OXYGEN In The Spotlight

Increased altitude capability of general aviation aircraft focuses attention on need and desirability of carrying a supply of 'bottled air' while flying

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Although the subject of adequate oxygen supply in flight has been in the foreground since man first took to the air, it remains a cloudy, gray area in the minds of too many general aviation pilots. An intangible, taken-for-granted element, oxygen has received little more than passing interest. With increasing numbers of lightplane pilots operating at altitudes where it is vital, however, supplemental oxygen use has begun to warrant more notice.

To help in informing its members why oxygen is needed, how to use it, where to get it and what it may be expected to cost, The AOPA PILOT recently sent a mail questionnaire to leading aviation oxygen and equipment companies. The U.S. Census of Manufacturers and the Thomas Register of American Manufacturers list about 275 breathing-oxygen producers and 56 oxygen-equipment makers in this country. About nine specialize in providing oxygen and associated equipment for general aviation use.

Reactions to the questionnaire from those companies indicate that they are poised to fulfill accelerated demands for their wares. They feel that greater demand hinges, however, on the ability and desire of general aviation leaders to make pilots more cognizant of the value of oxygen as a safety measure.

The general aviation industry and flying safety authorities seem to agree that widespread education in the use of oxygen in flying is sorely needed. There is less agreement on how that need might best be fulfilled. Some feel that the most direct and certain method would be to impose regulations, setting up arbitrary standards, and bring about education through enforcement. Others—and this includes most plane owners, manufacturers and AOPA—favor a form of industry-motivated orientation and education more in keeping with the private enterprise system.

The rapidly growing medical specialty known as aviation medicine was founded on man's need of supplemental oxygen to survive the effects of altitude. Studies in this area can be traced back to the earliest animal-bearing balloon flights in 1783.

What is oxygen? Briefly, it is a colorless, odorless, tasteless gaseous chemical element that makes up about 20% of the atmosphere and is essential to life processes and to combustion. The human system requires a continuous irrigation of 96% oxygen-saturated blood for peak mental function. If that oxygen saturation level falls below 87%, impairment of mental functioning occurs.

Due to the earth's gravitational pull, the atmosphere is most dense at sea level. As altitude increases, density decreases. The composition of the atmosphere remains unchanged up to an altitude of about 200 miles, but the partial pressure of oxygen varies with atmospheric pressure. It is the partial pressure of oxygen that controls the gaseous exchange in the lungs. As ascent is made, the total number of molecules of oxygen available to the body is diminished. The natural result is oxygen starvation, or hypoxia.

Depending on numerous factors, hypoxia may manifest itself in varied forms and at slightly different flight levels. Advanced age, anemia, emphysema, illnesses accompanied by fever, fatigue, alcohol, antihistamines and heavy smoking can lower individual tolerances to altitude. In all cases, hypoxia is insidious in its onset and may go unrecognized unless the pilot is aware of the phenomenon and knows what to expect in his individual case.

Technically, the flyer enters a new atmospheric environment the instant his plane clears the runway. Impairment of one's faculties does not occur, however, until he encounters a greatly rarefied atmosphere.

The first organ of the body to be affected by lack of an adequate supply of oxygen is the brain. It consists of nerve cells which, unlike those in other parts of the body, cannot function for more than 15 seconds without oxygen. Since the retina of the eye can be considered a direct extension of the brain, hypoxia's first evident toll is taken there, in night vision. This can be affected at altitudes as low as 5,000 feet.

Rapid and serious psychological consequences of flight without oxygen can occur between 10,000 and 15,000 feet, according to Dr. Harold N. Brown (AOPA 80227), chairman of the safety committee of the Flying Physicians Association. He claimed that, while oxygen pressure in the atmosphere decreases with altitude on a straight, smooth slope, the ability of the blood to assimilate oxygen goes down a slight slope for a period, then drops over a precipice.

A previous PILOT article (August 1959) established oxygen deprivation "plateaus" that may be applied as a rough yardstick to the onset and physical effects of hypoxia. At 5,000 feet, as has been mentioned, the retina is affected. At 10,000 feet there is definite but undetectable hypoxia. The oxygen saturation of the blood has dropped from 96% to 90%.

An altitude of 14,000 feet without supplemental oxygen brings on distinct dimming of vision, hand tremors, clouding of thought and memory. Oxygen is definitely required for maximum alertness. At 16,000 feet, one may act in a drunken manner—disoriented, belligerent or dangerously carefree—and completely lack rational judgment. Between 18,000 and 20,000 feet, 20% to 40% of efficiency and coordination is lost. Primary shock may occur and the individual may lose consciousness. Altitudes above 20,000 feet almost certainly will result in profound shock or even death after prolonged periods.

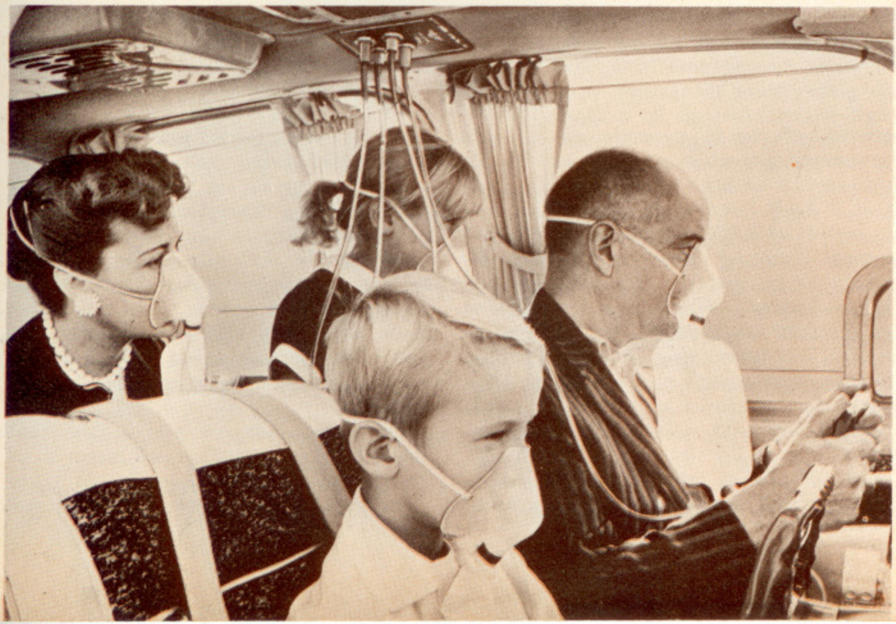
Dr. Stanley R. Mohler (AOPA 167639), director of FAA's Civil Aeromedical Research Institute, has compared the human "metabolic engine" to an aircraft engine. Both, he explained, require an adequate amount of oxygen to function properly. Neither is capable of storing oxygen.

At sea level and normal body temperature, the oxygen in the lungs is saturated with water vapor. That water vapor pressure produces a measurement of 47 millimeters of mercury (.9 pounds per square inch), as contrasted to an external pressure of 760 mm. of mercury, or 14.7 pounds of pressure per square inch. At an altitude of 12,000 feet the total air pressure is about 9.34 pounds per square inch but the lung water vapor pressure remains at .9 pounds per square inch. The water vapor content of the lungs therefore must take a larger "bite" out of the available air at 12,000 feet.

Although opinions differ on the altitude at which supplemental oxygen should appropriately be used, most authorities agree that extended flight without it at altitudes of 12,000 feet or more is unwise. AOPA resisted a move, launched by the Society of Automotive Engineers and adopted by FAA a few years ago, to enact a regulation that would make it mandatory to carry oxygen equipment aboard an aircraft in which flight to an altitude of 8,000 feet was anticipated.

Increased attention that is being focused on the use of supplemental oxygen has been engendered by the widespread appearance of higher-powered conventional and turbo-supercharged general aviation planes that are capable of operating most efficiently at altitudes formerly considered to be the exclusive realm of the military and air carrier. Increased usage of supercharged ships has accel-

A.I.R. oxygen system kits for general aviation planes, available with two- to 15-valve outlets, feature flush-mounted ceiling console to prevent injury on protrusions



Lightweight, high-pressure oxygen bottles for 10, 20 or 30-minute emergency supply, such as these developed by Pioneer Central Division of the Bendix Corporation, occupy little space and add little weight to light aircraft

Automatic oxygen console found in many single-engine and light twin aircraft is this Scott five-outlet unit

erated efforts to promote educational programs pointing up the safety requirements of high altitude flight. Last fall, FAA's Southwest Region initiated a series of highly successful "physiological training seminars" aimed directly at combatting the potential hypoxia hazard. AOPA has made plans to further that effort by helping to make available the AOPA Oxygen Course next month at Ohio State University in conjunction with the fourth annual National AOPA Flight Training Clinic at Columbus, O., June 17-19.

In addition to information and training provided through these educational courses, each manufacturer furnishes a comprehensive selection of "self-study" materials on request, covering selection and installation of oxygen equipment for specific purposes. They also provide virtually unlimited guidance to customers and prospective customers on how to use their equipment most effectively and economically, under what circumstances oxygen should and should not be used, and related matters.

One manufacturer emphasized that the bulk of information and material he furnishes to general aviation plane owners is designed to be educational

Emergency oxygen supply equipment for general aviation planes can be complex or as simple and economical as this Zep Aero portable "Zep-O-Life"

A portable oxygen unit offered by Puritan Compressed Gas Corporation for four-place aircraft consists of cylinder, manual regulator, quick-connect outlets, masks, rebreather bags and necessary tubing

rather than sales inducing. "Our marketing techniques take into consideration the fact that we have a responsibility to contribute to health and safety in aviation," he said. "We are more concerned that the plane owner have a clear understanding of the need for oxygen than that he buy his oxygen equipment from us."

Of the nine aviation oxygen equipment firms contacted by The PILOT, seven responded at length. The general feeling was that even the limited oxygen orientation to which the aviation community has been exposed thus far is having gratifying results.

Zep Aero, one of the largest suppliers of general aviation oxygen requirements, reported that its business has mushroomed to an even greater extent than that of the overall general aviation industry. Five years ago, private flying accounted for about \$200,000 of their gross. Today it approximates \$1,000,000. The firm enjoyed a 20% annual increase until 1964, when a 40% increase was posted.

Puritan Equipment, Inc., a subsidiary of Puritan Compressed Gas Corporation, pointed out that all private plane owners should have their aircraft equipped with oxygen because weather conditions frequently make it advantageous to fly at altitudes at which supplemental oxygen is definitely required. Scott Aviation Corporation, another leader in the field, feels that two important aspects necessitate the use of oxygen by all aircraft capable of being flown at hypoxic altitudes. These are the safety aspect and the health aspect. Regardless of what safety provisions have been designed and built into a plane, the combination of machine and man becomes unsafe when the pilot is affected by hypoxia.

Sierra Engineering Company only recently directed its energies toward providing oxygen equipment for general aviation aircraft, although it has been a major supplier to the military for many years. One factor cited by that firm in favor of equipping all private aircraft for oxygen is the hazard posed by carbon monoxide gases filtering into the cabin from faulty manifolds. The only safety measure possible under such a circumstance would be the use of oxygen.

Zep officials also spoke in favor of oxygen equipment in all planes. It is particularly important for instrument flight, for flying on top of clouds and for night flying, according to Wilbur J. Zepp (AOPA 25029), president of the firm. He also stressed the use of oxygen before letdown after a long and tiring flight. Many accidents that occur during long flights or on landing rollout might have been prevented through the use of oxygen, he claimed.

For the coming generation of pressurized private planes, Pioneer-Central Division of the Bendix Corporation believes that supplemental oxygen will be a necessity as an emergency backup. The incidence of emergencies requiring oxygen are constantly multiplying due to production of nonpressurized lightplanes that are capable of easily operating at hypoxic levels, however, the firm reported.

A.I.R. Corporation, while voicing gratification at the continuing increase in the use of oxygen by plane owners, indicated that it felt FAA is still in the "Jenny stage" of aviation where regulations governing oxygen in relation to general aviation are concerned. Actually, there are no operational regulations pertaining to the use of oxygen in general aviation aircraft except for those used for air taxi and similar commercial activities.

Equipment offered by these six

firms and others in the field range in sophistication and price from a few dollars for small portable units to several thousand dollars for elaborate systems designed to accommodate 10 or more passengers. Basically, however, all aviation oxygen systems fall into three general categories.

One is the small, lightweight unit, either portable or permanently installed, that gives a continuous flow of oxygen at a compensating rate. Although there is a certain amount of waste in oxygen delivery, such a unit has the advantage of scant weight and low initial cost. The second general category is made up of units with a manually controlled flow valve that can be regulated as altitude requires. The third and most sophisticated is the automatic diluter system which has an aneroid barometer to adjust automatically to the relative percentages of oxygen and outside air pressure as required to maintain sea-level or other predetermined pressure level. Both of the latter are commonly known as "demand" systems.

Two systems were developed for the Air Force that are appearing on the civil market. The diluter demand system allows exhaled air to leave through one port and 100% oxygen to be drawn into the user's lungs through another port. For flight at altitudes of 35,000 to 40,000 feet, a system is added that forces oxygen into the lungs at moderate pressure.

Nearly every oxygen equipment company responding to AOPA's questionnaire indicated that it can fulfill virtually any general-aviation-user requirement. Pioneer-Central offers panel and miniature regulators, pressure reducers, portable systems, mask assemblies and all other oxygen system components. Prices vary from $35 to $150 for plastic and metal breathing regulators, $250 for panel-mounted demand regulators, and $400 for the company's lowest priced complete oxygen system.

Scott's line for general aviation starts at $169.50 for a portable unit capable of accommodating two people for three hours and goes up to about $320 for a built-in system for four. All reportedly provide proper oxygen flow to maintain sea level equivalent pressure up to an altitude of 30,000 feet. In addition, the company offers small hand bottles for limited emergency use.

Sierra Engineering reported that its more sophisticated current assemblies were developed primarily for military and commercial use, but several new concepts are being developed and tested specifically for general aviation. Assemblies now available—oxygen masks and component parts—are priced from $40 to over $100. Projected equipment, although not yet priced, will be competitive, the firm promised.

Puritan specializes in oxygen systems for aircraft that fly at 20,000 to 41,000 feet. It has complete units priced from $400 to about $2,000, and does considerable work directly with aircraft manufacturers—among them, Aero Commander, North American, Douglas and Boeing.

Zep attributes about 95% of its business to contracts with aircraft manufacturers. It offers at retail portable units priced from $53 to $490, as well as four- or five-outlet installed systems at $390 to $500.

A.I.R. reported that its oxygen equipment sales volume today is six times as great in total units as it was five years ago. Offering fixed, automatic installations ranging in price from $237.50 to $300 and portable units priced from $69.50 to $157 (all subject to dealer discounts), A.I.R. does 85% of its business with dealers and 15% in direct retail sales.

Dye Oxygen Company offers in its Sky-Ox line equipment ranging in price from $129.95 to $397.50. Its vari-

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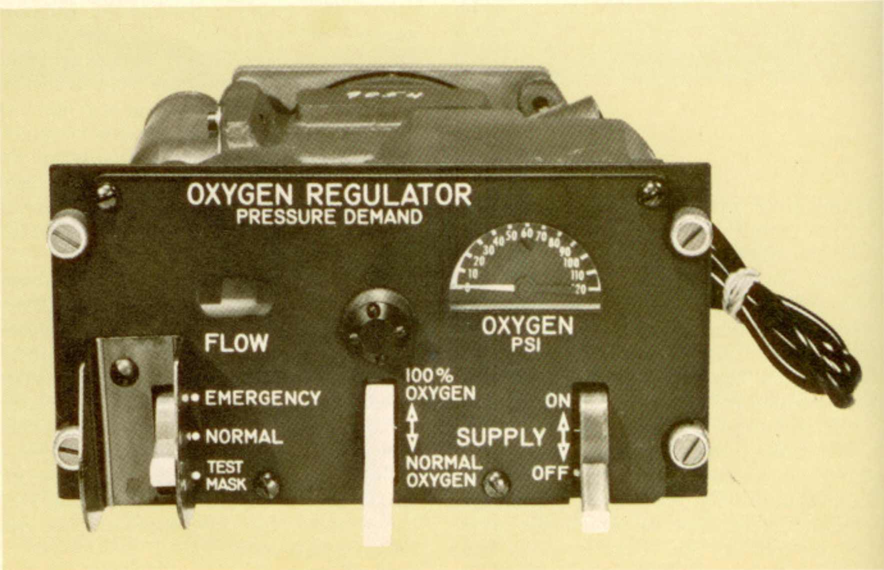
More complex oxygen units may include panel type regulator such as this designed for heavier corporate aircraft use



In addition to having oxygen available for high altitude flight, consideration has to be given to appropriate type and fit. In preparation for pressure chamber "flight" in San Antonio, Tex., AOPA staff member Michael Huck is "calibrated" for proper oxygen mask

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ous continuous flow and demand type installations are capable of accommodating from one to 20 people.

Service and maintenance of oxygen equipment today presents little difficulty, according to the manufacturers. Virtually every hub-type airport has facilities to refill oxygen tanks—cost will average $3 or $4—and most FAA certificated ground service personnel are capable of performing periodic and standard maintenance. Manufacturers recommend that overhaul of regulators or gages be performed by the factory of origin or authorized company representatives.

Because oxygen in mixture with some other elements can be highly combustible, it is often regarded by the uninformed pilot as an added hazard to flying rather than as a safety measure. But potential dangers associated with the respiratory use of oxygen can be minimized by common sense and integrity of equipment design, most manufacturers believe. Outmoded misconceptions and fears regarding the use of oxygen could be readily overcome if the general aviation industry would aggressively seek to promote greater understanding and if, during training in the use of navigation equipment, pilots were also given training in the need for and use of oxygen equipment, Puritan officials feel.

Other manufacturers pointed out a number of basic precautions to help enhance the safe use of oxygen. One should not smoke while using oxygen or for a few minutes after removing the mask. When eating or performing mechanical work, the hands should be thoroughly cleansed before handling oxygen plug-in fittings or masks. Since oil, grease or hydrocarbons of other types in combination with oxygen may result in spontaneous combustion, all oxygen equipment should be kept free of such properties.

Under high degrees of pressure, oxygen can be touchy. That is why all containers and equipment are conspicuously marked to be handled with care. If directions and warnings regarding its use are followed, however, safety is relatively assured.

Although supplemental oxygen in some form is universally recognized as a necessity to sustain high altitude flight, it cannot be regarded as the ultimate solution to all such aeronautical problems. There is too much about this life-sustaining element that is still conjectural or unknown. It is fairly certain, however, that contrary to widely held belief, it will not afford instantaneous cure for hangover.

Research into the use of pure oxygen over greatly extended periods of time indicates that, despite its life-saving quality, it might also be detrimental to health and safety. An experiment was reported recently in Aerospace Medicine in which mice, rats, guinea pigs, dogs and monkeys were exposed continuously to an atmospheric environment of 95%-99% oxygen. Only a few of the rats survived the full 240-hour duration of the project. Toxic effects, reflected by labored breathing and lethargy, occurred after 15 to 20 hours in rats, 36 to 42 hours in dogs, and 72 to 96 hours in monkeys.

No evidence exists that similar experiences would result in the case of man. In fact, use of oxygen at altitudes over 5,000 feet has been a regular practice of the military air services for many years and there has been no discernible detrimental effect.

Until a better solution presents itself, the vast majority of pilots obviously will have to rely on the use of supplemental oxygen to maintain peak mental and physical alertness during flight above 10,000 or 12,000 feet. With increasing numbers covetously eyeing airspace "above the weather," the oxygen equipment business can reasonably be expected to prosper. ●