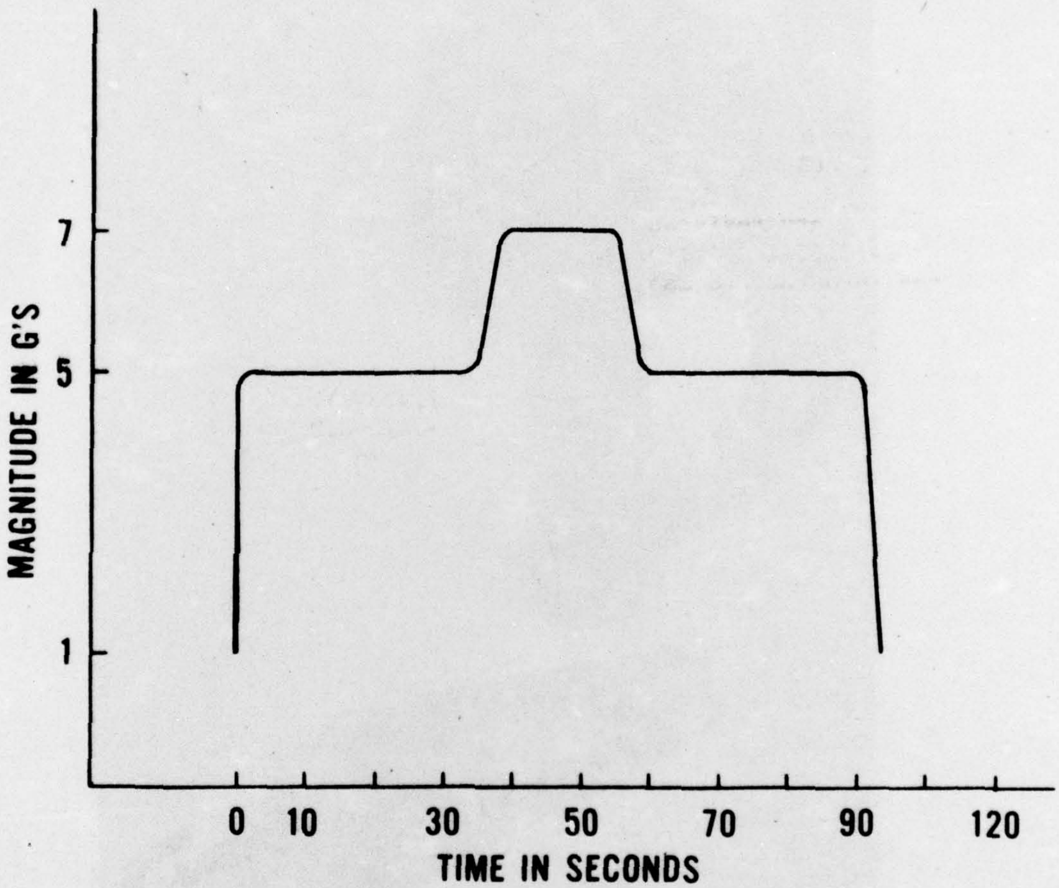

Figure 1. Centrifuge profile used to evaluate mask retention during sustained positive acceleration.

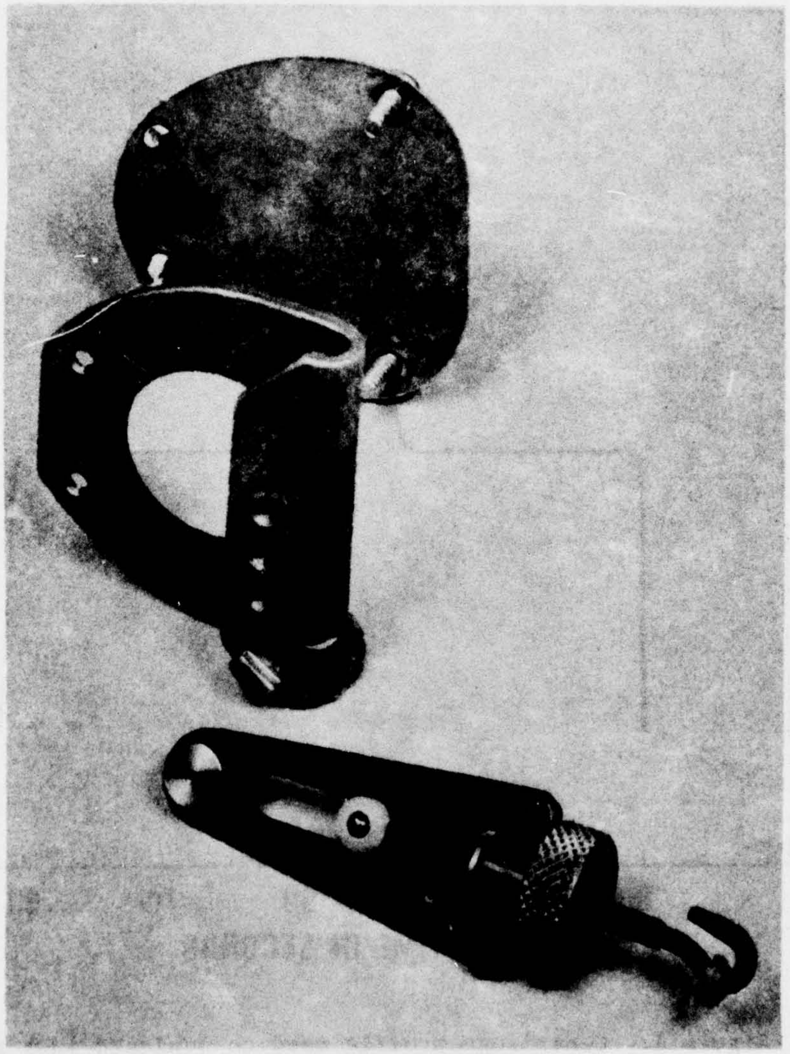

Figure 2. Attachment hooks and mounting plates designed by RAF/IAM for suspending the P/Q mask from the USAF flying helmet.

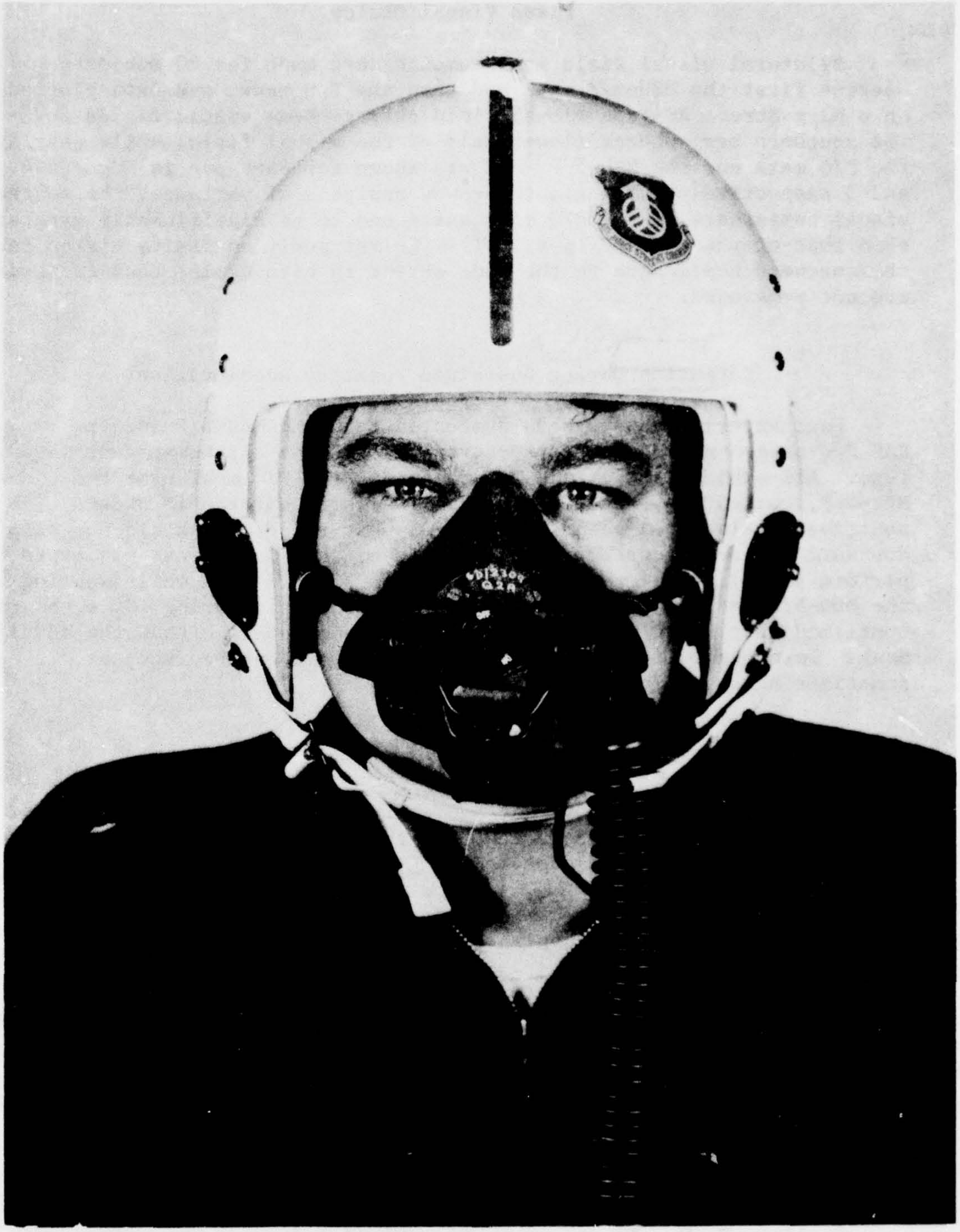

Figure 3. Mask/helmet assembly evaluated in this study.

Fixed Visual Fields

Bilateral visual field measurements were made for 20 subjects wearing first the MBU-5/P mask and then the P/Q mask, and data plotted on a Hagg Strett AG-type visual field chart. Mean visual fields for the southern hemispheres (lower half of the visual field) while wearing the P/Q mask and the MBU-5/P mask are shown for each eye in Figures 4 and 5 respectively. Using a three-way analysis of variance, the southern visual hemisphere of the P/Q mask was found to be significantly greater than that of the MBU-5/P ($p < .001$). Helmet position limits vision in the northern hemisphere to the same extent in both masks; thus these data are not presented.

Retention During Sustained Positive Acceleration

Four experienced subjects evaluated both the MBU-5/P and the RAF P/Q oxygen masks during exposures to +7 G_z on the human centrifuge. All subjects reported preference for the P/Q mask over the MBU-5/P, commenting that the P/Q mask was more comfortable under positive acceleration than the MBU-5/P; that the P/Q mask did not slip downward and restrict their nasal passages; and that it was easier to perform an M-1 maneuver while wearing the P/Q mask than while wearing the MBU-5/P mask. Observation of the test subjects during $+G_z$ exposure confirmed that the P/Q mask was more stable on the face than the MBU-5/P mask. In no case did the P/Q mask slip downward on the face, as sometimes happens with the MBU-5/P.

Comfort

Comfort of the P/Q mask was subjectively evaluated by 6 subjects. Each subject reported a preference for the P/Q mask over the MBU-5/P mask to which they were accustomed.

Inspiratory Resistance

The inspiratory resistance of a P/Q mask was tested under various environmental conditions; the results are shown in Table 1. The lessened inspiratory resistance of the P/Q mask is an improvement over the MBU-5/P mask, which at ground level requires approximately one inch of water pressure to open the inhalation valve.[1] A user can immediately detect the lessened inspiratory resistance with the P/Q mask.

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[1] Seller, H. W. Development of combined and pressure-compensated, inhalation-exhalation valve for pressure breathing, p 5. ASD Technical Report 61-379, Wright-Patterson AFB, Ohio, 1961.

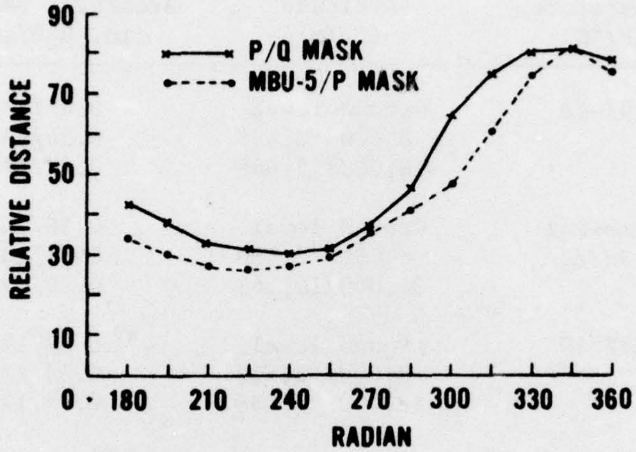

Figure 4. Fixed visual field for the right eye (180° - 360°) while wearing the MBU-5/P and the RAF P/Q masks.

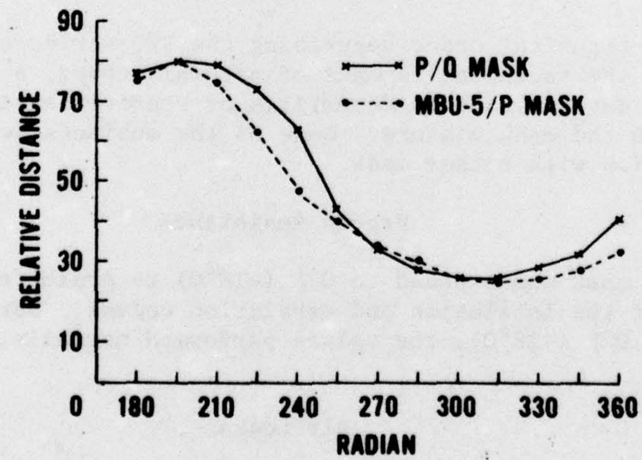

Figure 5. Fixed visual field for the left eye (180° - 360°) while wearing the MBU-5/P and the RAF P/Q masks.

TABLE 1. MEAN BREATHING RESISTANCE OF THE RAF P/Q PRESSURE DEMAND OXYGEN MASK AS WORN BY FOUR TEST SUBJECTS.

Temperature (°F/°C)	Altitude (ft/m)	Breathing resistance (in. H_2O/mm H_2O)
0/-18	Ground level	0.67/17.0
	8,000/ 2,438	0.54/13.7
	18,000/ 5,486	0.47/11.9
Ambient 72/22	Ground level	0.56/14.2
	8,000/ 2,438	0.51/13.0
	34,000/10,363	0.29/ 7.4
122/50	Ground level	0.53/13.5
	8,000/ 2,438	0.53/13.5
	18,000/ 5,486	0.44/11.2

Valsalva

Six subjects subjectively evaluated the P/Q mask for ease of Valsalva: three subjects reported that it was more difficult to Valsalva with the P/Q mask than with the MBU-5/P mask; the other 3 subjects reported that it was easier to Valsalva with the P/Q mask than with the MBU-5/P mask.

Skin Irritation

The RAF technical order describing the P/Q series of masks states that because the facepiece is made of natural rubber, a wearer will occasionally develop contact dermatitis or sensitivity to one of the components in the mask mixture. None of the subjects developed any skin irritation with either mask.

Freeze Resistance

The P/Q mask was exposed to 0°F (-18°C) to evaluate the freeze resistance of the inhalation and exhalation valves. During the four exposures to 0°F (-18°C), the valves performed normally and no freezing occurred.

Air Leaks

Because of the unique suspension system used with the P/Q mask, a superior fit was achieved and there was no mask leakage during any of the altitude tests. A physiological training technician and a physiological training officer wore the P/Q mask to 50,000 ft (15,240 m) in an altitude chamber, and both individuals reported no leakage with the mask. This is a marked improvement over the MBU-5/P which leaks profusely at that same altitude.

CONCLUSIONS

The helmet/mask suspension system designed by RAF/IAM allowed adequate adjustment for the proper fitting of each test subject. The mask attachment hooks must be shortened for use with the medium helmet. This shortening decreases the range of fore/aft adjustment available from 2.5 cm to 1.5 cm and makes it impossible to fit this mask/helmet combination to some aircrew members who wear the medium-size HGU-2A/P helmet.[2] In the Operational Test and Evaluation (OT&E) of the mask this should not be a factor, as the large and extra-large helmets fit approximately 65% of aircrew members. RAF/IAM has indicated that they can design adjustment hooks for the medium-size helmet to provide additional adjustment should this become necessary during the OT&E.

The internal position of the mounting plates is a potential safety problem. It is possible that during turbulence, uncontrolled flight, or similar situations, the wearer could suffer facial injuries due to contact with the mounting plates located within the helmet shell (Fig. 6). RAF/IAM has stated that in some individuals it may be necessary to attach a layer of sponge rubber over the internal surface of the attachment hooks and mounting plates to prevent possible contact of the assembly with the wearer's face. Additional structures located within the helmet are undesirable, and we believe that this could prejudice aircrew members against the mask during the OT&E. This prototype mask suspension system was designed for use in the laboratory and flight trials and should be acceptable for the OT&E conducted by the 412A Life Support System Program Office (SPO); however, it should not be considered the definitive design for the suspension system if the RAF P/Q mask is chosen as the replacement for the MBU-5/P.

ACKNOWLEDGMENTS

Our appreciation is expressed to A. W. Cresswell and Group Captain J. Ernsting, RAF/IAM, for their work in designing and evaluating the mask/helmet interface components. Also, this appreciation is expressed to the research technicians at USAFSAM/VNT, especially MSgt Charles D. Colley, MSgt Arnie A. Moore, Jr., and SSgt William D. Bentley.

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[2] Cresswell, A. W., and J. Ernsting. The RAF type P/Q pressure demand oxygen masks. A note in support of Air Standardization Test Project Agreement (RAF-USAF) 685-61, Annex A. Farnborough, Hants, United Kingdom, 1975.

Figure 6. Internal position of the RAF mounting plate and attachment hook on the HGU-2A/P helmet.

APPENDIX

DESCRIPTION OF THE RAF P/Q MASK

The following information is extracted from the RAF literature describing the P/Q mask.[3] The mask consists of a facepiece which fits over the mouth and nose, but leaves the chin exposed. The facepiece is fitted with inspiratory and expiratory valves, a microphone and lead, mask hose, and a chain-toggle harness. Over the facepiece is an exoskeleton molded to fit snugly to the face so that it exerts an even pressure over the facepiece. The skeleton provides a mounting for the harness, secured to it by spigoted set screws, and permits the outer bow of the harness to rotate from the normal position to the pressure breathing position.

The facepiece, molded in soft rubber, has a reflected edge so that increasing pressure within the mask--bearing on the inturned edge--increases the efficiency of the face/mask seal. The valves and the microphone are inserted into the facepiece: the inspiratory valve complete with iceguard is in the left cheek, the expiratory valve is over the mouth, and the microphone is immediately above the expiration valve. The inlet connector, to which the mask hose is fitted, is on the outside of the facepiece, directly over the inspiratory valve. A stiffening piece in the bridge of the nose enables the mask nose bridge to be shaped to fit the wearer's nose; this assists in achieving the best face/mask seal.

The inspiratory valve is a simple nonreturn valve consisting of a plastic molding in which is inserted a mushroom-shaped diaphragm; the diaphragm lifts as the wearer breathes in and permits the breathing gas to pass from the mask hose into the facepiece. The valve is protected by a fine mesh filter iceguard.

The expiratory valve is a compensated-return valve in which the mask hose pressure is applied to the underside of a diaphragm through a compensating tube. When the breathing gas is being supplied at pressures above ambient, the compensating pressure acting on the underside of the diaphragm forces a piston against the valve plate and prevents it from lifting under the pressure within the mask. Under normal use conditions, the piston is maintained in contact with the valve plate by a conical spring which is fitted between the piston and the valve body. During a heavy breathing demand and when the piston is drawn into the diaphragm chamber, the valve plate is kept on its seating by a second spring located between the piston and the valve plate. Thus, the valve plate lifts and allows the expired gases to

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[3] General and Technical Information, Oxygen masks, types P and Q. AP 108F-0902-12, pp 7-9. United Kingdom Defence Council, 1973.

pass through the expiratory duct when the pressure within the mask exceeds both the compensating and the spring load pressures. An orifice connects the compensating tube with the diaphragm chamber and eliminates transient instability.

The chain harness consists of two bows, one swiveling outside the other. The outer bow is connected to the anchorage plates by two short lengths of chain. Each is fitted with a swivel link to prevent the possibility of it being tightened due to twisting. The retention of the P/Q mask under increased G load is due in large extent to the design of the system used to attach the mask to the aircrew helmet.