DEVELOPMENT OF THE USAF SCHOOL OF AEROSPACE MEDICINE (USAFSAM) PORTABLE THERAPEUTIC LIQUID OXYGEN (LOX) BREATHING SYSTEM

SCHOOL OF AEROSPACE MEDICINE

DECEMBER 1973

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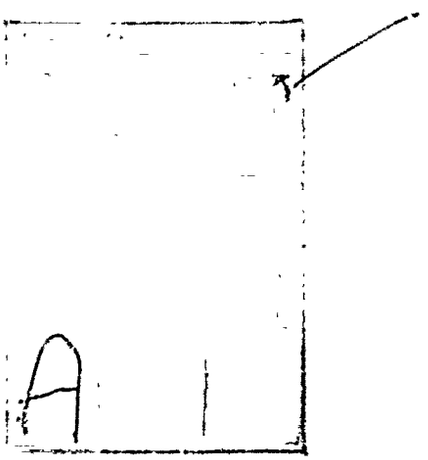

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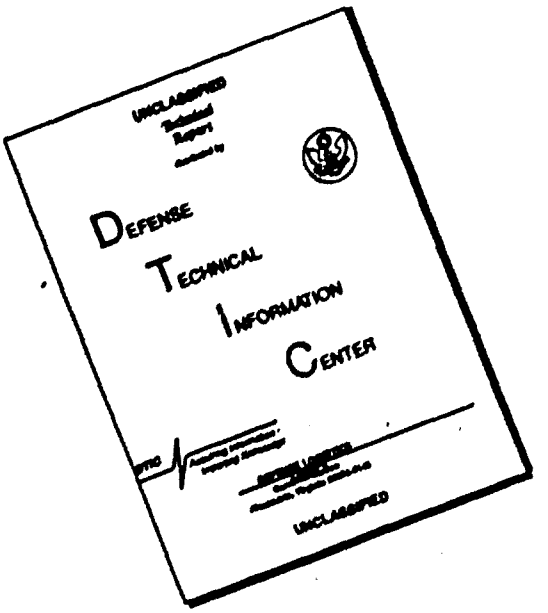

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The USAFSAM portable therapeutic liquid oxygen (LOX) breathing system was designed to meet an urgent operational requirement to provide a portable, low pressure, therapeutic oxygen system for use on multimission aeromedical aircraft that do not have an integral therapeutic oxygen system. Specifications required that the systems be safe, compact, lightweight, and self-contained. They were to be capable of delivering therapeutic oxygen at rates from 8 to 10 liters per minute to two patients simultaneously for a minimum of 6 hours.

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20. Abstract (continued)
Compatibility of the system with all USAF approved ventilatory, resuscitative, and inhalation therapy equipment was required. The units were also to be rechargeable from standard USAF oxygen supply trailers (LOX carts). Contractual efforts produced a poor design concept that did not meet specification. The contract was terminated and the systems were redesigned and fabricated inhouse. Development test and evaluation of several prototype models verified the feasibility and defined the final configuration. Preproduction prototypes were fabricated for operational test and evaluation by aeromedical personnel of Pacific Air Forces (PACAF), Tactical Air Command (TAC), and USAF School of Aerospace Medicine Aerospace Nursing Branch. The evaluations indicated the portable LOX system performed the function for which it was designed in a satisfactory manner and recommended it be standardized for routine use in Air Force aeromedical evacuation missions.

PREFACE

The author is grateful to Mr. Donald McDougall and Sgt. Bernard Humes of the Instrument Shop for fabricating the prototypes.

DEVELOPMENT OF THE USAF SCHOOL OF AEROSPACE MEDICINE (USAFSAM) PORTABLE THERAPEUTIC LIQUID OXYGEN (LOX) BREATHING SYSTEM

INTRODUCTION

Several multipurpose aircraft (C-118, C-7A, C-97, C-130, C-131) used for aeromedical missions do not have integral therapeutic oxygen systems.

The need for contingency oxygen administration inflight is met by carrying therapeutic kits (containing small "D" size oxygen cylinders) or large, high-pressure (2200 psi), hospital-type "H" size cylinders. The "D" size cylinders provide only a 15-minute supply of oxygen; the "H" size supplies several hours but weighs nearly 200 pounds when full. The use of the high-pressure tank is potentially hazardous in the event of an aircraft emergency or enemy attack. The cylinders are not only cumbersome and heavy but, should the securing mechanism fail or the valve be broken off, the cylinder could become a projectile which could cause serious damage to an aircraft and endanger passengers and crew.

The need for a portable, lightweight, low-pressure liquid oxygen (LOX) system was identified in 1967 by the Command Surgeon, Pacific Air Forces, when it was reported that "the availability of oxygen resources was a limiting factor when the workload of the 9th Aeromedical Evacuation Squadron increased because of hostile action in SEA."

EQUIPMENT DESCRIPTION

The USAFSAM portable therapeutic liquid oxygen system is a compact unit enclosed in a metal case, 14" high x 12 3/4" wide x 16" long. It weighs 30.5 pounds empty and 43.0 pounds filled. The unit contains a standard aircraft-type 5-liter LOX converter assembly, a filler, pressure buildup-and-vent valve, an oxygen regulator, a pressure gage, and a liquid quantity gage. The converter assembly is a vacuum-insulated container. Evaporating coils, a pressure-closing valve, a check valve, and two relief valves are attached internally. The gas pressure at the outlet is preset to 50 psi. Handles, web straps, and buckles are attached on two sides of the case for carrying and aircraft/vehicle tiedown and securing. An accessory kit (containing 2 each

pressure compensating oxygen flowmeters, humidifiers, 12-foot low-pressure oxygen hoses, and oxygen masks) accompanies each system. (See Figures 1 and 2.)

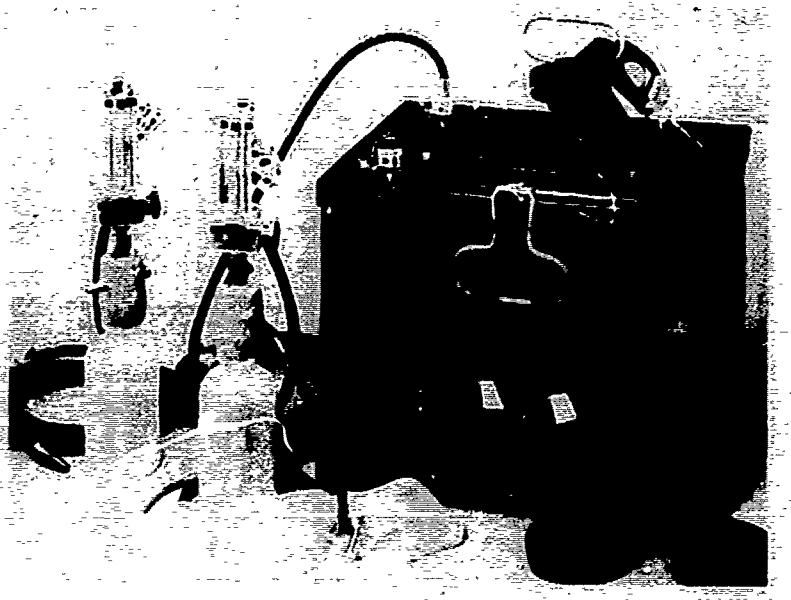

Figure 1. USAFSAM portable therapeutic liquid oxygen system with accessories.

METHODS

In 1969, a contract was let to modify an off-the-shelf item to meet Air Force needs. This effort, when tested, proved unsuccessful. The contract was terminated in October 1969, and an inhouse developmental effort was begun.

With emphasis placed on operational effectiveness, patient-user safety, and compatibility with existing aircraft systems, the first in-house prototypes were fabricated in December 1969. Development test and evaluation pointed out the need for minor design changes, and these modifications were made.

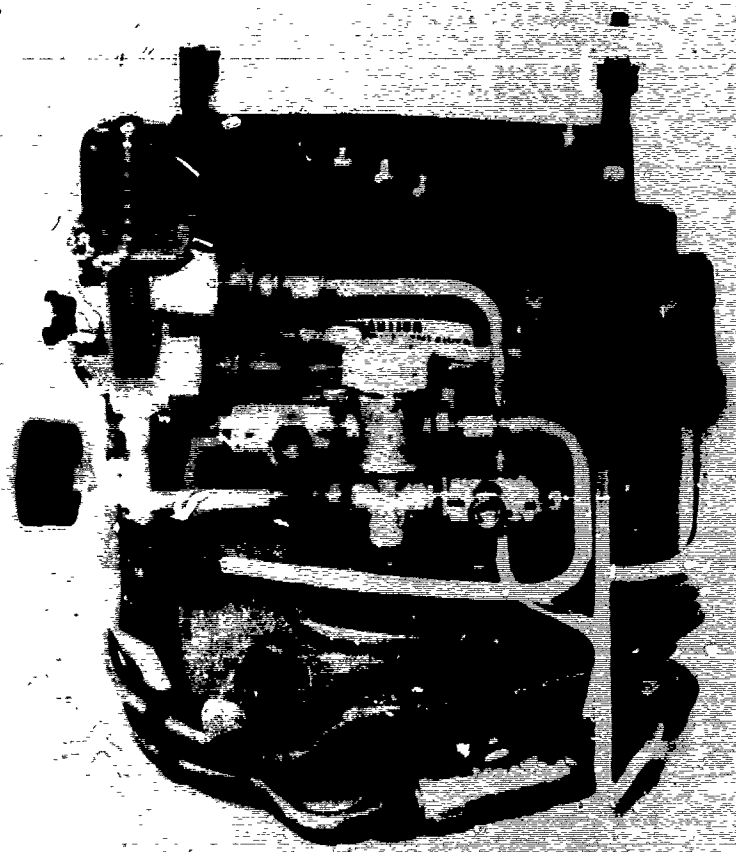

Figure 2. Modified 5-liter LOX converter assembly.

In July 1970, 17 preproduction prototypes were delivered to the Aerospace Nursing Branch, USAFSAM, and to aeromedical evacuation squadrons of PACAF and TAC for operational test and evaluation.

Based on test results and value engineering efforts, 22 second-generation prototype units were fabricated inhouse. They, too, were tested by operational aeromedical evacuation squadrons.

RESULTS

The first prototypes were used operationally on C-130's, C-131's, and C-7A's from August 1970 to February 1972. Although deficiencies were identified, the aeromedical crewmembers judged the therapeutic LOX systems far superior to the portable systems in use. Recommendations made and incorporated into the second-generation prototypes included: redesigning the plumbing so that the system could be quickly filled with a LOX delivery pressure of 25 psi by deleting the relief valve on the vent opening of the filler valve assembly, sealing the corners of the bottom outer case so it could serve as a drip pan, and changing to larger carrying handles.

The second-generation prototypes were tested from February 1972 to January 1973 as primary therapeutic oxygen equipment on C-130 and C-131 aircraft. Minor problems were encountered during testing; 3 leaking or defective filler valves were replaced onsite, and handle screws which vibrated loose were repaired onsite by applying self-locking nuts. A pertinent observation made during field testing concerned the amount of venting (i.e., standby loss) which increased in hot climates.

The LOX units were enthusiastically endorsed by aeromedical crewmembers. Comments elicited during testing included: the size and portability of the unit were outstanding; the system extended patient movement capability by increasing the readily available therapeutic oxygen supply; the ability to provide the therapeutic oxygen for two patients simultaneously was excellent; reliability, safety, and ease of securing the units inflight were satisfactory; the outlet pressure of 50 psi allowed the operation of all ventilatory, resuscitative, and inhalation therapy equipment; maintenance and storage arrangements for the LOX units were made easily at most of the test squadrons with a host-tenant agreement.

DISCUSSION

This item meets design and performance specifications and fulfills the development objectives. Each system will deliver a continuous oxygen flow up to 15 liters per minute to one or two patients simultaneously for extended periods of time (i.e., at a flow rate of 5 liters per minute one patient can receive oxygen for over 13 hours) (Fig. 3). The theoretical operating times at STP (temperature 0° C and pressure 1 atmosphere) are shown in Table 1.

Figure 3. Example of placement of the VCA unit between litters.

TABLE 1. THEORETICAL OPERATING TIME AT STP[a] ASSUMING THE CONVERTER IS FILLED TO CAPACITY WITH FIVE LITERS OF LIQUID OXYGEN

Liter flow/min	1 patient Hr	Min	2 patients Hr	Min
5	13	24	6	42
7	9	34	4	47
10	6	42	3	21
15	4	28	Not recommended	

[a]Temperature 0° C and pressure 1 atmosphere.

At a delivery rate of 15 liters per minute, the temperature of the oxygen at the patient outlet is no more than 4.5° F (2.5° C) lower than the temperature of the ambient air. It will serve as an oxygen source with all ventilatory, resuscitative, and inhalation therapy equipment (Fig. 4). The units can be filled quickly and easily from standard USAF oxygen supply trailers (LOX carts) at the flightline.

Engineering data for the system is identified as Air Force Drawing Number AF 721177 and may be obtained in accordance with AFR 67-28.

CONCLUSIONS

The USAFSAM portable therapeutic liquid oxygen system was designed and fabricated for use during aeromedical operations in multimission aircraft that have no integral oxygen capability; they may also be used in ambulances, ambuses, and helicopters. This item meets development objectives and was enthusiastically endorsed by aeromedical crewmembers during operational test and evaluation.

Figure 4. [illegible] ...ive,
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