Hypoxia
and You!

Rules and Regs

- For the general aviation pilot, 14 CFR section 91.211 applies.
  - Required for cabin pressure altitude of 12,500 feet mean sea level (MSL) for flights over 30 minutes
  - Required for all flights above 14,000 feet MSL
  - There are additional rules for pressurized aircraft in paragraph (b).

- FAA resources and training tools covering hypoxia include:
  - Advisory Circular (AC) 61–107B CHG 1, Aircraft Operations at Altitudes Above 25,000 Feet Mean Sea Level or Mach Numbers Greater than .75.
  - FAA's Pilot Handbook of Aeronautical Knowledge, Chapter 17.
  - Videos (e.g., youtu.be/E56AmOTSues), Aeromedical Safety Brochures, and an in-person, one-day course in Oklahoma City. The latter includes training in either the altitude chamber or the PROTE (Portable Reduced Oxygen Training Enclosure).

Symptoms

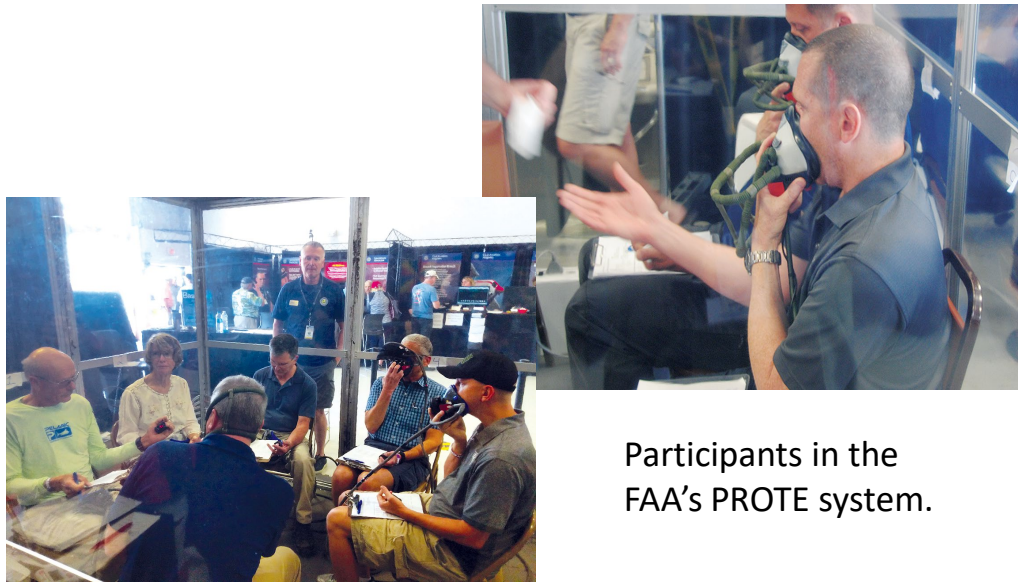
- Everyone's response to hypoxia varies. Unless you've had special training to recognize its symptoms, hypoxia doesn't give you much warning. It steals up on you, giving your body subtle clues.

- The order of symptoms varies among individuals and include the following:
  - Increased breathing rate
  - Headaches
  - Lightheadedness
  - Dizziness, tingling, or warm sensations
  - Sweating
  - Poor coordination, impaired judgment, tunnel vision, and euphoria.

- See FAA's Aerospace Medical Education Division's (AMED) online hypoxia brochure to learn more about how to recognize your symptoms of hypoxia.

Training

- To recognize the onset of hypoxia, you can do so safely, and on the ground in altitude training devices that allow participants to breathe air with a lower percentage of oxygen. A quick internet search will show a number of commercial providers who offer this training.
- The FAA version of this training is the Portable Reduced Oxygen Training Enclosure, or PROTE, a traveling altitude training device.
- Besides the physiological training course with altitude chamber and vertigo demonstrations, you can also take a one-day survival course at FAA's Civil Aerospace Medical Institute (CAMI) in Oklahoma City.



Participants in the FAA's PROTE system.

Equipment

- A basic knowledge of oxygen equipment can be critical whether you are flying a commercial, commuter, or a general aviation aircraft. This equipment is the first line of defense against the potentially lethal effects of hypoxia and carbon monoxide poisoning. It is the responsibility of the pilot that all aboard the aircraft — crewmembers and passengers — know how to use this life-saving equipment safely and efficiently.

- Per FAA's brochure on oxygen equipment use in GA, there are three components to most oxygen systems, whether they are portable or installed systems.
  - A storage system (containers)
  - A delivery system
  - Mask or nasal cannula

Storage System

- Oxygen can be stored in the aircraft as a gas, liquid, or a solid.
  - Gaseous aviator's breathing oxygen (ABO)
    - Advantage: more economical
    - can be stored in high-pressure (1800–2200 psi) containers or low-pressure (400–450 psi) containers
    - Disadvantage: weight and bulk of the storage containers
  - Liquid aviators breathing oxygen (LOX)
    - Nine hundred-to-one expansion ratio (one liter of LOX will expand into 900 gaseous liters of ABO)
    - Provides a three-to-one space and a five-to-one weight savings over gaseous ABO
    - Disadvantages: Stored at its critical temperature of minus 197º F and its volatile nature when it comes in contact with petroleum products. If LOX comes in contact with exposed skin, severe frostbite may occur.
  - Sodium chlorate candles (solid-state oxygen candles)
    - Advantage: Weight and space savings over ABO (provides a six hundred-to-one expansion ratio)
    - Disadvantages: Once the chemical reaction starts (the candle is activated), it can't be stopped easily. Additionally, the candle produces a great deal of heat and precautions must be taken to avoid a fire hazard
  - Molecular sieve oxygen generators (MSOG)
    - takes ambient air and separates oxygen from the nitrogen and inert gases. The separated oxygen is concentrated and used to supply the aircraft.
    - Used by the military for many years, as well as medical patients who need a portable oxygen system. Civil aviation hasn't embraced MSOG

Delivery Systems

- Oxygen delivery systems deliver oxygen from the storage containers.

- Continuous flow
  - Typically used at 28,000 feet and lower
  - Economical, doesn’t need complicated masks or regulators to function
  - very wasteful — the oxygen flow is constant whether you’re inhaling, exhaling, or pausing in between breaths.

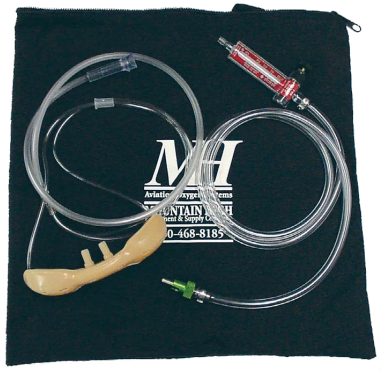
- The diluter demand system
  - Typically used at altitudes up to 40,000 feet
  - Compensates for waste by giving the user oxygen on-demand (during inhalation) and stops the flow when the demand ceases (during exhalation).

- Pressure demand system
  - Provides oxygen under positive pressure that slightly over-inflates the lungs allowing you to fly at altitudes above 40,000 feet, where 100% oxygen without positive pressure is insufficient.

Masks and Nasal Cannulas

- Oxygen masks and cannulas need to be compatible with the delivery system you are using.

- Quick-don masks
  - Must have the capability to be donned with one hand in five seconds or less, while accommodating prescription glasses.
  - Typically rated to altitudes up to 40,000 feet
- Airline drop-down units (“Dixie cups”)
  - Used at altitudes up to 40,000 feet,
  - Use an external reservoir bag and a series of one-way valves working in sequence to allow a mixture of 100% oxygen and cabin air into the mask.
- Nasal cannulas
  - Continuous-flow and offer the advantage of personal comfort.
  - Restricted by federal aviation regulations to 18,000 feet service altitude because of the risk of reducing blood oxygen saturation levels if one breathes through the mouth or talks too much.
- Oral-nasal re-breathers
  - the most common, the least expensive, and the simplest to use.
  - Used up to 25,000 feet
  - Exhaled air is captured and mixed with 100% oxygen from the system.



- For a more detailed overview of aviation oxygen system installations in non-pressurized aircraft, see chapter six of AC 43.13–2B, *Acceptable Methods, Techniques, and Practices for Aircraft Alterations*.

Pre-check

- With any system you use, and prior to every flight, you should perform the “PRICE” check to inspect oxygen equipment.

  PRESSURE: Ensure that there is enough oxygen pressure and quantity to complete the flight.

  REGULATOR: Inspect the oxygen regulator for proper function. If you are using a continuous-flow system, ensure that the outlet assembly and plug-in coupling are compatible.

  INDICATOR: Don the mask and check the flow indicator to ensure a steady flow of oxygen.

  CONNECTIONS: Ensure that all connections are secured. This includes oxygen lines, plug-in coupling, and the mask.

  EMERGENCY: Keep oxygen equipment in your aircraft ready to use for emergencies that require oxygen (e.g., hypoxia, smoke and fumes, rapid decompressions/decompression sickness). Also, brief passengers on the location of oxygen and how to use it.

- Know the equipment you have on board, know when to use it, and most importantly, know its limitations. You can learn more about the O_2 equipment you need for a safe and enjoyable flight by downloading FAA’s brochure (PDF).

References

- No Air Up There. Hypoxia Awareness, FAA Safety Briefing, Mar 2023