HIGH ALTITUDE OPERATIONS

Lesson Outline

LESSON OBJECTIVE

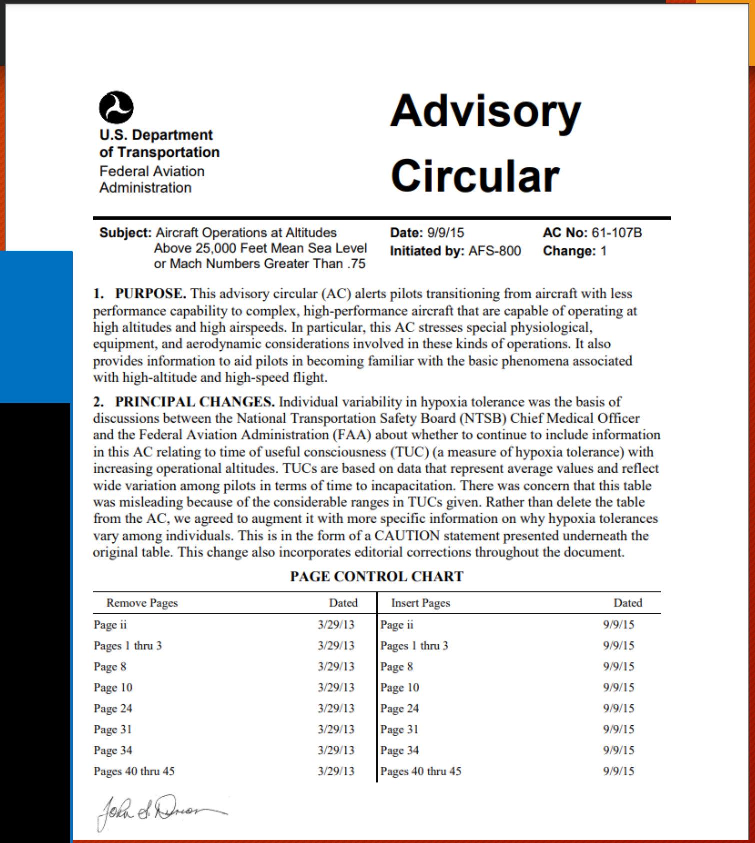
To determine that the student exhibits proficient knowledge of the elements related to high altitude operations by describing the elements on the following slide.

LESSON SOURCE(S)

Advisory Circular 61-107

Airplane Flying Handbook
FAA-H-8083-3

Pilot's Handbook of Aeronautical Knowledge
FAA-H-8083-25



U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Aircraft Operations at Altitudes Above 25,000 Feet Mean Sea Level or Mach Numbers Greater Than .75
Date: 9/9/15
Initiated by: AFS-800
AC No: 61-107B
Change: 1

1. **PURPOSE.** This advisory circular (AC) alerts pilots transitioning from aircraft with less performance capability to complex, high-performance aircraft that are capable of operating at high altitudes and high airspeeds. In particular, this AC stresses special physiological, equipment, and aerodynamic considerations involved in these kinds of operations. It also provides information to aid pilots in becoming familiar with the basic phenomena associated with high-altitude and high-speed flight.

2. **PRINCIPAL CHANGES.** Individual variability in hypoxia tolerance was the basis of discussions between the National Transportation Safety Board (NTSB) Chief Medical Officer and the Federal Aviation Administration (FAA) about whether to continue to include information in this AC relating to time of useful consciousness (TUC) (a measure of hypoxia tolerance) with increasing operational altitudes. TUCs are based on data that represent average values and reflect wide variation among pilots in terms of time to incapacitation. There was concern that this table was misleading because of the considerable ranges in TUCs given. Rather than delete the table from the AC, we agreed to augment it with more specific information on why hypoxia tolerances vary among individuals. This is in the form of a CAUTION statement presented underneath the original table. This change also incorporates editorial corrections throughout the document.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
Page ii	3/29/13	Page ii	9/9/15
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Lesson Outline

LESSON ELEMENTS	TIMEFRAME	EQUIPMENT/TOOLS
Regulatory Requirements for Use of Oxygen Physiological Hazards Pressurized Airplane Characteristics Supplemental Oxygen Systems Aviator’s Breathing Oxygen Care of Oxygen Bottles Rapid Decompression Cabin Pressurization	40 Minutes *approximately* Discuss Objectives Present and Review Material Student Questions Conclusion and Quiz	Lesson Presentation Whiteboard and Markers FAA Sources and References

Lesson Outline

INSTRUCTOR ACTIONS	STUDENT ACTIONS	COMPLETION STANDARDS
Present Objectives and Standards Teach Lesson from Presentation Ask and Answer Student Questions Assign Homework Check Student’s Post Lesson Quiz	Participate in Lesson Take Notes Ask and Respond to Questions Pass the Post Lesson Quiz	Student is able to understand and differentiate between the different lesson elements. Student is further able to apply this acquired knowledge in flight training/flight operation scenarios effectively and appropriately.

Oxygen Use Requirements

The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>12,500’ to 14,000’

No person may operate an aircraft:

“At cabin pressure altitudes above 12,500 feet (MSL) up to and including 14,000 feet (MSL) unless the required minimum flight crew is provided with and uses supplemental oxygen for that part of the flight at those altitudes that is of more than 30 minutes duration.”

14,000’ MSL

Anytime in Excess Of 30 Minutes

For the Minimum Flight Crew

12,500’ MSL

Oxygen Use Requirements

The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>14,000’

No person may operate an aircraft:

“At cabin pressure altitudes above 14,000 feet (MSL) unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes.”

Entire Duration

For the Minimum Flight Crew

14,000’ MSL

Oxygen Use Requirements

The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>15,000’

No person may operate an aircraft:

“At cabin pressure altitudes above 15,000 feet (MSL) unless each occupant of the aircraft is provided with supplemental oxygen.”

Must Be Provided

To Each Aircraft Occupant

15,000’ MSL

Oxygen Use Requirements

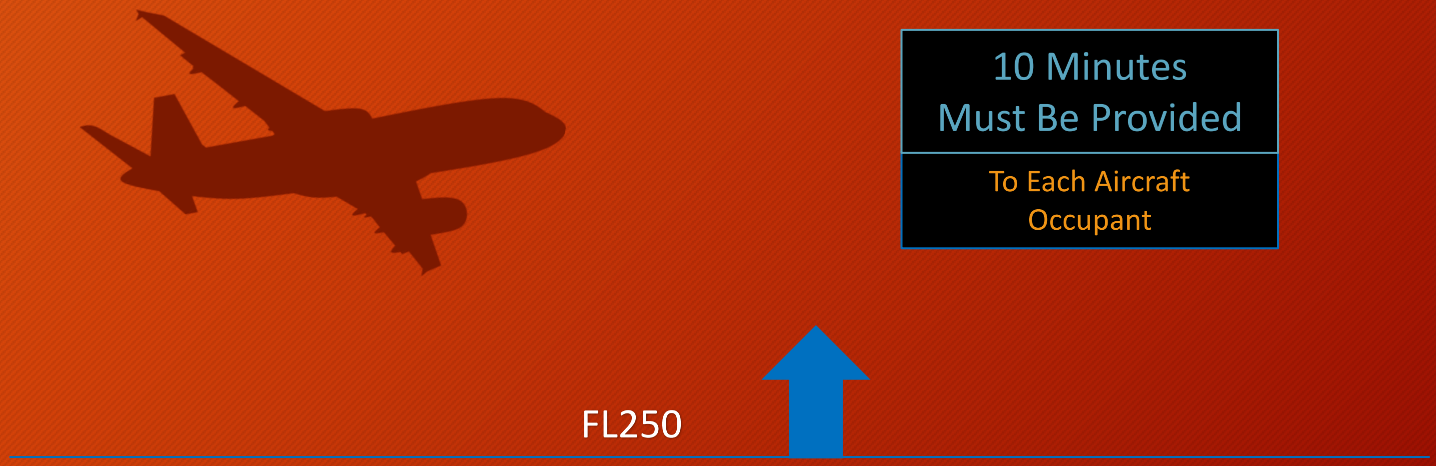
The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>FL250

No person may operate an aircraft with a pressurized cabin:

"At flight altitudes above flight level 250 unless at least a 10-minute supply of supplemental oxygen, in addition to any oxygen required to satisfy paragraph (a) of this section, is available for each occupant of the aircraft for use in the event that a descent is necessitated by loss of cabin pressurization."



10 Minutes
Must Be Provided

To Each Aircraft Occupant

Oxygen Use Requirements

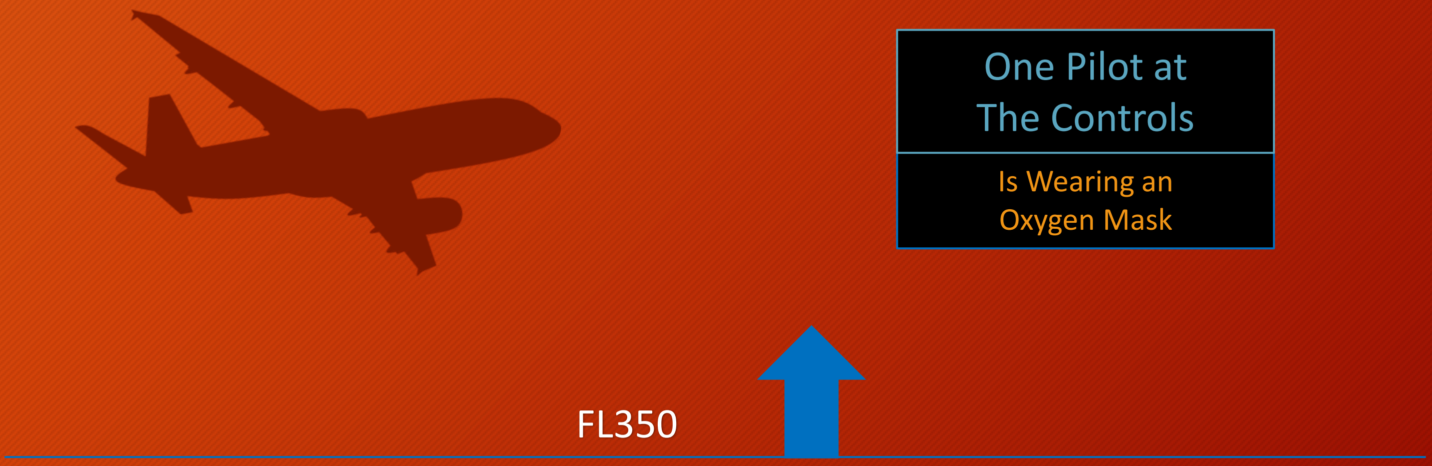
The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>FL350

No person may operate an aircraft with a pressurized cabin:

"At flight altitudes above flight level 350 unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed and that either supplies oxygen at all times or automatically supplies oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000 feet (MSL)."



One Pilot at The Controls

Is Wearing an Oxygen Mask

Oxygen Use Requirements

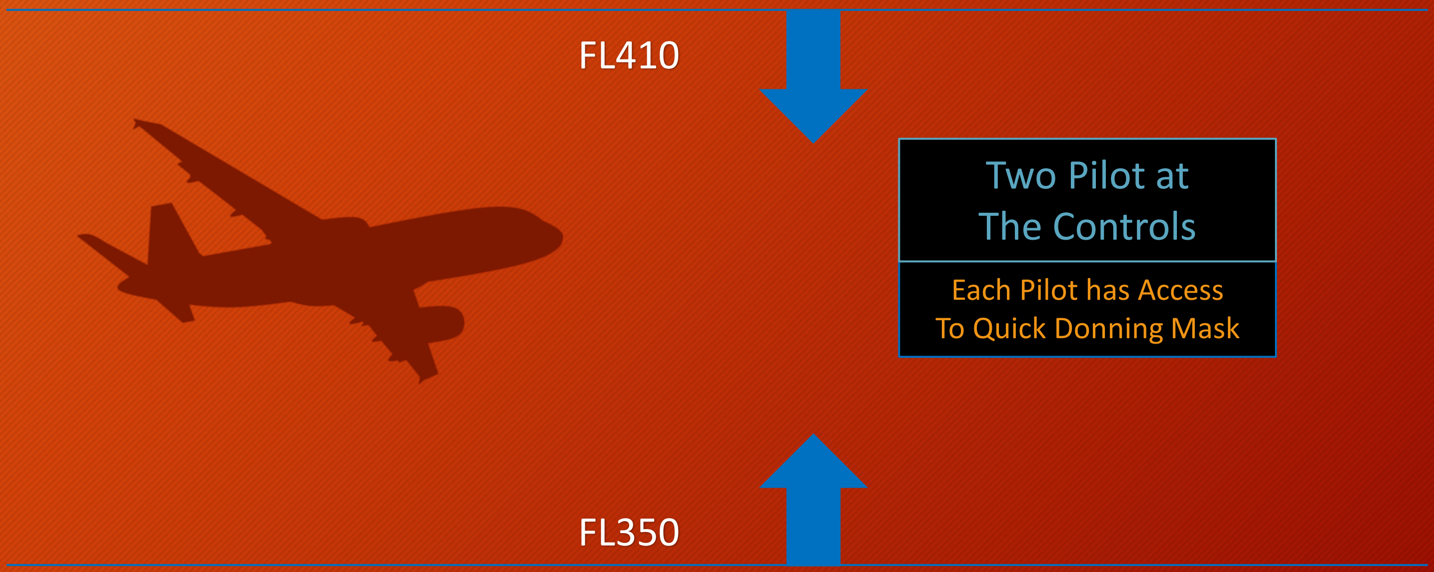
The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>FL350 Exception

No person may operate an aircraft with a pressurized cabin:

"Except that the one pilot need not wear and use an oxygen mask while at or below flight level 410 if there are two pilots at the controls and each pilot has a quick-donning type of oxygen mask."



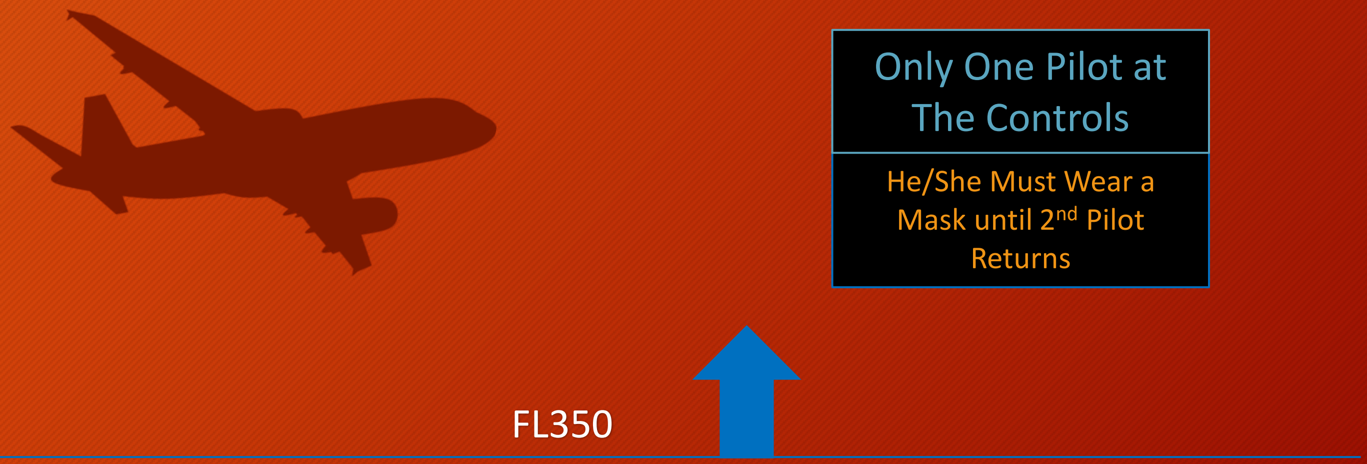
Oxygen Use Requirements

The Federal Aviation Regulations specify the times when crew members and passengers must use or be supplied with supplemental oxygen.

FAR 91.211

>FL350 Additional

"If for any reason at any time it is necessary for one pilot to leave the controls of the aircraft when operating at flight altitudes above flight level 350, the remaining pilot at the controls shall put on and use an oxygen mask until the other pilot has returned to that crewmember's station."



Only One Pilot at The Controls

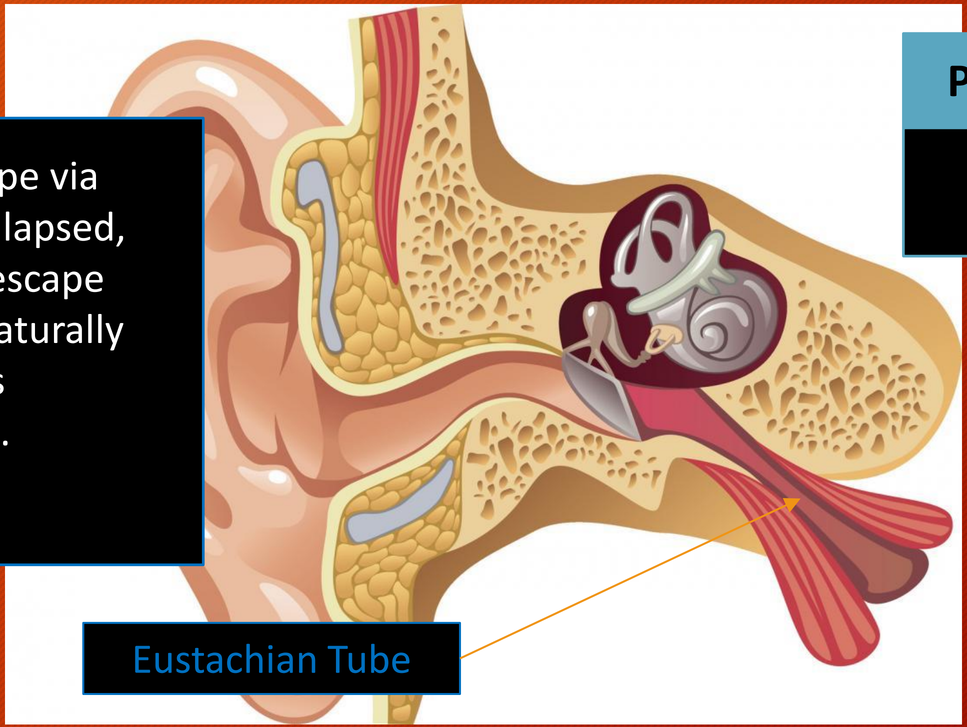
He/She Must Wear a Mask until 2nd Pilot Returns

Physiological Hazards

To ensure safe flights at high altitudes, pilots of high-altitude aircraft must understand the physiological effects of high-altitude flight and the effect of hypoxia on an individual's ability to perform complex tasks in a changing environment.

Middle Ear

On ascent, the air and pressure of expanding gases will escape via the eustachian tube. The base of each eustachian tube is collapsed, which acts as a one-way valve to allow gases and liquids to escape and not travel up to the middle ear. On descent, the gas is naturally trapped. Because of the increasing pressure on descent, this pressure will need to be equalized or an ear block will result.



Problem Phase

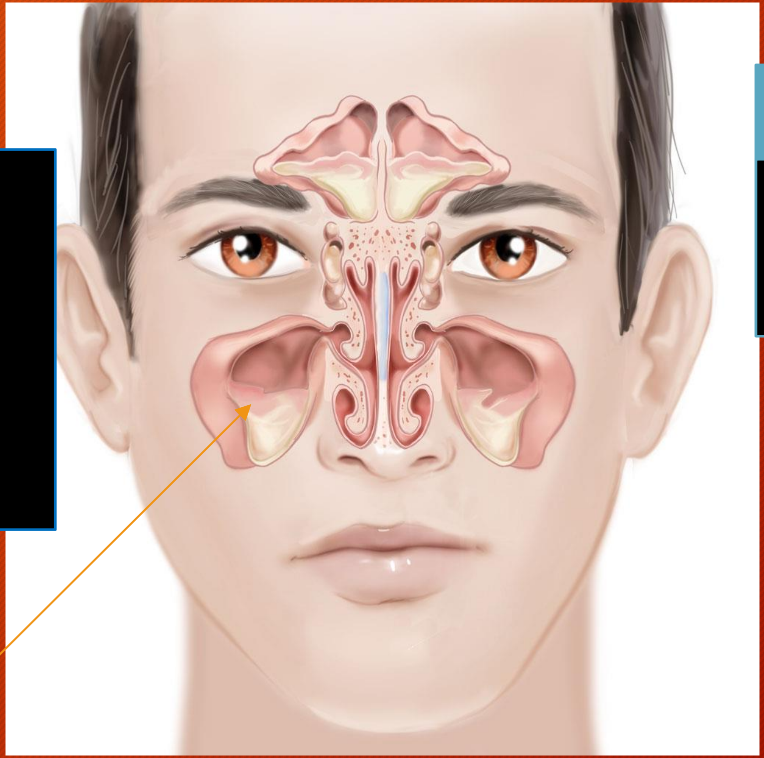
During Descent

Physiological Hazards

To ensure safe flights at high altitudes, pilots of high-altitude aircraft must understand the physiological effects of high-altitude flight and the effect of hypoxia on an individual's ability to perform complex tasks in a changing environment.

Sinus Congestion

The maxillary sinuses that sit under the cheekbones and the frontals that lie under the eyebrows have an unobstructed opening that will allow gas to enter and escape. In the event of an upper respiratory infection (URI), the openings will be swollen and possibly closed, allowing no route for the gas and pressure to equalize, resulting in a sinus block.



Maxillary Sinuses

Problem Phase

During Descent
Ascent is Rare

Physiological Hazards

To ensure safe flights at high altitudes, pilots of high-altitude aircraft must understand the physiological effects of high-altitude flight and the effect of hypoxia on an individual's ability to perform complex tasks in a changing environment.

Tooth Block

A tooth block is very rare. They can occur if you have had a recent cavity filling. If there is any airspace trapped between the filling and the pulp of the tooth, it will expand on ascent and cause pain.

Problem Phase

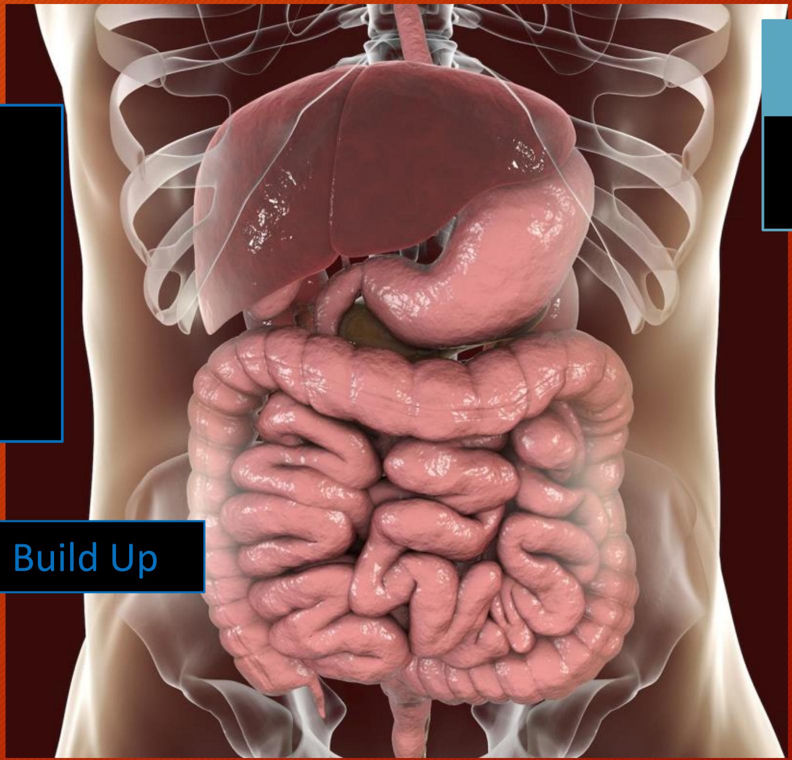
During Ascent

Physiological Hazards

To ensure safe flights at high altitudes, pilots of high-altitude aircraft must understand the physiological effects of high-altitude flight and the effect of hypoxia on an individual's ability to perform complex tasks in a changing environment.

GI Tract

The GI tract will always contain a varying amount of gas. This gas is usually a result of the digestion process and can escape by either flatulation or belching. If the gas expands, as in unpressurized flight to altitude, and is not allowed to escape, it could result in pain and possible syncope (fainting).



Pressure Build Up

Problem Phase

During Ascent

Physiological Hazards

To ensure safe flights at high altitudes, pilots of high-altitude aircraft must understand the physiological effects of high-altitude flight and the effect of hypoxia on an individual's ability to perform complex tasks in a changing environment.

The Lungs

Gas in the lungs will normally enter and escape via the trachea. If the breath is held during a rapid increase in altitude, the gas within the lungs will expand but have no pathway to escape. This could cause possible lung damage.

Problem Phase

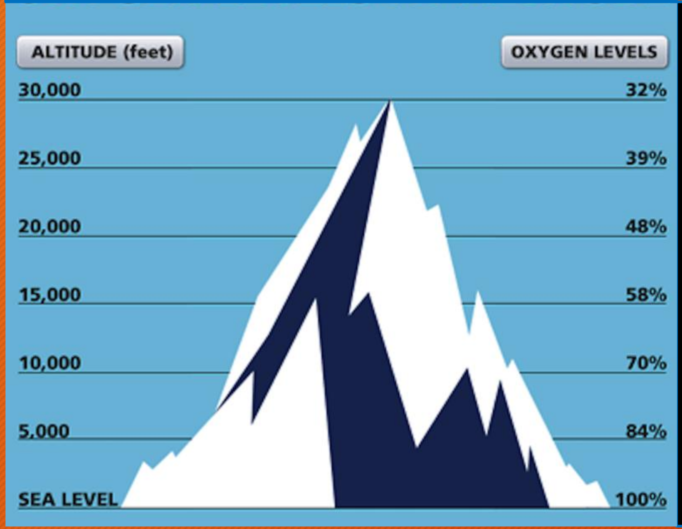
Decompression

Gas Expansion

Hypoxia

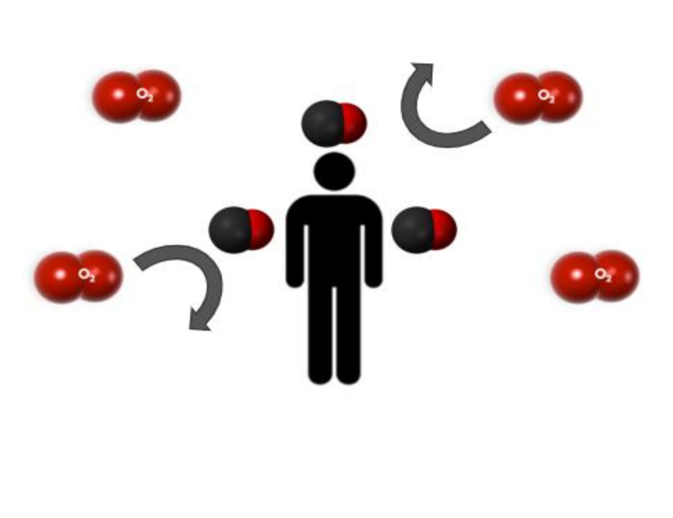
Hypoxia means "reduced oxygen" or "not enough oxygen." If the brain is subjected to oxygen deprivation it will affect a pilots decision making processes and can lead to life-threatening errors in judgement.

Hypoxic Hypoxia



Caused by a decrease in partial pressure when flying at higher altitudes. The oxygen molecules are spread further apart so the lungs receive less oxygen when inhaling.

Hypemic Hypoxia

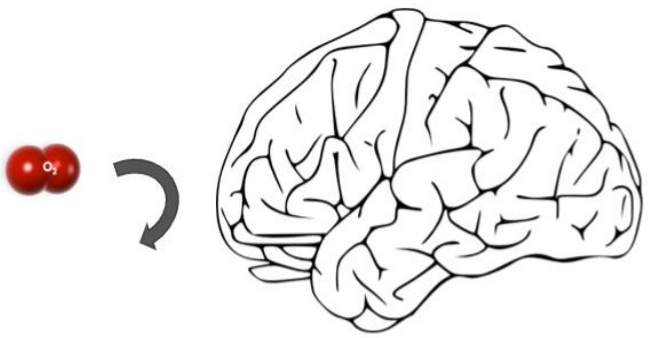


Occurs when the blood cells in the body are unable to take up and transport oxygen molecules. Most common cause in aviation is Carbon Monoxide (CO) Poisoning.

Hypoxia

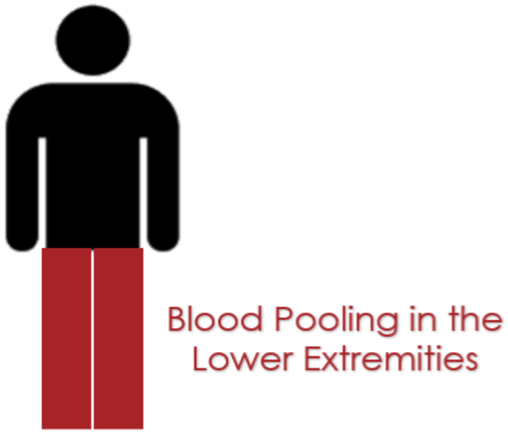
Hypoxia means “reduced oxygen” or “not enough oxygen.” If the brain is subjected to oxygen deprivation it will affect a pilots decision making processes and can lead to life-threatening errors in judgement.

Histotoxic Hypoxia



Occurs when the brain rejects the oxygen molecules being delivered by the blood stream. Most common cause is alcohol and drugs.

Stagnant Hypoxia



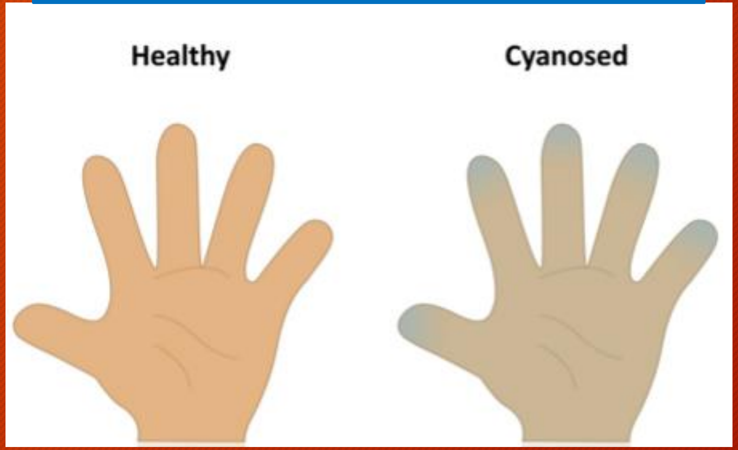
Occurs when the blood is not flowing to the brain. It is pooling in the lower extremities. Most commonly caused by G-Forces.

Hypoxia Symptoms

Symptoms of Hypoxia can include things such as:

- Peripheral Cyanosis
- Headache
- Decreased Response Times
- Impaired Judgement
- Euphoria
- Visual Impairment
- Drowsiness
- Dizzy Sensations
- Numbness
- Tingling in Fingers and Toes

Peripheral Cyanosis



Hypoxia Corrective Actions

Descend to Lower Altitude

Stop Pulling G-Forces

Don an Oxygen Mask

DCS and Scuba Diving

Decompression Sickness

DCS is a condition characterized by a variety of symptoms resulting from exposure to low barometric pressures that cause inert gases (mainly nitrogen), normally dissolved in body fluids and tissues, to come out of physical solution and form bubbles.

Scuba Diving

Scuba diving subjects the body to increased pressure, which allows more nitrogen to dissolve in the body tissues and fluids.

Scuba Diving Wait Times

Controlled Dive

A controlled dive is when a person dives deep enough that they cannot immediately return to the surface at will. They must return in stages to avoid bodily injury.

Wait Times

24 Hours

24 Hours

Uncontrolled Dive

An uncontrolled dive is when a person does not dive deep enough that they need to return to the surface in stages. They can return at will.

Wait Times

24 Hours

12 Hours

Cabin Pressurization

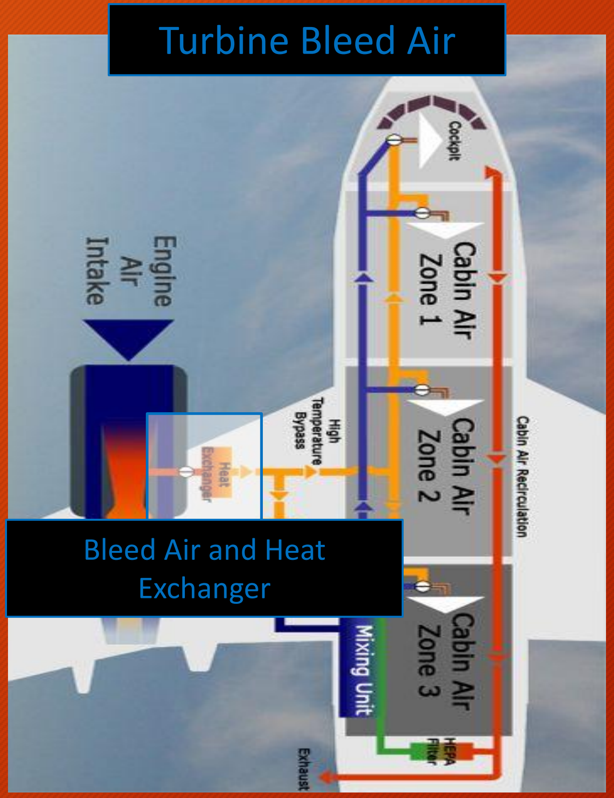
Cabin pressurization is the compression of air in the aircraft cabin in order to maintain a cabin altitude lower than the actual flight altitude. Because of the ever-present possibility of decompression, the aircraft still requires supplemental oxygen.

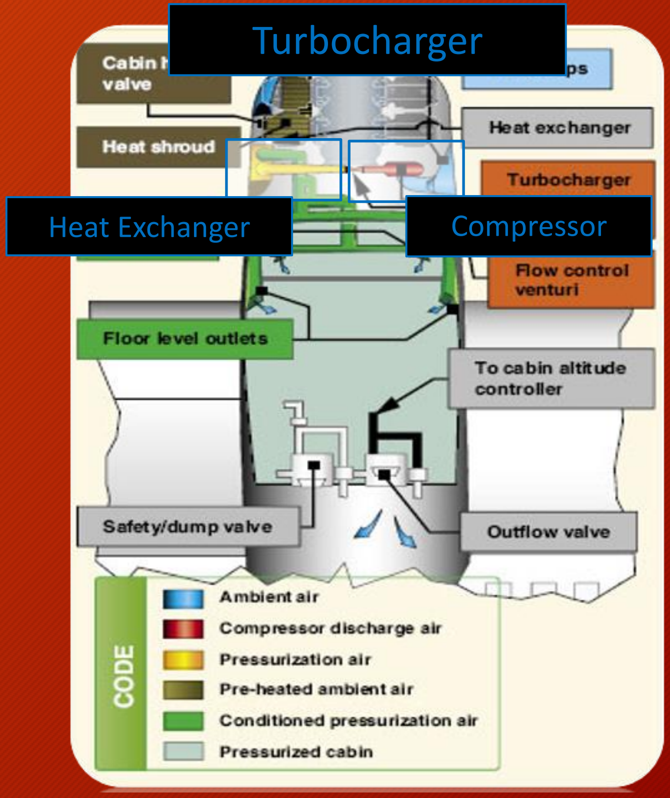
Pressurization Characteristics

Turbine aircraft use a steady supply of engine bleed air for cabin pressurization. Most pressurized light aircraft use the air supply from the turbocharger's compressor or from an engine driven fuel pump.

Heat Exchangers

Compressed air is very hot. This means it must go through a heat exchanger before being supplied to the cabin.





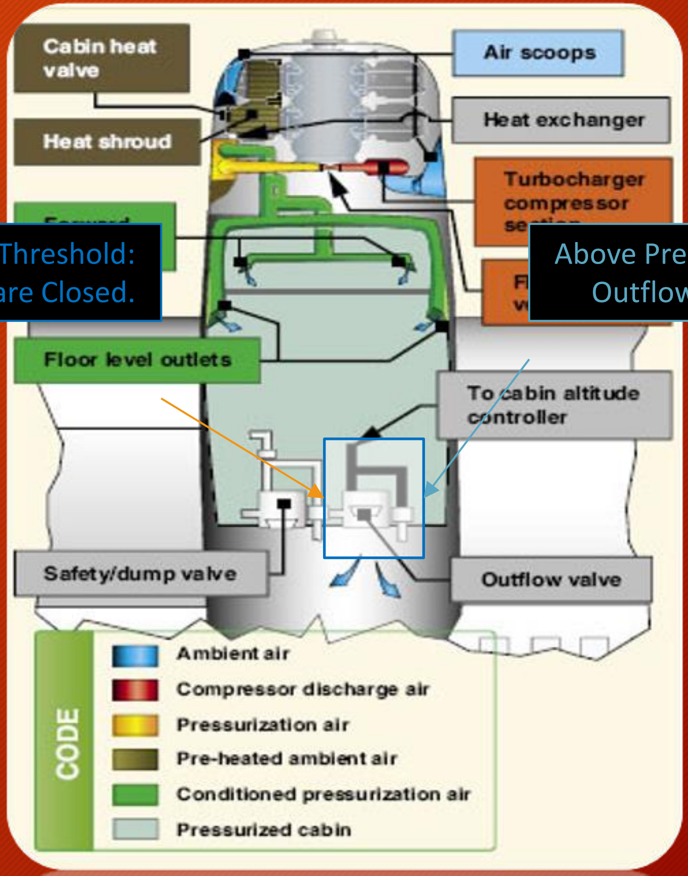
Cabin Pressurization

Cabin pressurization is the compression of air in the aircraft cabin in order to maintain a cabin altitude lower than the actual flight altitude.

Outflow Valves

Since bleed air is constantly being supplied to the cabin, there must be a way to release some of that air once it reaches a certain threshold. Otherwise the cabin could over-pressurize. This is accomplished through the use of outflow valves. These valves open (when a certain pressure threshold is reached) to release some of the pressurized cabin air into the atmosphere. Thus maintaining a stabilized pressure.

Below Pressure Threshold: Outflow Valves are Closed.



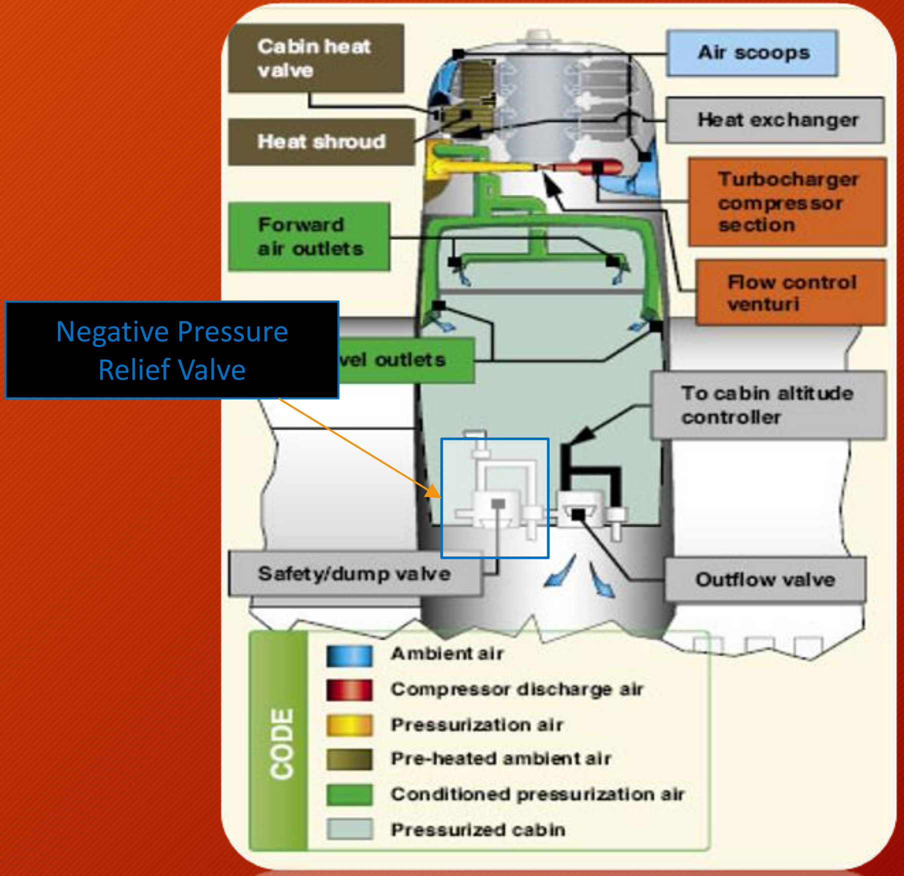
Above Pressure Threshold: Outflow Valves Open

Cabin Pressurization

Cabin pressurization is the compression of air in the aircraft cabin in order to maintain a cabin altitude lower than the actual flight altitude.

Pressure Differential

Each pressurized aircraft has a determined maximum pressure differential, which is the maximum differential pressure between the cabin and ambient altitudes that the aircraft can support. An aircraft should never have a negative pressure differential (lower pressure in the cabin that outside the cabin) because this could lead to structural damage and/or failure. For this reason, some aircraft have a negative pressure relief valve in the event of sudden cabin depressurization.



Cabin Decompression

Decompression is defined as the inability of the aircraft's pressurization system to maintain its designed pressure differential. This can be caused by a malfunction in the pressurization system or structural damage to the aircraft.

Rapid Decompression

This is a change in cabin pressure where the lungs can decompress faster than the cabin. The risk of lung damage is significantly lower in this type of decompression compared to Explosive Decompression. The main problem with decompression is the probability of Hypoxia.

Cabin Decompression

Decompression is defined as the inability of the aircraft’s pressurization system to maintain its designed pressure differential. This can be caused by a malfunction in the pressurization system or structural damage to the aircraft.

Explosive Decompression

This is a change in cabin pressure where the cabin decompresses faster than the lungs and can be hazardous to them. It is typically any decompression that occurs in 0.5 seconds or less and most likely caused by structural damage to the aircraft. This type of decompression can also cause fog to form in the cabin due to the rapid drop in temperature and the change of relative humidity.

Supplemental Oxygen Systems

To combat the effects of Hypoxia or possible cabin depressurization, pilots and passengers can use oxygen masks.

Continuous Flow System

The continuous flow system supplies oxygen at a rate that may be controlled automatically or by the user. The mask is designed so the oxygen can be diluted with ambient air by allowing the user to exhale around the facepiece, and comes with a rebreather bag, which allows the individual to reuse part of the exhaled oxygen.

Supplemental Oxygen Systems

To combat the effects of Hypoxia or possible cabin depressurization, pilots and passengers can use oxygen masks.

Diluter and Pressure Demand

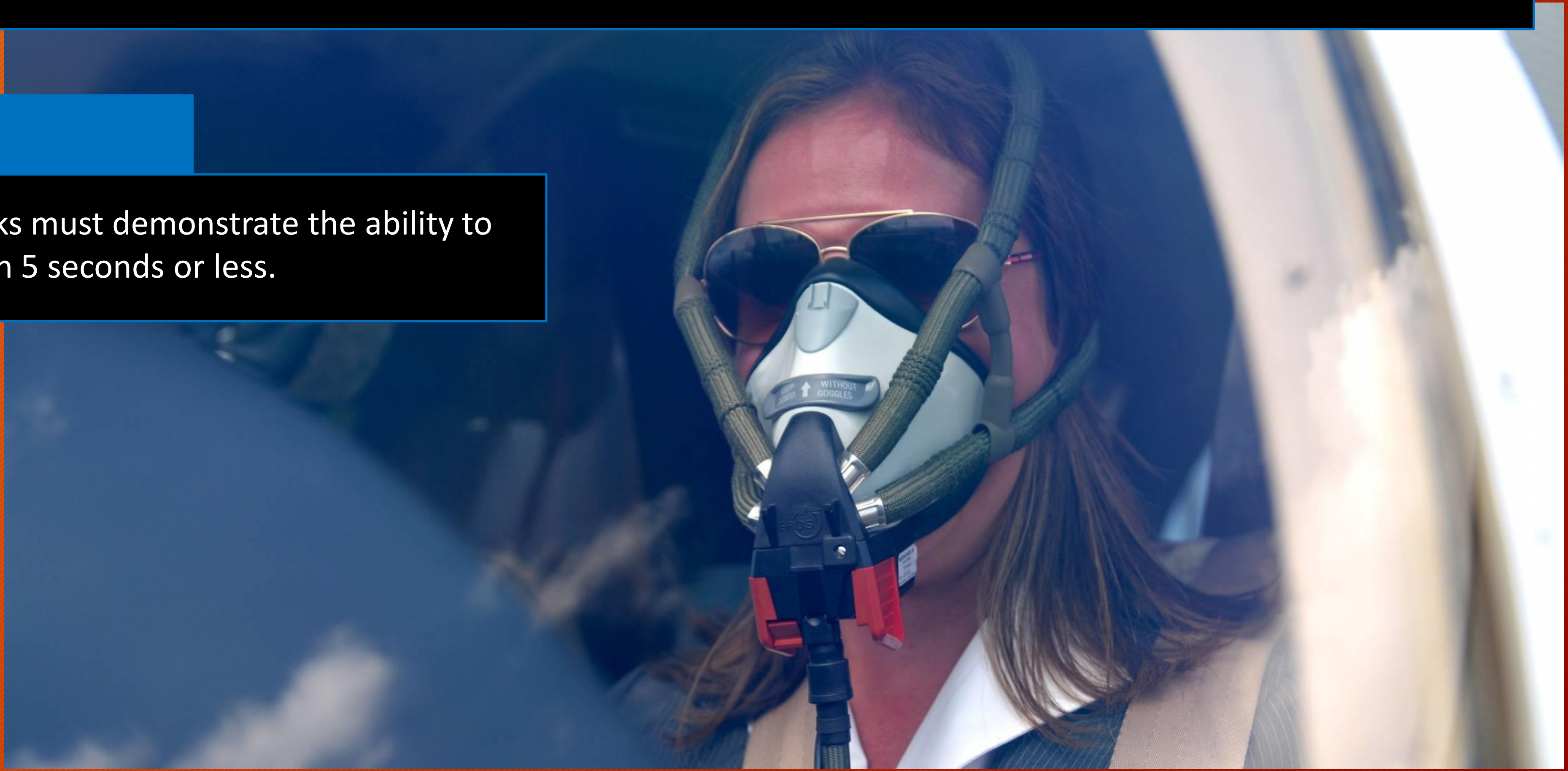
Diluter demand and pressure demand systems supply oxygen only when the user inhales through the mask. An automix lever allows the regulators to automatically mix cabin air and oxygen or supply 100 percent oxygen, depending on the altitude. The demand mask provides a tight seal over the face to prevent dilution with outside air and can be used safely up to 40,000 ft MSL. Pressure demand regulators also provide a positive pressure application of oxygen to the mask facepiece, which allows the user's lungs to be pressurized with oxygen. This feature makes pressure demand regulators safe at altitudes above 40,000 ft MSL.

Supplemental Oxygen Systems

To combat the effects of Hypoxia or possible cabin depressurization, pilots and passengers can use oxygen masks.

Quick Donning Mask

These types of oxygen masks must demonstrate the ability to be donned with one hand in 5 seconds or less.

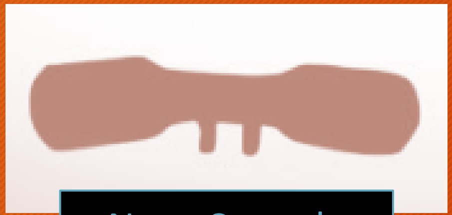


Supplemental Oxygen Systems

To combat the effects of Hypoxia or possible cabin depressurization, pilots and passengers can use oxygen masks.

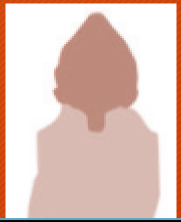
Which Mask is Right?

Each oxygen system comes with associated altitude limits.



Nose Cannula

Below 18,000’



Re-Breather

18,000 – 25,000’

Diluter

25,000 – 40,000’

Pressure

Above 40,000’

Supplemental Oxygen Systems

To combat the effects of Hypoxia or possible cabin depressurization, pilots and passengers can use oxygen masks.

Aviator's Breathing Oxygen

Aviator's Breathing Oxygen is 100% pure oxygen. This is different from medical oxygen because it does not contain water. Water cannot be present in aviation oxygen because it could freeze in the lines when flying at high altitudes and low temperatures.

Care of Oxygen Bottles

Make sure to securely fasten oxygen bottles in the aircraft so they are no disrupted in turbulence. Make sure they are inspected regularly and accordingly. Never smoke around oxygen bottles as they are highly flammable.

Useful Consciousness

This is the period of time from interruption of the oxygen supply, or exposure to an oxygen-poor environment, to the time when an individual is no longer capable of taking proper corrective and protective action. The faster the rate of ascent, the worse the impairment and the faster it happens.

Altitude	Time of Useful Consciousness
45,000 feet MSL	9 to 15 seconds
40,000 feet MSL	15 to 20 seconds
35,000 feet MSL	30 to 60 seconds
30,000 feet MSL	1 to 2 minutes
28,000 feet MSL	2½ to 3 minutes
25,000 feet MSL	3 to 5 minutes
22,000 feet MSL	5 to 10 minutes
20,000 feet MSL	30 minutes or more

Lesson Summary

In this lesson we discussed supplemental oxygen types and their use requirements, physiological factors related to high altitude flight, pressurization characteristics and control, and rapid and explosive decompression.