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EFFECT OF OXYGEN FLOW ON PASSENGER FACE MASK PERFORMANCE

Ronald D. Holden, B.A.

M. Stephen Haswell, Ph.D.

Estrella M. Forster, B.S.

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, TX 78235-5301

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The voluntary informed consent of the subjects used in this research was obtained in accordance with AFR 169-3.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

RONALD D. HOLDEN, B.A.
Project Scientist

JOHN B. BOMAR, Jr.
Colonel, USAF, BSC
Supervisor

JEFFREY G. DAVIS, Colonel, USAF, MC
Commander

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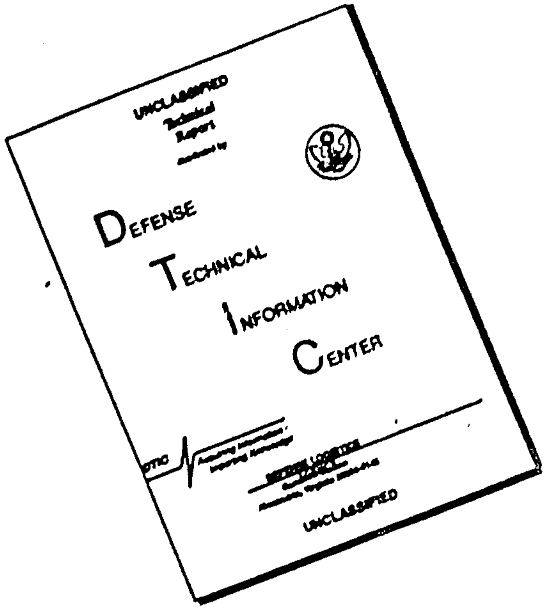

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The passenger emergency oxygen system presently used onboard USAF transport aircraft is a phase dilution continuous flow system, and is similar to that on commercial aircraft. The mask is certified for emergency use up to 40,000 ft, when provided with an oxygen flow in accord with military specifications (MIL-D-19326F). We have evaluated the effect on arterial hemoglobin saturation (SaO_2), of reductions in oxygen flow (below those specified) to the emergency mask; the volunteer subjects were exposed to simulated altitudes of 40, 35, 30, and 25 thousand feet. At reduced oxygen flows to the emergency passenger mask, SaO_2 was: 88 ± 2.8%, 92 ± 3.5%, 98 ± 1.2%, and 97 ± 1.0%; at 40, 35, 30, and 25 thousand ft, respectively.

Although halving the oxygen flow to the mask at 25,000 ft and 30,000 ft resulted in acceptable levels of SaO_2, reductions in flow--at 35,000 ft and, especially, at 40,000 ft--were not as well tolerated. At 40,000 ft and, to a lesser extent, 35,000 ft, inboard

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19. ABSTRACT (Cont'd.)

leakage of ambient air around the face and through the anti-suffocation valve seriously compromised SaO_2.

Because passengers suddenly exposed to a 40,000-ft cabin altitude would undoubtedly suffer from anxiety and would tend to hyperventilate, and because of limitations inherent in continuous flow oxygen systems, we recommend that oxygen flow to the passenger mask (as specified in MIL-D-19326F) be reduced with great caution.

CONTENTS

ILLUSTRATIONS

(Continued on next page)

CONTENTS: Illustrations (*Cont'd.*)

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EFFECT OF OXYGEN FLOW ON PASSENGER FACE MASK PERFORMANCE

INTRODUCTION

The passenger emergency oxygen system presently used onboard USAF transport aircraft is very similar to that on commercial aircraft. The masks [produced by Scott Aviation, Sierra Products Division, Sierra Madre, CA (part #289601AF2)] are disposable and are approved for emergency use to 40,000 ft. The mask facepiece, made of silicone rubber, has a cupped shape and is often referred to as the "Dixie Cup" mask. It covers both the nose and mouth, and is held to the face by a single elastic strap. The mask cup is connected, through a one-way valve, to a 1-Liter (L) plastic reservoir bag. Oxygen flows into the bag at a constant prescribed rate, depending upon the altitude at which the oxygen is used. If the bag is emptied during inspiration, a spring-loaded valve (mounted in the face cup) opens to allow ambient air to enter the mask. The first part of each inspiration consists of pure oxygen, unless leakage around the mask-face seal allows ambient cabin air to enter. Because the mask thus acts as a phase diluter system, a higher alveolar PO_2 results than if air and oxygen were mixed prior to inhalation.

At 40,000 ft, military specifications require an oxygen flow to the Dixie Cup of at least 4.7 L/min NTPD [normal temperature pressure dry, 70°F (21°C) 760 mm Hg, dry]. Reduced flow to the transport passenger oxygen mask, below the levels stated in the specification, may presently exist. The operational consequences of minor reductions in flow are not totally clear, and are cause for concern. Lowered flows of 4.1 - 4.3 L/min NTPD may exist on the C-5 aircraft. In addition, certain C-141B aircraft may have been so modified that as many as 208 passengers are connected to a system originally designed for 100. This overloading could create a demand of 1,350 L/min NTPD from a system designed to accommodate only 900 L/min NTPD maximum. Since neither a 100-man regulator nor the two installed, 75-L, liquid oxygen converters are designed to handle these flows, flow to the passengers may be diminished. Thus, in order for potential hazards to be assessed, the true minimum constraints in flow while the mask is in use must be known.

McFadden (1), using a similar Dixie Cup mask, demonstrated that flows of 3.1 L/min NTPD at 40,000-ft altitude resulted in acceptable levels of blood oxygenation in 6 human subjects, even during moderate levels of exercise. Apparently, on this basis, the military specifications for oxygen flow to the transport passenger mask might be relatively conservative. Thus, we have ascertained the minimum acceptable mask flows, and have determined if existing emergency life-support equipment for passengers is adequate without modifying current USAF transport aircraft.

MATERIALS AND METHODS

A military specification (2), MIL-D-19326F, requires that all passengers be provided supplemental oxygen whenever cabin altitude exceeds 10,000 ft. Thus, a 10,000-ft air-breathing equivalency in arterial hemoglobin saturation (SaO_2 = 87%) has been used as a desirable and maintainable threshold; for breathing 100% oxygen at 39,000 ft is equivalent to breathing air at 10,000 ft.

To evaluate the effect of reduced oxygen flow to the transport passenger oxygen mask, the following protocol was utilized: after the rationale for the investigation had been explained and the potential hazards outlined, 14 active-duty USAF volunteer subjects were exposed to simulated altitudes in the USAF School of Aerospace Medicine altitude chambers. All subjects were fitted with an especially designed leather helmet, to accommodate an ear oximeter probe and a standard USAF aviators' oxygen mask (MBU-5/P). They then pre-breathed 100% oxygen for 60 min, for denitrogenation protection from decompression sickness (DCS). During the 60-min denitrogenation period, each subject was fitted with the ear oximeter device (No. 47201A, Hewlett-Packard, Waltham, MA) to determine arterial hemoglobin saturation. After an ear and sinus check at 5,000 ft, the chamber pressure was reduced (5,000 ft/min) to simulate a 40,000-ft altitude. During ascent, the subject and the inside observer (who also pre-breathed 100% oxygen for 60 min) continued to breathe from their MBU-5/P masks and CRU-73 oxygen regulators to ensure protection from hypoxia. Upon reaching 40,000-ft simulated altitude, each subject was requested to remove the aviators' mask and don the transport passenger oxygen mask. Oxygen and carbon dioxide levels within the passenger-mask face-cup were determined by using a clinical mass spectrometer (Perkin-Elmer Model MGA-1100), with sampling lines plumbed through the chamber bulkhead and fitted to the mask. After 1 or 2 min had been allowed for a new respiratory steady state to occur, arterial hemoglobin saturation was noted and oxygen flow to the passenger mask was decreased. After steady state in the physiologic variables reoccurred, flow was further reduced.

The process was continued until arterial saturation fell below 80%, or until flow was reduced by 50%. After the lower flow limitation had been defined at 40,000 ft, the chamber was descended to 35,000 ft and the procedure was repeated at that altitude. This process was then repeated at 30,000 and 25,000 ft. Whenever arterial hemoglobin saturation fell below 80%, the subject was immediately returned to the MBU-5/P aviators' oxygen mask. Additionally, between each altitude evaluation the subject was returned to the aviators' oxygen mask. Aviators' breathing oxygen, dry, was provided to the passenger mask from large compressed gas cylinders ("K" bottles). Oxygen flow was measured outside the chamber at ground level by using a pneumotachometer, but the internal diameter of the delivery tube experienced the actual chamber pressure. Oxygen flow to the mask was controlled by using a standard two-stage regulator (Model 580, Matheson Gas Products, East Rutherford, NJ) with needle-valve assembly. Military specifications call for flows measured in liters per minute NTPD. During the course of these investigations, ambient conditions around the altitude chambers resulted in a temperature range of 70-74°F (21-23°C), and a barometric pressure range of 745 - 755 mm Hg. Temperature inside the altitude chamber ranged from 70-80°F (21-27°C), while the pressure where measurements were accomplished ranged from 141 - 282 mm Hg. Correction of ambient values to standard NTPD values was not routinely accomplished; i.e., flows were reported as measured, under ATPD conditions. The relationship between ATPD flows (as specified in this Report) to standard NTPD values, at the various test altitudes, is given in Table 1. Therefore, flows are reported as ATPD (ambient temperature and pressure, dry) rather than NTPD, which is specified in MIL-D-19326F. The relationship between the values is:

$$\text{Flow (ATPD)} = \text{Flow (NTPD)} \times \frac{T\ \text{ambient}}{T\ \text{normal}} \times \frac{P\ \text{normal}}{P\ \text{ambient}} \quad \text{[see Table 1]},$$

in which T = absolute temperature,

and P = absolute pressure.

Statistical significance was evaluated by using the Student's t-test for paired and unpaired data, as appropriate.

RESULTS

Fourteen volunteer subjects, using the transport passenger oxygen mask (Table 2), were evaluated at simulated altitude. The altitude-chamber simulated-flight profile utilized in the investigation is illustrated in Figure 1. Whenever the transport passenger oxygen mask was provided with oxygen in accordance with military specifications, the mean arterial hemoglobin saturation values observed for the subject group at each of the four test altitudes equalled or exceeded the 10,000-ft air-breathing equivalency level (SaO_2 = 87%) (Table 3). Nonetheless, at 40,000 ft, only 8 of the 11 subjects tested were able to achieve stable arterial hemoglobin saturations after donning the Dixie Cup mask. Furthermore, of the 8 subjects who obtained stable arterial hemoglobin saturations, only 3 were able to do so on their first attempt. Thus, for 5 subjects, upon first donning the mask, arterial hemoglobin saturation levels fell below 80%

EDITOR'S NOTE: For the convenience of the reader, all tables have been grouped at the close of this Report.

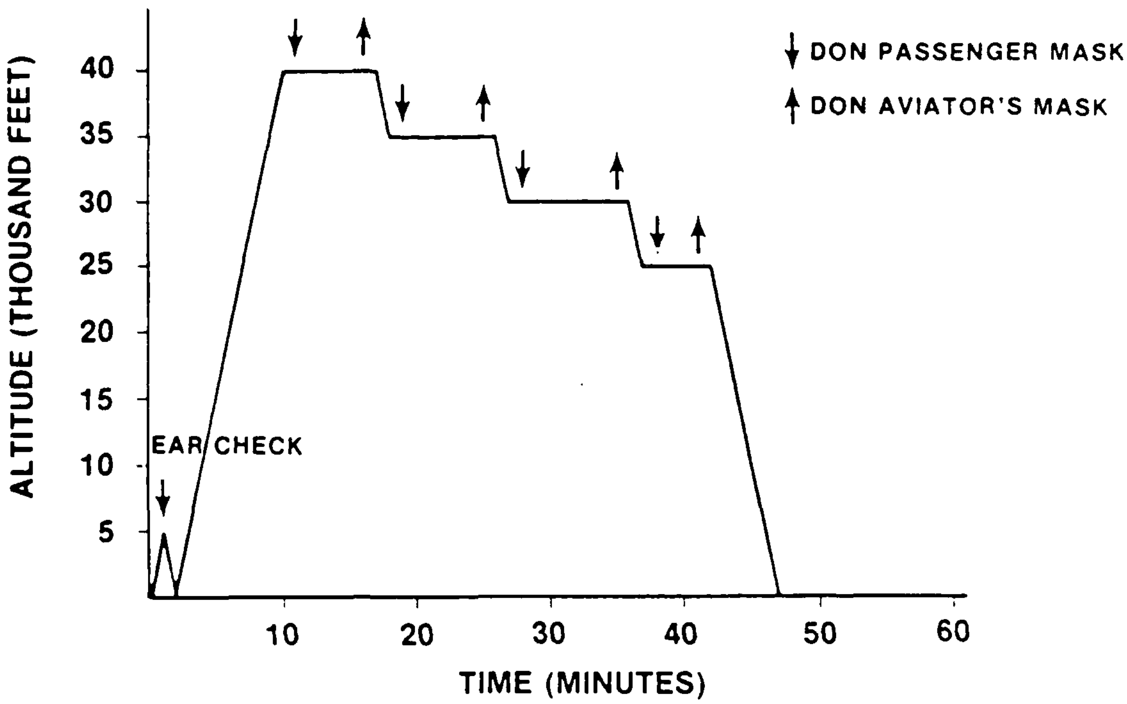

Figure 1. Altitude chamber profile depicting the sequential altitude decrease from 40,000 ft to ground level.

after approximately 1 min; and the subject was returned to the MBU-5/P aviators' mask.

The investigators then verbally coached each subject on how to optimize efficiency of the mask by consciously controlling his rate and depth of ventilation. Of the 5 subjects, 4 were then able to re-don the passenger mask and obtain a stable arterial hemoglobin saturation value. The fifth subject required two attempts before achieving a stable value. Two subjects were never able to achieve a stable arterial hemoglobin saturation value, and the eleventh subject lost consciousness after 1 min 40 sec, thus requiring the inside observer to facilitate the subject's recovery by use of the MBU-5/P aviators' mask. That subject was returned to ground level; his recovery was uneventful, and he was not evaluated further. At 35,000 ft, 11 of 13 subjects were able to achieve stable values for arterial hemoglobin saturation. As for the other 2 subjects, the first failed to achieve a stable SaO_2, while the second complained of hypoxia symptoms and initiated his own recovery on the MBU-5/P mask. This last subject was clearly suffering from anxiety, and was therefore returned to ground level. At 30,000 and 25,000 ft, all subjects successfully maintained sea-level equivalent arterial hemoglobin saturation levels without requiring recovery on the MBU-5/P mask. Presented in Tables 4-7 are the effects of reducing flow at 40, 35, 30, and 25 thousand feet, respectively. At 40,000 ft, reducing the flow resulted in an unacceptably low level (78%) in arterial hemoglobin saturation (Table 5). Further, the SaO_2 on this reduced flow was not stable, and usually required recovery of the subject on the MBU-5/P. Only 2 subjects were able to maintain safe blood oxygen saturation levels when flow was reduced to 3.1 L/min ATPD.

At 35,000 ft, reducing the flow from 4.2 to 3.2 L/min ATPD resulted in an insignificant reduction in arterial hemoglobin saturation from 92% to 89%. When flow was further reduced to 2.0 L/min ATPD, arterial hemoglobin saturation fell to stable but unacceptably low values. At 30,000 and 25,000 ft, reducing by half the flow to the transport passenger oxygen mask still produced arterial hemoglobin saturation levels well above the 10,000-ft altitude air-breathing SaO_2 threshold value of 87% (Tables 6 and 7).

DISCUSSION

Our original interest in the transport passenger oxygen mask concerned the possibility that modest reductions in oxygen flow, as specified by MIL-D-19326F (2), might exist in USAF operational aircraft. In the event of a loss of cabin pressure, USAF aircraft by regulation must descend to, and remain at or below, 25,000 ft until mission completion or until cabin pressurization is regained. Therefore we have evaluated the effect of oxygen flow to the mask at altitudes at and above this ceiling; namely, 25, 30, 35, and 40 thousand feet. That the mask is capable of maintaining SaO_2 equal to or in excess of 87% (10,000-ft air-breathing equivalent SaO_2), when provided with oxygen flows in accord with MIL-D-19326F (2) at altitude, was not surprising. What was surprising was the difficulty in achieving these acceptable levels of SaO_2--at 40,000 ft and, to a lesser extent, at 35,000 ft--commensurate with reductions in flow. Only 1 subjects were able to don the mask and maintain acceptable levels of SaO_2 on the initial attempt at 40,000 ft. The apparent poor performance of this mask at the higher altitudes is probably a result of mask fit and altitude-chamber protocol.

Most previous investigations utilizing a phase-dilution type of emergency oxygen mask have attempted to have the masks fitted to each subject, usually at ground level. We made no attempt to optimize mask fit; indeed, we did not give instructions to the subjects except for the fact that the elastic headband should be worn. Nearly all subjects, of their own free will, used one hand to hold the mask to their face. Depicted in Figure 2 is the oxygen concentration in the Dixie Cup mask from one subject breathing at 30,000 ft. This subject was using only the elastic headband to secure the mask to his face. When the subject was instructed to use his hand to better secure the mask (at the 20-sec mark in Fig. 2), oxygen concentration was increased dramatically as inboard mask leakage was reduced. The second factor which probably contributed to the poor mask performance is the altitude protocol itself. Figure 3, taken from McFadden (1), is fairly typical of previous investigations and certification runs with phase-dilution-type oxygen masks. After an air-breathing baseline, an ear and sinus check is performed at low altitudes; the subject then dons the passenger mask, and the chamber altitude is increased in a stepwise fashion. After the final altitude is attained and data recorded, the chamber altitude is brought directly to ground level. During this investigation, the chamber altitude was brought directly to the highest altitude before the mask was donned (Fig. 1). Initially, no one knew how long each subject might have to remain above 30,000 ft to complete the evaluation; but this protocol seemed to offer the most protection to our subjects with respect to decompression sickness.

In retrospect, this sequence of altitude exposure--while perhaps minimizing DCS-related phenomenon--did not allow our subjects the opportunity to gain confidence with the Dixie Cup mask at the lower altitudes. Indeed, all our subjects have undergone altitude chamber training and are taught to recognize their own hypoxia symptoms. These subjects, each wearing a novel mask for the first time, at 40,000 ft may have been consciously or subconsciously more alert regarding their own symptoms of hypoxia. This increased alertness may have resulted in some over-breathing of the system. This possibility is supported by the observation that most subjects could be coached into receiving adequate protection from hypoxia by monitoring their rate and depth of breathing.

At 40,000 ft, upon successful transfer of the subjects from the MBU-5/P mask to the Dixie Cup, reductions in flow from 4.7

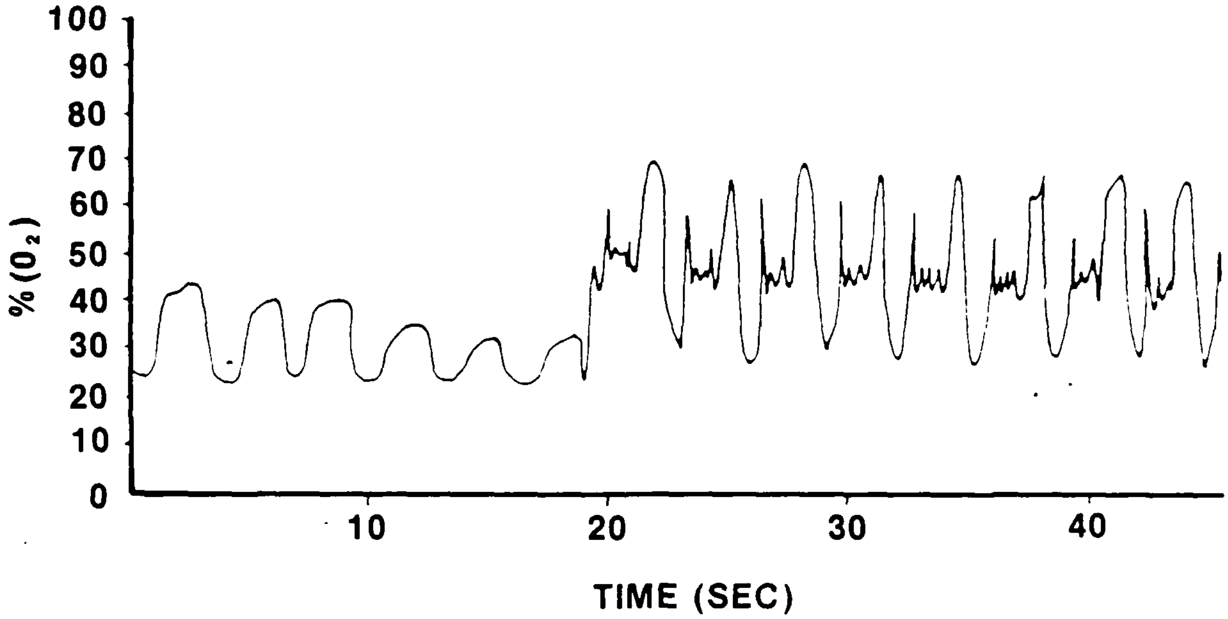

Figure 2. Percentage oxygen concentration, in the mask cavity, obtained from a subject exposed to 30,000-ft simulated altitude.

At the 20-sec mark, the subject was instructed to utilize his hand to further secure the mask to his face. This action resulted in a large improvement in oxygen concentration in the mask cavity. Oxygen concentration went from about 32% up to 70%. This increase in mask oxygen concentration probably resulted from a decrease in inboard leakage of ambient air into the mask cavity.

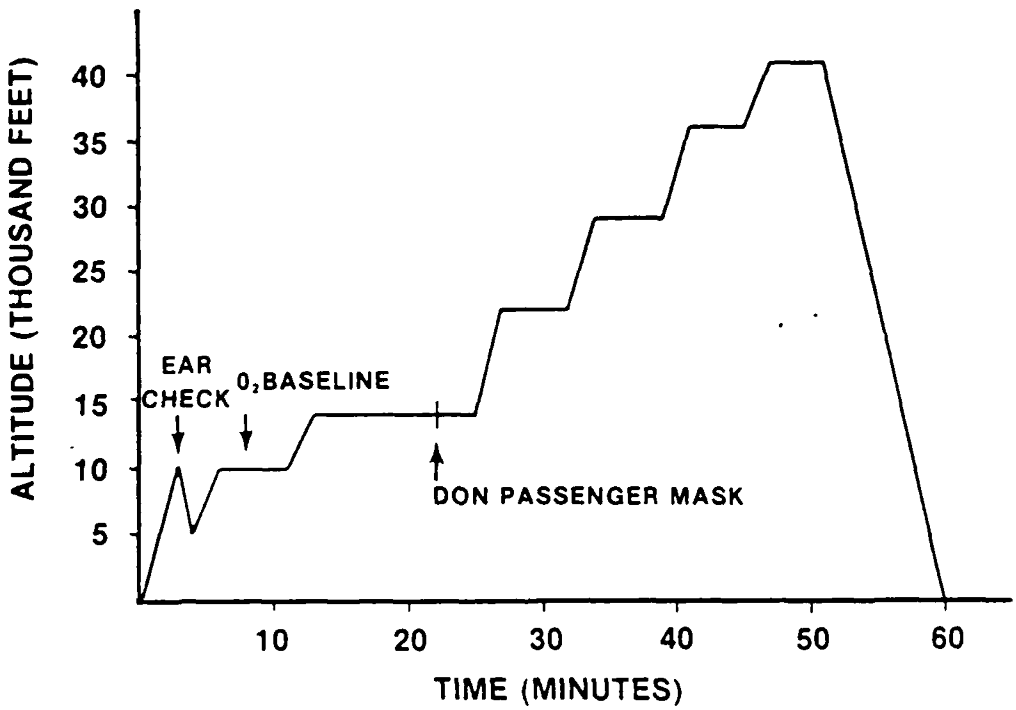

Figure 3. Altitude chamber profile used in evaluation of SIERRA 2039-601 series prototype of passenger disposable oxygen mask. [Original Fig. 1 from McFadden (1).]

to 3.6 L/min ATPD resulted in a mean SaO_2 of 78%. Two subjects maintained their SaO_2 at 84%; however, reducing flow to their masks by another 1/2 L/min resulted in an SaO_2 of 80% and 76%, respectively. McFadden (1) also using the Sierra passenger mask, utilized a flow of 3.1 L/min (NTPD) at 40,000 ft to maintain SaO_2 in his subjects, even during 3 min of moderate exercise. The difference between 3.1 L/min NTPD and ATPD is considerable, especially at the higher altitudes. McFadden also used ear oximetry to determine SaO_2, but employed instrumentation other than the Hewlett-Packard utilized in this study (1). McFadden cited a mean SaO_2 value of 93.8% for subjects, at rest, breathing air at 14,000 ft. The Handbook of Respiratory Data in Aviation (3) suggests that an SaO_2 value of 82% would be expected at this altitude. Indeed (as stated in the "Introduction"), an SaO_2 of 87% occurs at about 10,000 ft. If McFadden's ear oximetry values, obtained while the subjects breathed oxygen at altitude, are in error by a similar magnitude, then our SaO_2 results would not be so different.

At 35,000 ft, while using the passenger mask, one subject was unable to attain a stable SaO_2 after two attempts; and another subject complained of hypoxia symptoms. The second subject, who was suffering from anxiety and hyperventilation and was returned to ground level, had an SaO_2 of 78% at recovery. The remaining 11 subjects were able to use the passenger oxygen mask without any problem. When flow to the mask was reduced from 4.2 to 2.6 L/min ATPD, the mean SaO_2 went from 92% to 85%. Further reductions in flow resulted in unacceptable reductions in SaO_2.

At 30,000 and 25,000 ft, all subjects were successfully transitioned to the Dixie Cup mask without incident. At 30,000 and 25,000 ft, reducing the flow to the mask by one-half still resulted in an SaO_2 of 88% and 92%, respectively.

Several subjects were retested at higher flow rates, as shown in Table 8 (2.7 L/min NTPD - 14.5 L/min ATPD at 40,000 ft). Unfortunately, the fact that this retesting did not contribute to higher SaO_2 values is apparent when Tables 4 and 8 are compared. Note that several tests shown on Table 4 were made after second and third attempts, and diligent coaching by the investigators. Also, SaO_2 levels are not always repeatable, even at similar altitudes and flows--a fact which we believe to be especially true at altitudes above 30,000 ft, where the need for 100% oxygen is so great. Unfortunately, these altitudes also maximize the effect of mask leakage, whereby the passenger cannot fully utilize sufficient oxygen even when the supply flow is adequate. Continuous flow oxygen systems normally have an operational ceiling of 30,000 ft and an emergency ceiling of 35,000 ft.

In conclusion, we have utilized a laboratory environment to simulate an operational field problem. While resting quietly, well-trained and experienced human subjects can apparently successfully utilize these passenger emergency oxygen masks to avoid catastrophic hypoxia in the controlled environment of an altitude chamber. Should a rapid decompression occur in a transport aircraft at 39,000-41,000 ft, we suspect that few (if any) passengers would have the presence of mind to control their rate and depth of breathing and remain calm. At 35,000-40,000 ft, the over-breathing of this emergency system and excessive mask leakage are continual problems. We therefore conclude that severe reductions in mask oxygen flow, below those values specified in MIL-D-19326F (2), are not to be considered. Lowered flows in the range of 3.5 to 4.0 L/min NTPD, as presently experienced onboard certain aircraft, should be well tolerated by the majority of passengers for short periods. This finding does not, however, preclude the possibility of loss of consciousness (in rare circumstances) by certain individuals. Furthermore, we suggest that guidelines on the most effective use of these masks be incorporated into all MAC preflight safety briefings.

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TABLES 1 - 8

TABLE 1. COMPARISON OF ATPD AND NTPD FLOW OF OXYGEN AT THE FOUR TEST ALTITUDES

Oxygen flow (L/min NTPD):	4.7	4.0	3.5	2.7	2.0
Approximate oxygen flow (L/min ATPD)[a]:					
40,000 ft (141 mm Hg)	25.3	21.5	18.8	14.5	10.8
35,000 ft (179 mm Hg)	19.9	17.0	14.8	11.4	8.5
30,000 ft (226 mm Hg)	15.8	13.4	11.7	9.1	6.7
25,000 ft (282 mm Hg)	12.6	10.7	9.4	7.2	5.4

[a]Corrected for pressure changes only.

TABLE 2. DATA ON AGE, HEIGHT, AND WEIGHT OF SUBJECTS

Subject	Age	Height (in)	Weight (lb)
1	26	68	150
2	39	76	229
3	32	71	174
4	41	72	168
5	29	73	170
6	29	65	139
7	36	71	180
8	33	70	164
9	27	70	157
10	26	71	161
11	37	66	140
12	38	70	155
13	38	71	175
14	39	68	170
$\bar{X}$	33.6	70	166.6
S.D.	±5.35	±2.80	±21.89

TABLE 3. ARTERIAL OXYGEN SATURATION FOR SUBJECT POPULATION UTILIZING THE TRANSPORT PASSENGER OXYGEN MASK (DIXIE CUP) AT SPECIFIED OXYGEN FLOWS AT 40, 35, 30, AND 25 THOUSAND FEET. MEAN ± S.D.

Altitude in ft. (No. of subjects)	Flow to mask (L/min ATPD)	SaO_2
40,000 (n = 8)	4.7	88 ± 2.8
35,000 (n = 11)	4.2	92 ± 3.5
30,000 (n = 13)	3.6	98 ± 1.2
25,000 (n = 13)	2.7	97 ± 1.0

TABLE 4. EFFECT OF REDUCING OXYGEN FLOW TO THE TRANSPORT OXYGEN MASK AT 40,000-FT SIMULATED ALTITUDE ON ARTERIAL BLOOD OXYGEN SATURATION

Subject No.	Oxygen flow at 40,000 ft (L/min ATPD) 4.7	3.6	3.1
	[Arterial oxygen saturation]		
1	90[a]	84	80
2	84[b]	75	--
3	91[a]	72	--
5	87[a]	75	--
6	90	84	76
7	90[a]	78	--
8	84	80	--
9	89	76	--
10	LOC	--	--
11	U	--	--
14	U	--	--
$\bar{X}$	88	78	78
S.D.	±2.8	±4.4	±2.8

a = Second attempt to don mask
b = Third attempt to don mask
LOC = Subject lost consciousness, and was recovered by inside observer.
U = Unable to attain stable SaO_2.

TABLE 5. EFFECT OF REDUCING OXYGEN FLOW TO THE TRANSPORT OXYGEN MASK AT 35,000-FT SIMULATED ALTITUDE ON ARTERIAL BLOOD OXYGEN SATURATION

Subject No.		Oxygen flow at 35,000 ft (L/min ATPD) 4.2	3.2	2.6	2.0
		[Arterial oxygen saturation]			
1		91	92	90	80
2		88	80	--	--
3		U			
4		88	92	88	80
5		U			
6		92	90	80	--
7		96	90	--	--
9		97	86	78	--
10		92	86	--	--
11		98	96	88	79
12		88	88	--	--
13		92	--	86	--
14		92	86	--	--
n	=	11	10	6	3
$\overline{X}$	=	92	89	85	80
S.D.	=	±3.5	±4.4	±4.9	±0.6

U = Unable to attain stable SaO_2.

TABLE 6. EFFECT OF REDUCING OXYGEN FLOW TO THE TRANSPORT OXYGEN MASK AT 30,000-FT SIMULATED ALTITUDE ON ARTERIAL BLOOD OXYGEN SATURATION

Subject No.	Oxygen flow at 30,000 ft (L/min ATPD) 3.6	2.6	1.8
	[Arterial oxygen saturation]		
1	98	98	94
2	97	90	--
3	98	92	78
4	98	94	91
5	98	96	92
6	98	84	78
7	98	96	88
8	99	98	98
9	98	97	88
10	98	94	85
11	98	97	92
12	94	88	89
13	98	92	84
n =	13	13	12
$\bar{X}$ =	98	94	88
S.D. =	±1.2	±4.2	±6.1

TABLE 7. EFFECT OF REDUCING OXYGEN FLOW TO THE TRANSPORT OXYGEN MASK AT 25,000-FT SIMULATED ALTITUDE ON ARTERIAL BLOOD OXYGEN SATURATION

Subject No.	Oxygen flow at 25,000 ft (L/min ATPD) 2.7	1.7	1.4
	[Arterial oxygen saturation]		
1	98	98	--
2	98	--	90
3	96	90	--
4	95	90	84
5	97	97	94
6	97	--	94
7	98	96	91
8	98	--	98
9	98	88	--
10	98	--	92
11	98	--	95
12	96	92	--
13	98	--	91
n =	13	7	9
$\bar{X}$ =	97	93	92
S.D. =	±1.0	±4.0	±3.9

TABLE 8: PARTS A AND B. EFFECT OF REDUCING OXYGEN FLOW TO THE TRANSPORT OXYGEN MASK AT 40,000-FT (PART A) AND 35,000-FT (PART B) SIMULATED ALTITUDE ON ARTERIAL BLOOD OXYGEN SATURATION (RE-TEST OF FIVE SUBJECTS; COMPARE WITH TABLES 4 AND 5)

Part A

Subject No.	Oxygen flow at 40,000 ft (L/min ATPD) 14.5	10.8
	[Arterial oxygen saturation]	
5	70	--
6	80	--
7	76	--
10	78	--
12	72	--
$\bar{X}$ =	75	
S.D. =	±4.15	

Part B

	Oxygen flow at 35,000 ft (L/min ATPD) 11.4	8.5
	[Arterial oxygen saturation]	
5	88	76
6	94	86
7	- Probe off ear -	
10	94	88
12	94	85
$\bar{X}$ =	92	84
S.D. =	±3.05	±5.3