Task II.I: High Altitude Operations

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Lesson Overview

Objective

The student should develop knowledge of the elements related to high altitude operations be able to explain the necessary elements as required in the PTS.

Reference

- 14 CFR Part 91
- AC 61-107B, Aircraft Operations at Altitudes Above 25,000 ft MSL or Mach Numbers Greater than .75
- FAA-H-8083-25B, Pilot’s Handbook of Aeronautical Knowledge (Chapter 7, Chapter 17)
- POH/AFM
- AIM

Key Elements

- Regulations
- Aviator’s oxygen
- Decompression and hypoxia

Elements

- Regulatory requirements
- Physiological factors

- Pressurization
- Oxygen systems
- Aviator’s breathing oxygen
- Care and storage of high-pressure oxygen bottles
- Rapid decompression problems and their solutions

Equipment

- White board
- Markers
- References

Schedule

1. Discuss objectives
2. Review material
3. Development
4. Conclusion

Instructor Actions

1. Discuss lesson objectives
2. Present lecture
3. Questions
4. Homework

Student Actions

- Participate in discussion Take notes

Completion Standards

The student understands and can explain the elements involve in high altitude operations.

Instructor Notes

Attention

We’re not learning to fly airplanes to stay close to the ground, we want to go high. Often to get over mountain peaks and sometimes have optimal winds for traveling long distances, altitude is a great choice. A lot of things change as the altitude increases, and this lesson will teach you what you need to know in the flight levels.

Overview

Review Objectives and Elements/Key ideas

What

The required equipment, how it functions, the unique hazards and regulations associated with flying at high altitudes.

Why

There are many advantages to flying at high altitudes (jet engines are more efficient, weather and turbulence can be avoided, etc.), so many modern GA airplanes are being designed to operate in that environment. Therefore, it is important that pilots be familiar with at least the basic operating principles.

Lesson Overview

High altitude operations can have significant benefits, but also carry certain risks. As discussed in section 2-A: Aeromedical Factors increased altitude has certain physiological risks which must be addressed. Due to these risks there are a number of regulations and best practices which are mandated when engaging in high altitude operations.

Regulatory requirements

1. No person may operate a US-registered civil aircraft at cabin pressure altitudes above:
    a. 12,500’ MSL up to/including 14,000’ unless the required minimum flight crew is provided with and uses supplemental oxygen for the part of the flight at those altitudes that is over 30 min.
    b. 14,000’ unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes.
    c. 15,000’ unless each occupant of the aircraft is provided with supplemental oxygen.
2. No person may operate a civil aircraft of a US-registered aircraft with a pressurized cabin at flight altitudes above:
    a. FL 250 unless at least a 10 min supply of supplemental oxygen is available for each occupant of the aircraft for use in the event that a descent is necessitated by a loss of cabin pressure.
        i. This is in addition to oxygen required above.
        ii. FL 350, unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed.
            A. The mask must supply oxygen at all times or automaticallysupply oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000’ MSL.
            B. Exception: One pilot need not wear and use an oxygen mask while at or below FL 410 if there are two pilots at the controls and each pilot has a quick donning type of oxygen mask that can be placed on the face with one hand from the ready position within 5 seconds, supplying oxygen and properly secured and sealed.
            C. If one pilot leaves the controls, the remaining pilot shall put on and use an oxygen mask until the other pilot has returned.

Physiological hazards

The body functions normally from sea level to approximately 12,000 feet MSL. At these altitudes brain oxygen saturation is at a level for normal functioning, which is 96% saturation. As the body nears 12,000 feet MSL the saturation level has declined to about 87% which is close to a performance affecting level. Above 12,000 feet MSL oxygen saturation decreases further and peformance is affected. Note that these values and responses to altitude are very individualized, so each person may have somewhat different responses to altitude.

> - Optimal function — 96% saturation.
> - At 12,000’ oxygen saturation ~87%--gets close to performance affecting level.

Hypoxia (as discussed in 2-A: Aeromedical Factors) is the main risk, and is specifically concerned with an inadequate supply of oxygen to the brain. To reprise briefly the different types of hypoxia, they are listed here :

Hypoxia

Reduced oxygen, or not enough oxygen. The brain is particularly vulnerable to deprivation—need to get enough oxygen to the brain.

- Hypoxic hypoxia (insufficient oxygen available to the lungs)
- Hypemic hypoxia (blood cannot transport enough oxygen to tissues/cells)
- Stagnant hypoxia (oxygen rich blood not moving to tissues)
- Histotoxic hypoxia (“histo” is tissues/cells, “toxic” is poison)

Symptoms of hypoxia

Hypoxia can cause a pilot to have a false sense of security.

- Cyanosis
- Headache
- Decreased reaction time
- Impaired judgment
- Euphoria
- Visual impairment
- Drowsiness/lightheaded—dizzy sensation
- Tingling in fingers or toes, numbness

Useful consciousness

Maximum time available to make rational, life saving decisions, and carry them out at a given altitude. Above 10k’ the time begins to decrease rapidly.

Treatment

- Fly at lower altitudes (emergency descent).
- Use supplemental oxygen.

Oxygen use

Take oxygen gradually to build up in small doses—the sudden supply of pure oxygen following decompression can aggravate hypoxia. Prolonged oxygen use can be harmful to health. 100% aviation oxygen can create toxic symptoms if used for too long.

Symptoms: bronchial cough, fever, vomiting, nervousness, irregular heartbeat, lowered energy.

Nitrogen

Most inhaled nitrogen is exhaled with CO_2, but some is absorbed into the body. Normally not an issue (when in liquid state)--if the ambient pressure lowers drastically, it can return to a gas in the form of bubbles.

Decompression sickness—evolving and expanding gases in the body.

- Trapped gas—expanding/contracting gas in cavities during altitude changes can result in abdominal pain, toothache, or pain in ears and sinuses if the pressure change isn't equalized.
- Evolved gas—with a sufficient pressure drop, nitrogen forms bubbles which can have adverse effects on some body issues. Scuba diving compounds this problem.

Vision

Vision deteriorates with altitude, because the eyes require oxygen. Glare and deteriorated vision are enhanced at night—body more susceptible to hypoxia.

Empty visual field can cause inaccuracies during the day when judging traffic (cloudless, blue skies, for example).

Pressurization

Cabin pressurization — the compression of air to maintain a cabin altitude lower than the flight altitude. Removes the need for full-time use of supplemental oxygen. Maintains cabin pressure of ~8,000' and prevents rapid changes of cabin altitude that may be uncomfortable or cause injury.

Differential pressure — the difference between cabin pressure and atmospheric pressure. Normally expressed in psi. Higher flight altitude = higher differential pressure.

Cabin, flight, and baggage compartments are incorporated into a sealed unit capable of containing air under a differential pressure. Maximum differential pressure varies by airplane. Be familiar with limitations.

- Turbine-powered aircraft—bleed air from engine compressor section used to pressurized

- Light aircraft—turbocharger's compressor/engine-driven pneumatic pump used to pressurize. Compression heats the air, so it's routed through a heat exchange unit before entering the cabin.

Cabin pressure control system

Provides pressure regulation, pressure relief, and vacuum relief, as well as the means for selecting the desired cabin altitude. Uses a cabin pressure regulator, an outflow valve, and a safety valve.

- Cabin pressure regulator (CPR) — controls cabin pressure. If we reach the maximum difference, an increase in outside altitude will result in an increase inside.
- Outflow valve — keeps pressure constant by regulating flow of compressed air.
- Safety valve — combination of a pressure relief, vacuum relief, and a dump valve.
- Pressure relief — prevents cabin pressure from exceeding a predetermined differential pressure above ambient pressure.
- Vacuum relief — prevents ambient pressure from exceeding cabin pressure by allowing external air to enter when ambient pressure exceeds cabin pressure.
- Dump valve — dumps cabin air to atmosphere. Cockpit switch.

Instruments

- Cabin differential pressure gauge — indicates the difference between inside and outside pressure.
- Cabin altimeter — shows altitude inside the airplane.

Differential pressure gauge and cabin altimeter could be combined into one instrument.Cabin rate of climb/descent.

Oxygen systems

Three types: continuous flow, diluter demand, and pressure demand.

Continuous flow

Most common in GA airplanes—usually for passengers. Rate can be controlled automatically or by the user.

Reservoir bag collects oxygen from the system when exhaling. Ambient air is added to the oxygen during inhalation after the reservoir oxygen supply is depleted. Exhaled air is released into the cabin.

Oxygen can be diluted with ambient air by allowing user to exhale around the facepiece. Rebreather bag allows the user to reuse part of the exhaled oxygen.

Diluter demand

Supply oxygen only when the user inhales through the mask. Depending on altitude, regulator can provide 100% oxygen or mix cabin air and oxygen.

Mask provides tight seal. Can be used up to 40,000'.

Pressure Demand

Oxygen supplied to mask under pressure at cabin altitudes above 34K'. Provides a positive pressure application of oxygen that allows the lungs to be pressurized with oxygen. Some systems include the regulator on the mask to eliminate purging a long hose of air. Safe at altitudes above 40K'.

Aviator's breathing oxygen

- Aviation Oxygen Specified at 99.5% pure oxygen. Not more than 0.005mg of water per liter.
- Medical oxygen—has too much water, which can collect in various parts of the system and freeze, reducing or stopping the flow of oxygen.
- Industrial oxygen—not intended for breathing, may have impurities in it.
- Medical/scuba diving oxygen don't work for aviation

Care and storage of high-pressure oxygen bottles

Portable oxygen equipment must be accessible in flight if the airplane does not have a fixed installation.

Oxygen usually stored at 1,800-2,200 psi. When the ambient temperature surrounding the cylinder decreases, the pressure within the cylinder will decrease—no reason to suspect supply depletion if you notice a drop in indicated pressure.

Fire danger — materials that are nearly fire proof in ordinary air may be susceptible to burning in pure oxygen. Oils and greases may catch fire if exposed to pure oxygen and cannot be in oxygen systems.

Smoking is prohibited during any kind of oxygen equipment use. Thoroughly inspect and test all oxygen equipment before each flight. Available supply, operational check, assure it is readily available. Do periodic inspections and servicing.

PRICE checklist to inspect oxygen equipment:

- **P**ressure—is there enough oxygen pressure and quantity to complete the flight.
- **R**egulator
- **I**ndicator—check to assure steady flow of oxygen
- **C**onnections—all secured
- **E**mergency—have equipment readily available, brief passengers

Rapid decompression

Decompression—the inability of the pressurization system to maintain its designated differential pressure. May be caused by a malfunction in the pressurization system or structural damage to the plane.

- **Explosive decompression** — change in cabin pressure faster than the lungs can decompress (less than 0.5 seconds).
- **Rapid decompression** — change in cabin pressure where lungs can decompress faster than the cabin (i.e. no likelihood of lung damage).
- During explosive decompression, there may be noise, and one may feel dazed for a second.
- During most decompressions, the cabin will fil with fog (the result of the rapid change in temperature and change of relative humidity), dust, and flying debris.
- Air will rush from the mouth and nose due to the escape from the lungs.
- Differential air pressure on either side of the eardrum should clear automatically.
- Exposure to wind blast and extremely cold temperatures may occur.

Primary danger—hypoxia. If proper use of oxygen equipment is not accomplished quickly, could quickly result in unconsciousness.

Effective performance time—reduced to one third or one fourth of its normal time.

Revovery

- Don oxygen masks. Emergency descent.
- **Top priority**: reaching safe altitude.
- Be aware that rapid descent from high altitude could result in cold shock in piston engines, and cylinder cracking.
- For explosive decompression, the time to make a recovery before loss of useful consciousness is even less.

Conclusion

The fundamental concept of cabin pressurization is that it is the compression of air in the airplane's cabin to maintain a cabin altitude lower than the actual flight altitude. If your airplane is equipped with a pressurization system, you must know the normal and emergency operating procedures.

ACS Requirements

1. To determine that the applicant exhibits instructional knowledge of the elements of high altitude operations by describing:
2. Regulatory requirements for use of oxygen.

3. Physiological hazards associated with high altitude operations.
4. Characteristics of a pressurized airplane and various types of supplemental oxygen systems.
5. Importance of “aviator’s breathing oxygen.”
6. Care and storage of high-pressure oxygen bottles.
7. Problems associated with rapid decompression and corresponding solutions.
8. Fundamental concept of cabin pressurization.
9. Operation of a cabin pressurization system.