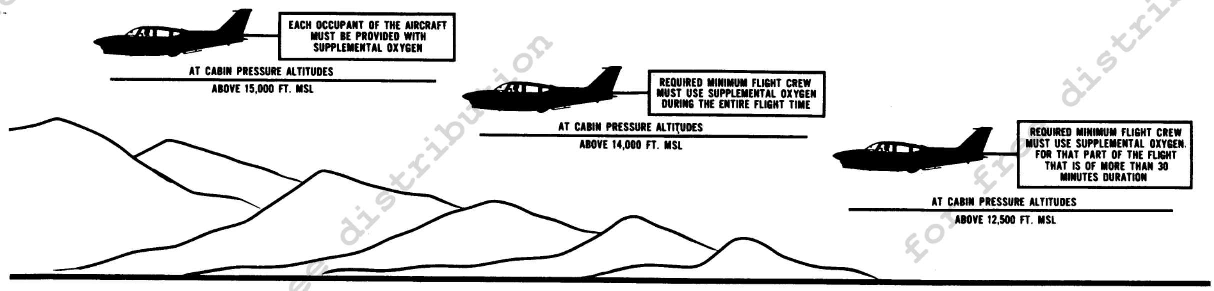
Department of Transportation
FEDERAL AVIATION ADMINISTRATION

VFR PILOT EXAM-O-GRAM NO. 49

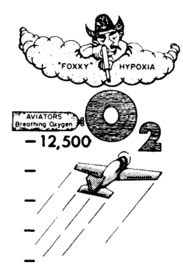
USE OF OXYGEN IN GENERAL AVIATION AIRCRAFT



Continuing increases both in the number of high-performance and light turbocharged general aviation aircraft and the number of aircraft concentrated in lower altitudes, encourage more pilots to get out of the "physiological zone" (sea level to 12, 000 ft.) into the "physiological deficient zone" (12, 000 to 50, 000 ft.) as a matter of economy and safety. In the lower zone, only minor oxygen problems exist. However, in the higher zone, oxygen deficiency can result in a pilot or passenger becoming a severe hypoxic case.

WHAT IS HYPOXIA? Hypoxia is the result of a lack of sufficient oxygen in the body cells or tissues. There are several types of hypoxia but this Exam-O-Gram discusses only the hypoxic type or altitude hypoxia -- that occurs in the "physiological deficient" zone.

WHAT ARE HAZARDS OF HYPOXIA? The most important single hazard characteristic of hypoxia at altitude is that if the pilot becomes too engrossed with his flight duties, he may not notice the symptoms or effects of hypoxia. For example: A pilot, flying at 24, 000 feet in an unpressurized aircraft, inadvertently pulls his mask connector out of the oxygen system outlet. Engrossed with radio communications and flying "instruments, " he fails to notice the separation. At this altitude, without supplemental oxygen, his time of useful consciousness (amount of time a pilot is able to effectively or adequately fly his aircraft with an insufficient supply of oxygen) is 3 minutes. Beyond this he will probably be unable to recognize his problem or do anything about it.
At flight altitudes, above 12, 000 ft., the onset of hypoxia is insidious. All persons begin to deteriorate in alertness and mental efficiency to some degree above 12, 000 ft. without supplemental oxygen. Above 14, 000 ft., distinct impairment of mental functions occurs--especially with respect to mathematical and reasoning capabilities.



WHAT ARE SYMPTOMS OF HYPOXIA? Since individuals differ widely in their reaction to hypoxia, it is impossible to group symptoms in a specific order. Therefore, in order to detect hypoxia, you need to know your own symptoms from the following list: (1) Increased breathing rate, headache, fatigue; (2) light headed or dizzy sensations, listlessness; (3) tingling or warm sensations, sweating; (4) poor coordination, impairment of judgment; (5) loss of, or reduced vision, sleepiness; (6) blue coloring of skin, fingernails, and lips; and (7) behavior changes, a feeling of well being (euphoria).

IS VISION AFFECTED BY LACK OF OXYGEN? The cellular retina of the eye is highly susceptible to lack of oxygen. Since rod cells are several hundred percent more sensitive to lack of oxygen than cone cells, night vision is sharply impaired at higher altitudes -- even though other symptoms of hypoxia may not be apparent. It is said that a pilot flying at night is 24 % blind at 8, 000 ft. ; 50% blind at 12, 000 ft. This is why supplemental oxygen is recommended when flying above 5, 000 ft. at night.

AT WHAT ALTITUDE ARE YOU LIKELY TO GET HYPOXIA? Anyone flying above 12, 000 ft. in an unpressurized aircraft without supplemental oxygen is a potential hypoxia case. However, there is a wide, individual variation in susceptibility to hypoxia. Physical fitness and other factors (alcohol, drugs, tobacco, etc.) may change your ability to tolerate hypoxia even from day to day. (If the smoke of 3 cigarettes is inhaled at sea level, a person's visual acuity and dark adaptation are reduced to the extent of mild hypoxia encountered in flight at 8, 000 ft. Smoking at 10, 000 ft. produces effects equivalent to those experienced at 14, 000 ft. without smoking.) NOTE: 10, 000 ft. is a good operational practice "physiological zone" upper limit.

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HOW CAN HYPOXIA BE PREVENTED? By flying at altitudes below 12, 000 ft. ; by flying in pressurized aircraft; or by breathing supplemental oxygen when above 12, 000 ft. in unpressurized aircraft.

HOW IS OXYGEN STORED IN THE AIRCRAFT? It is stored in metal cylinders generally attached to the aircraft, outside of the cabin area -- e. g., in the baggage area. However, portable systems are often used, in which case, the cylinder would normally be stored in the cockpit or cabin and should be securely anchored. In a high-pressure system, oxygen is stored at a pressure of 1800 psi. ; in a low-pressure system at 450 psi. General aviation and airlines use the high-pressure system extensively. The low-pressure system is used primarily by the military.

CAN THE TWO PRESSURE SYSTEMS BE EASILY DIFFERENTIATED? Military services have a color-coding system, civilian industry does not. In the military, high-pressure cylinders are green; low-pressure cylinders, yellow. In civilian industry cylinders may be any color. Know the pressure-capacity of your oxygen cylinder. A castastrophic disintegration may occur if someone attempts to fill a low-pressure cylinder to a pressure of 1800 psi.

CAN ANY KIND OF OXYGEN BE USED FOR AVIATOR'S BREATHING OXYGEN? No! Oxygen used for medical purposes or welding normally should not be used because it may contain too much water. The excess water could condense and freeze in oxygen lines when flying at high altitudes. This could block oxygen flow. Also, constant use of oxygen containing too much water may cause corrosion in the system. Specifications for "aviators breathing oxygen" are 99. 5% pure oxygen and not more than . 005 mg. of water per liter of oxygen. So, always ask for "aviators breathing oxygen."

HOW CAN YOU DETERMINE IF OXYGEN SERVICE IS AVAILABLE AT AN AIRPORT? The Airman's Information Manual, Part 2, includes this information in the airport data. The upper illustration to the left is excerpted from the airport data for Addison Airport in AIM, Part 2; the lower illustration is an excerpt from the AIM "legend." The arrows point out that both "high pressure" and "low pressure" bottles can be serviced with oxygen at Addison Airport in Dallas, Texas. Since the numbers "3" and "4" do not appear after the "Ox" in the airport data, replacement bottles are not available.

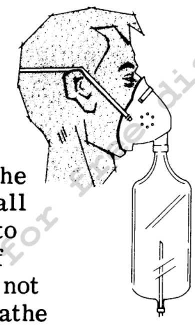
§ **DALLAS,** ADDISON(ADS) 9 N IFR **FSS:** Dallas (LC FL 2-8491)
643 H72/15-33 (2) (S-80, T-100, TT-160) BL5, 7A, 11 S5
F12, 18, 22, 34 Ox 1, 2 U-2 **REIL:** Rnwy 33
Remarks: (£) F[illegible] additional info see Part 3.

OXYGEN

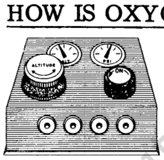
Ox1	High pressure
Ox2	Low pressure
Ox3	High pressure—replacement bottles
Ox4	Low pressure—replacement bottles

WHAT ARE THE 3 TYPES OF OXYGEN BREATHING SYSTEMS NORMALLY USED? Continuous Flow -- used up to 25, 000 ft. ; Demand -- used up to 35, 000 ft. ; and Pressure Demand -- used up to 45, 000 ft. Most general aviation aircraft use the Continuous-Flow type. The more sophisticated general aviation aircraft ("bizjets," etc.) have the Pressure-Demand type for crew members because of the altitudes at which they are flown, but a Continuous-Flow type is generally used for passengers, as the masks are simpler to don and passengers do not require as much oxygen as the pilot.

HOW DOES A CONTINUOUS-FLOW OXYGEN SYSTEM OPERATE? It is usually characterized by the bag attached to the mask. Oxygen is constantly dispensed from the oxygen storage bottle through the regulating system to the bag and mask. As the wearer inhales the oxygen from the "rebreather" bag, it deflates; as he exhales, some of the unused oxygen is forced back into the bag and mixed with 100% oxygen for the next inhalation. Some is forced out through a cluster of small orifices either in the nose of the mask or on either side. To check for oxygen flow, there is usually a mechanical oxygen flow indicator (of some color) in the tubing leading to the rebreather bag. If, when you inhale, the colored indicator disappears behind a small opaque section of the tube, oxygen is flowing. Another way of checking for flow is to pinch off the tube between the mask and the point at which oxygen enters the bag. If the bag inflates, oxygen is flowing. Remember, just because you can breathe does not mean that oxygen is flowing. Even though oxygen is not flowing, you could still breathe through the cluster of holes in the mask, but you would only be getting cabin air.

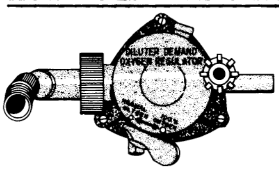


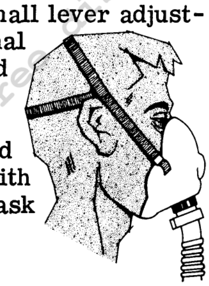
HOW IS OXYGEN-FLOW RATE CONTROLLED IN CONTINUOUS-FLOW TYPE SYSTEMS? By fixed orifices or packing, manually, or fully automatic. In those controlled by a fixed orifice or packing, the orifices for the pilot and crew members are larger or the packing is less dense than for passengers because pilot and crew members are more active and, therefore, need more oxygen. In the manually-controlled type, a knob on the regulator may be adjusted to the flight altitude. The higher the altitude to which the regulator is set, the greater the flow rate. In fully automatic types, an altitude-sensing device changes flow rate automatically as the aircraft climbs or descends. For those systems in which



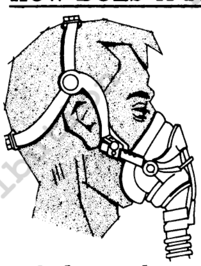
packing is used to control flow-rate, one must be sure that the plug-in and the outlet into which it is plugged are compatible. Why? Because one company may put the packing in the plug-in and another may put the packing in the outlet. If you use a plug-in with the packing, in an outlet with the packing, you may totally cut off the flow of oxygen. Conversely, if you use a plug-in with no packing, in an outlet with no packing, flow-rate would be too great and the oxygen would be depleted in a short time. Generally, the only way you can join non-compatible units is by forcing the plug-in into the receptacle. Don't do this! If it doesn't insert easily, check for non-compatibility.

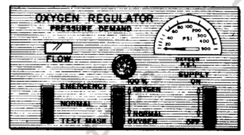
<u>HOW DOES A DEMAND OXYGEN SYSTEM OPERATE?</u> This system furnishes oxygen to the user only when he demands it -- that is, when he inhales. A small lever adjustment enables the pilot to select either of 2 settings, "normal oxygen" or "100% oxygen." The amount of oxygen received depends upon the flight altitude. As altitude is increased, the amount of cabin air is automatically decreased and the amount of oxygen is automatically increased. Most demand regulators are designed to give 100% oxygen by the time 30,000 ft. is attained. With the "100% oxygen" setting, the user receives 100% oxygen at all altitudes. The mask used for this system is designed to give an air-tight and oxygen-tight seal for the face. This system can be used safely to 35,000 ft.





<u>HOW DOES A PRESSURE-DEMAND OXYGEN SYSTEM OPERATE?</u> This system operates in exactly the same way as the "demand" system except that, at higher altitudes, oxygen is delivered under positive pressure to the face mask. Positive oxygen pressure can be automatically or manually activated at approximately 30,000 ft. and automatically increases as altitude increases. Positive pressure is needed in order to maintain proper lung oxygen pressure, and blood oxygen saturation during flight to altitudes of 35,000 to 45,000 ft. in an unpressurized aircraft. In this system it is essential that the mask be adjusted to obtain a leak-proof seal to the face. Inhaling is effortless but, because of the positive pressure, conscious effort must be exerted to exhale, and one may find it difficult to talk.





<u>WHAT IS A PRESSURIZED AIRCRAFT?</u> It is an aircraft in which pressure in the cockpit and passenger compartment is maintained at an altitude lower than the actual flight altitude by compressing air into these areas.

<u>WHAT IS MEANT BY DECOMPRESSION?</u> Decompression is the inability of the aircraft's pressurization system to maintain the designed "aircraft cabin" pressure. For example, an aircraft is flying at an altitude of 29,000 feet but the aircraft cabin is pressurized to an altitude equivalent to 8,500 ft. If decompression occurs, the cabin pressure may become equivalent to that of the aircraft's altitude of 29,000 ft. The rate at which this occurs depends on the severity of decompression. This could be caused by a malfunction in the pressurization system or by structural damage to the aircraft. There are two kinds of decompression:

EXPLOSIVE DECOMPRESSION - Cabin pressure decreases faster than the lungs can decompress. Most authorities consider that any decompression which occurs in less than 1/2 second as explosive and potentially dangerous. This type could only be caused by structural damage, material failure, or by a door "popping" open.

RAPID DECOMPRESSION - A change in cabin pressure when the lungs decompress faster than the cabin. There is no likelihood of lung damage in this case. This type could be caused by a failure or malfunction in the pressurization system itself, or through slow leaks in the pressurized area.

<u>WHAT ARE THE DANGERS OF DECOMPRESSION?</u> The primary danger is hypoxia, but some cases of bends have occurred. If oxygen equipment is not used properly above 30,000 ft., unconsciousness will occur in a very short time. The average <u>time of useful consciousness</u> without oxygen is 30 seconds. This is why the oxygen mask should be worn when flying at high altitudes--35,000 ft. or higher, and ready for immediate donning at lower altitudes. Crew members should select the 100% oxygen setting on their oxygen regulator at high altitude if the aircraft is equipped with a demand or pressure-demand oxygen system.

WHAT ARE SOME GENERAL RULES FOR OXYGEN SAFETY? (1) Do not inspect oxygen equipment with greasy hands or permit an accumulation of oily waste or residue in the vicinity of the oxygen system (the combination of grease and 100% gaseous oxygen creates an explosive situation); (2) do not use "military-surplus" oxygen equipment unless it is inspected by a certified FAA-inspection station and approved for use; (3) do not smoke or permit smoking or ignite any flame while the oxygen system is being used; (4) do not place a portable oxygen container in an aircraft unless it is securely fastened to prevent movement or displacement in case of turbulence, unusual attitudes, etc.; (5) utilize a check list to check your oxygen system for condition and proper operation prior to taking off on any flight during which you might need oxygen; and (6) brief your passengers on the proper use of the oxygen equipment. This is extremely important in case of an emergency in larger general aviation pressurized aircraft in which the cockpit and passenger compartments are separate. Passengers should know what to expect, what to do, and how to use the equipment. Use the check-list recommended for your equipment. If factory installed, you should find it in the Airplane Flight Manual or Owner's Manual.

IS THERE ANY PLACE WHERE CIVILIAN PILOTS CAN OBTAIN PHYSIOLOGICAL TRAINING? Yes! The Aeromedical Education Branch of the FAA's Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma, gives one-day physiological training courses -- including an altitude chamber flight in which you would get a chance to see what your hypoxia symptoms are. This training is open to the aviation public and courses are given on a "demand" basis as funds are available. This course is also given to civilian pilots under FAA sponsorship at various Air Force Bases across the country. For further information write to: Civil Aeromedical Institute, Attention: Aeromedical Education Branch, AC-140, P. O. Box 25082 - 6500 South MacArthur, Oklahoma City, Oklahoma 73125.

DO FARs REQUIRE THAT GENERAL AVIATION AIRCRAFT HAVE OXYGEN ABOARD? Yes! FAR 91.32 requires that the required minimum flight crew, for all aircraft operating at cabin pressure altitudes above 12,500 ft. MSL up to and including 14,000 ft. MSL, be provided with and use supplemental oxygen for any part of the flight of more than 30 min. duration at these altitudes; above 14,000 ft. MSL, the required minimum flight crew is required to use supplemental oxygen during the entire flight time at these altitudes; and above 15,000 ft. MSL, each occupant must be provided with supplemental oxygen. Additional rules are specified for pressurized aircraft.

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