Pressurization and Oxygen Systems

Session Time: Two, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Innovations in aviation are driven by the desire to make aircraft safer, more capable, and more efficient. (EU3)

A deep understanding of how an aircraft operates enables a pilot to fly the aircraft to its maximum capabilities in both normal and abnormal situations. (EU5)

ESSENTIAL QUESTIONS

1. How do aircraft pressurization systems work?
2. How do pilots get adequate oxygen at high altitudes?

LEARNING GOALS

Students Will Know

- Why some aircraft are pressurized
- How pressurization works
- How oxygen is supplied at high altitudes in non-pressurized aircraft

Students Will Be Able To

- *Assess* the need for pressurized aircraft at high altitudes. (DOK-L3)
- *Analyze* the relative merits of flying pressurized aircraft and supplemental oxygen systems. (DOK-L3)
- *Compare* the functions and features of pressurization and supplemental oxygen systems. (DOK-L3)

ASSESSMENT EVIDENCE

Warm-up
Students will state what they recall about air pressure and available oxygen versus altitude. Much of this information should be recalled from when they studied air volume and density in previous lessons. The teacher should write the students' correct responses on a board, where everyone can see in order to keep track and potentially address them as they come up in the lesson. Students will then watch a short video and answer questions about what they see as it relates to pressure.

Formative Assessment
Students will match terms and definitions for components of an aircraft pressurization system.

Summative Assessment

Divide students into teams and have each team put together a brief presentation about either pressurized cabins or supplemental oxygen systems. The presentation should include information about how the system works and why it is vital to their particular aircraft's mission/operation (their choice of mission). The team with the most persuasive, fact-filled presentation wins. Have students collect facts related to their chosen topic in-class as the final assessment. If time allows, direct them to complete further research, assemble the presentations, and plan to present them in another class session.

LESSON PREPARATION

MATERIALS/RESOURCES

- Pressurization and Oxygen Systems Presentation
- Pressurization and Oxygen Systems Student Activity 1
- Pressurization and Oxygen Systems Student Activity 2
- Pressurization and Oxygen Systems Student Activity 3
- Pressurization and Oxygen Systems Teacher Notes 1
- Pressurization and Oxygen Systems Teacher Notes 2
- Pressurization and Oxygen Systems Teacher Notes 3
- Access to Internet (per group)

Teaching Tip
Consider presenting the summative assessment (**Pressurization and Oxygen Systems Student Activity 3**) at the beginning of Session 1, so that student groups can select a topic and gather information about it as you progress through the presentation. Then, you may wish to assign the research portion of the assessment as homework after Session 1, so that students can spend most of Session 2 creating their presentations.

Recommended Student Reading

- **Pilot's Handbook of Aeronautical Knowledge**
  Chapter Seven, Aircraft Systems, pages 7-34 to 7-40 https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/09_phak_ch7.pdf

LESSON SUMMARY

Lesson 1 - Pressurization and Oxygen Systems
Lesson 2 - Anti-Icing Systems

This lesson begins by allowing students to share their existing knowledge about both pressure and oxygen. This will help to create a shared mental model and engage them before jumping into the lesson.

Students will then learn about the importance of providing pressurized environments and supplemental oxygen at high altitudes. The will go on to take a closer look at aircraft pressurization systems, including key components and controls, the pilot's role in managing the system, and the types of problems that can develop. Students will also review an accident that concerns both pressurization and oxygen and analyze why it occurred and how it could have been prevented.

During the next session of the lesson, students will consider supplemental oxygen systems, including the various types that are available, their key components, and their effectiveness under different circumstances.

Students will be assessed on what they learned regarding pressurization by completing a worksheet that matches key terms and definitions. At the conclusion of the lesson, students will answer private pilot knowledge test questions. Finally, students will create a presentation to demonstrate how much they learned and how they can incorporate that knowledge into an aircraft's particular mission.

BACKGROUND

Aircraft are flown at high altitudes because they achieve a higher true airspeed and consume less fuel than they do at lower altitudes. Additionally, pilots may avoid adverse weather systems by flying above them at high altitudes. For these reasons, most modern aircraft operate at high altitudes, and, therefore, they must have pressurization and supplemental oxygen systems for the comfort and safety of the crew and passengers.

In a typical pressurization system, the cabin, flight compartment, and baggage compartments are incorporated into a sealed unit capable of containing air under a pressure higher than outside atmospheric pressure. In the event that these pressurization systems fail, or in the event of a sudden loss of cabin pressure, supplemental oxygen must be available to both flight crew and passengers to prevent hypoxia and subsequent loss of consciousness.

Oxygen and pressurization systems work in tandem to prevent hypoxia. FAA regulations require that flight crew be on supplemental oxygen after 30 minutes in cabin pressure altitudes between 12,500 and 14,000 feet. Flight crews must be on supplemental oxygen immediately at cabin altitudes above 14,000 feet. Above 15,000 feet, every occupant must be on supplemental oxygen, even though most people will begin to feel the initial effects of hypoxia, such as disorientation, at lower altitudes. Although oxygen itself is non-flammable, it supports combustion in that it causes the flammability of the items around it to significantly increase. For this reason, safety and knowledge of an aircraft's oxygen systems is critical.

MISCONCEPTIONS

Students may think that travelling in a commercial aircraft has exposed them to the effects of high altitudes. However, it's likely that the highest altitudes that they've experienced on these flights were less than 8,000 feet.

DIFFERENTIATION

To support student engagement and motivation, extend learning by introducing students to the story of Wiley Post and the oxygenated pressure suit created by B.F. Goodrich that was worn during a high-altitude transcontinental flight.

To support student learning in the **EXPLAIN** section, break students into learning stations to explore the Helios Airways 522 crash and other pressure-related aircraft accidents in preparation for completing **Pressurization and Oxygen Systems Student Activity 1**. Centers may include an accident case study, related news articles, passenger accounts, accident investigation reports, and **Pressurization and Oxygen Systems Student Activity 1**.

LEARNING PLAN

ENGAGE

Teacher Material: Pressurization and Oxygen Systems Presentation

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slides 4-5: Conduct the **Warm-Up**.

Warm-Up

To activate prior knowledge, ask students to state what they remember about the relationship between pressure and oxygen. Much of this information they should already know from studying air volume and density in previous lessons. Write the students' correct responses on a board where everyone can see in order to keep track and potentially address them as they come up in the lesson.

Possible correct statements/assumptions:

- *Air density/pressure decreases as altitude increases.*
- *Engine performance decreases as altitude increases.*
- *Aircraft can fly at higher true airspeeds at high altitude because air density is lower.*
- *The amount of available oxygen available for the human body or aircraft decreases with altitude.*
- *At high altitudes in pressurized aircraft, there is a significant pressure difference inside versus outside, which is a strain/load carried by the aircraft hull/main body.*
- *Any rapid loss of pressure in an aircraft will also result in a loss of available oxygen and must be quickly mitigated by supplemental oxygen for both pilots, aircrew, and passengers.*

Then, watch the following video together as a class. In the video, the aircraft is a Beechcraft 1900D starting at 25,000 ft and descending down to the airfield elevation of 450 ft.

- "Aircraft Pressurization" (Length 1:06)
  https://video.link/w/Fzmh

After watching, divide the class into pairs, and partners should exchange their answers to each question. Give students a few minutes to discuss, and then elicit responses from student volunteers.

- Why does the bottle react this way?

Answer: The bottle is sealed and the pressure on the inside of the bottle is less than that outside the aircraft, causing the bottle to crumple inward.

- If the bottle cap were off, would it react the same way? Why or why not?

Answer: No, it would not react the same way because the pressure inside would equalize itself to that outside as the descent occurred.

- What would happen if the bottle were sealed and altitude increased rather than decreased?

Answer: In an effort to equalize pressure, the air pressure inside the bottle would increase, and the bottle would expand because the inside air is more dense than the outside air.

- Do the human lungs react in the same way? Why or why not?

Answer: No, human lungs do not react the same way because like an open bottle, pressure would equalize itself. However, if pilots held their breath during a rapid depressurization, the air inside their lungs would rapidly expand and attempt to equalize, potentially causing injury to the lungs.

[DOK-L2; *Describe*]

EXPLORE

Teacher Material: Pressurization and Oxygen Systems Presentation

Slide 6: Aircraft are flown at high altitudes because they achieve a higher true airspeed and consume less fuel than they do at lower altitudes. Additionally, pilots may avoid bad weather by flying above it. For the safety of the crew and passengers at high altitudes, aircraft must pressurization and supplemental oxygen systems.

Show this video to summarize pressurization and breathing on an airplane.

- "How Can You Breathe On An Airplane?" (Length 3:31)
  https://video.link/w/x3mh

Slide 7: In most aircraft, the cabin, flight deck, and baggage areas are pressurized. They are sealed in order to maintain higher air density/pressure and oxygen than that outside the aircraft. This is accomplished by routing engine bleed air from the compressor section (or superchargers on older model turbine-powered aircraft, which students should recall from an earlier lesson) that pumps the more dense air into those compartments. Since air is being pushed into the compartments, air must also be discharged. The discharge is accomplished by outflow valves throughout the fuselage which regulate the exiting air to maintain a constant pressure.

Slide 8: The flight deck is able to set the desired cabin pressurization based on the recommended system settings and capabilities. Generally, the majority of airliners, cargo, and large military aircraft maintain a cabin altitude of approximately 8,000 feet when operating at the aircraft's maximum cruise altitude. In other words, the air inside the cabin is at the same pressure as air atop an 8,000-foot mountain. Maintaining a lower cabin altitude would put increased stress and pressure on the hull of the aircraft. The pressurization system allows for a reasonably quick exchange of incoming to outgoing air in order to remove odors and stale air.

Pressurization also protects the crew and passengers from hypoxia, which is a serious medical condition caused by a lack of oxygen reaching the brain and organs. At an 8,000-ft cabin altitude, occupants can be transported comfortably and safely for an extended period of time. However, the flight crew must always be prepared to handle an accidental loss of cabin pressure, whether sudden or slow, and accomplish the emergency procedure.

Slide 9: The cabin pressure control system regulates the following:

- Cabin pressure
- Pressure relief
- Vacuum relief
- Differential pressure
- Dumping/venting (via outflow valves, regulator, and safety valve)

Slide 10: The cabin pressure regulator controls cabin pressure via the isobaric range (actual set cabin altitude) and differential range (limitations of internal vs. external pressures). For instance, when an aircraft reaches an altitude where the set cabin altitude/internal pressure meets the maximum differential pressure, any increase in altitude would cause an in increase in the cabin altitude. This is a safeguard known as differential control, which prevents the differential pressure from exceeding its limitations. This differential pressure is determined by the structural strength of the cabin. Also, the cabin size and probable areas of rupture (windows and doors) play a factor in how the engineers determined this value.

Slide 11: The cabin air pressure safety valve (known as a ram valve on some aircraft) combines pressure and vacuum relief, acting as a dump valve. While the pressure relief valve prevents cabin pressure from exceeding the differential pressure allowable, the vacuum relief prevents external pressure from exceeding cabin pressure.

Questions

Why would an aircraft need vacuum relief? Can you think of a situation?

Possible response: In the event of a rapid descent, perhaps with a medical emergency, the vacuum relief would ensure the pressure from the outside air doesn't press inward on the aircraft. Like the plastic bottle from the video, the inside of the aircraft would be sealed during the descent and could not regulate the pressure differential.

The flight deck has a switch which can actuate the dump/ram valve if necessary. When this switch is positioned to ram, a solenoid valve opens, causing the valve to dump the cabin air outside.

Questions

Why would a dump/ram valve be necessary?

Possible response: It would be necessary to rapidly remove smoke from an aircraft.

Slide 12: Pilots monitor gauges to track system performance. The cabin differential pressure gauge indicates the difference between inside and outside pressure. The cabin altimeter reveals the internal cabin pressure. In some cases, these two instruments are combined together. The cabin rate-of-climb indicator indicates the cabin's rate of climb or descent. This is also important for crew/passenger comfort, as rapid descent may cause pain since air pressure inside the body may struggle to equalize quickly.

Pilot monitoring of these gauges is critical, and many aircraft are equipped with warning sounds and/or lights to alert the flight crew if safety limitations are being exceeded.

Slide 13: Explosive decompression is a change in cabin pressure that happens faster than the lungs can decompress, possibly resulting in lung damage. Normally, the time required to release air from the lungs without restrictions (e.g., masks, etc.) is 0.2 seconds. Most authorities consider any decompression that occurs in less than 0.5 seconds to be explosive and potentially dangerous.

During an explosive decompression, the noise may be so loud that it damages the eardrums and may cause those experiencing it to feel dazed momentarily. The air tends to fill with fog, dust, or flying debris. The rapid drop in temperature and change in relative humidity causes the fog. The victims' ears should clear automatically over the period of a few minutes, and sometimes they will notice that air rushes from the mouth and nose as the pressures equalize rapidly.

If significant structural damage occurs, the explosive decompression endangers those on board with the risk of being sucked out of the aircraft due to the pressure rapidly equalizing. This is one reason everyone should wear their harnesses or seatbelts when seated.

In the event of such a decompression, pilots should expedite a descent to a lower altitude. In the event of a slow decompression, which may not be so obvious, visual and aural warning systems have been incorporated into pilot instruments as well.

Show students this clip from "Air Disasters: Getting Out Alive" (Length 3:50), which shows a re-enactment of an explosive decompression situation in which all passengers survive. https://video.link/w/qPNh

Slide 14: Because the pressure equalization causes the oxygen in the lungs to exit rapidly during explosive decompression, the time of useful consciousness is significantly lowered. This also reduces the amount of oxygen in the bloodstream, reducing the pilot's reaction and performance time by one-third to one-fourth. Due to the risk of rapid decompression and its devastating effects, some regulations mandate that an oxygen mask be worn when flying above a set altitude, often 35,000 feet. Further, pilots are instructed per their checklists to set their oxygen settings to 100 percent for aircraft with pressure demand oxygen systems.

Take a look at the time of useful consciousness table and note the drastic change as altitude increases. Hypoxia followed by loss of consciousness are the chief dangers of decompression. This is why training and practice of rapid and proper donning of supplemental oxygen equipment is critical.

Slide 15: Rapid decompression at high altitude also poses the threat of decompression sickness, something SCUBA divers may know as "the bends." Gases, particularly nitrogen, that are normally dissolved in the blood come out of solution and form bubbles inside tissues, including organs, joints, lungs, and brain. It is a serious condition and can be fatal. It can be treated by placing the victim in a pressurized hyperbaric chamber where they breathe pure oxygen, then slowly lowering the pressure, giving the body time to decompress.

EXPLAIN

Teacher Materials: Pressurization and Oxygen Systems Presentation, Pressurization and Oxygen Systems Teacher Notes 1, Pressurization and Oxygen Systems Teacher Notes 2
Student Materials: Pressurization and Oxygen Systems Student Activity 1, Pressurization and Oxygen Systems Student Activity 2

Slide 16: In this activity, students will review an aircraft accident and reach conclusions as to possible causes and solutions. Distribute a copy of **Pressurization and Oxygen Systems Student Activity 1** to each student, and direct them to read the scenario, watch the video, and answer the questions independently. If time allows, consider watching the video together as a class, allowing students to ask questions.

Correct answers for each question are provided in **Pressurization and Oxygen Systems Teacher Notes 1**.

Slide 17: Complete the **Formative Assessment**.

Formative Assessment

Distribute a copy of **Pressurization and Oxygen Systems Student Activity 2** to each student. In this activity, students will match each term related to pressurization systems to its correct definition.

The correct answers are provided in **Pressurization and Oxygen Systems Teacher Notes 2**.

This activity is worth 8 points: 1 point per match.

[DOK-L1; *Identify*]

Slide 18: Oxygen and pressurization systems work in tandem to prevent hypoxia. FAA regulations require that:

- Flight crew be on supplemental oxygen after 30 minutes in cabin pressure altitudes between 12,500 and 14,000 feet.
- Flight crew must be on supplemental oxygen immediately at cabin altitudes above 14,000 feet.
- Every occupant must be on supplemental oxygen above 15,000 feet, even though most people will begin to feel the initial effects of hypoxia, such as disorientation, at lower altitudes.

Fatigue and poor physical fitness can exaggerate these effects. Therefore, pilots are encouraged to use supplemental oxygen above 10,000 feet cabin altitude during the day and above 5,000 feet at night.

The majority of aircraft that frequent high altitude travel have a fixed oxygen system rather than simple standalone bottles. If this is not available, portable oxygen equipment must be readily accessible during flight. The portable equipment usually consists of a container, regulator, mask outlet, and pressure gauge. These systems both have their own sets of standards, limitations, and must be inspected regularly, including during every preflight, to ensure safety.

Slide 19: Although oxygen itself is non-flammable, it supports combustion in that it causes the flammability of the items around it to significantly increase. Oils and greases may not be used on the seals, valves, and fittings of oxygen equipment in part because it may ignite if exposed to oxygen and any kind of ignition source (e.g., a spark) is present.

Show students this video to support this important point, and ask them the question that follows.

- "Oxygen Accelerated Fire Demonstrations" (Length 1:23)
  https://video.link/w/lJmh

Questions

Why would this be dangerous on an aircraft?

Because of the enclosed space of an aircraft, a fire that is oxygen-accelerated could rapidly spread, become out of control and life-threatening.

Slides 20-21: Many different types of oxygen masks are used in aviation. Regardless of which is used, the flight crew must ensure that the oxygen mask is compatible with the oxygen system itself. The majority of system-integrated masks are equipped with a microphone. Just as the oxygen supply, the mask, system, and microphone must be tested before each flight. No matter the type of mask, they should all seal tightly over the user's face to prevent dilution or contamination with the air surrounding it. Different types of systems are effective under different conditions. For example, a cannula system may not be effective at the highest cabin altitudes.

There are various types of oxygen systems in terms of the oxygen delivery method.

- Diluter-demand oxygen systems supply oxygen only when the user inhales. An automix lever regulates to automatically mix cabin air and oxygen or to supply 100 percent oxygen, depending on either the setting or the altitude. Many large and commercial aircraft utilize this type of system because the user does not need to switch anything 'on' when the need arises (assuming everything was already correctly set up during preflight). These systems are typically rated to be used safely up to a cabin altitude of 40,000 feet
- Pressure-demand oxygen systems are similar to diluter demand, except that oxygen is automatically supplied under positive pressure to the user's lungs. These regulators create tight seals as well, and some have the regulator attached directly to the mask rather than inside the system's instrument panel. Most commercial air passengers are familiar with continuous-flow oxygen systems because these are the ones typically provided on airlines in the event of a depressurization. The passenger mask typically has a reservoir bag that collects oxygen when the user is exhaling into the mask. This oxygen creates a higher flow during inhalation and also cuts down on the dilution of the air it's providing. Though less common in aviation, portable electrical pulse-demand oxygen systems deliver oxygen by detecting an individual's inhalation effort and provide oxygen during the initial inhalation. Pulse demand systems do not waste oxygen during the breathing cycle because oxygen is only delivered during inhalation. Most pulse-demand oxygen systems incorporate an internal barometer that automatically compensates for altitude increase by increasing the amount of oxygen delivered.
- A cannula is a piece of plastic that fits into the nose with attached oxygen supply tubing. Although they can be more comfortable and less restrictive than masks, they are not as reliable for providing adequate oxygen flow. This is a safety concern when operating at higher altitudes. Older regulations allowed for airplanes to be equipped with these on-board oxygen systems. However, current regulations require oxygen masks rather than cannulas for operations above 18,000 feet.

Slide 22: A pulse oximeter is not a method of oxygen delivery, but rather a measurement tool. It is a non-invasive device that measures the amount of oxygen in a person's blood. It does this by using a light beam to measure the color changes in red blood cells. The color of the cells will change depending on how saturated they are with oxygen.

This tool is quite handy, especially when flying a non-pressurized aircraft. These portable and relatively inexpensive devices allow both pilots and passengers to determine whether or not they require supplemental oxygen.

Questions

Why would a pulse oximeter be necessary in aviation?

A pulse oximeter could be necessary because the initial onset symptoms of hypoxia are often subtle and hard to detect. Even slight oxygen deprivation can cause delayed reaction time and decreased pilot cognition/performance. In a critical phase of flight, this could lead to unfortunate consequences.

EVALUATE

Teacher Materials: Pressurization and Oxygen Systems Presentation, Pressurization and Oxygen Systems Teacher Notes 3
Student Material: Pressurization and Oxygen Systems Student Activity 3

Slide 23-26: Quiz students on questions from the Private Pilot Knowledge Test.

Slide 27: Conduct the **Summative Assessment**.

Summative Assessment

Divide the class into small groups of 3-4 students, depending on the number devices available, to access the Internet. Distribute **Pressurization and Oxygen Systems Student Activity 3**.

In this activity, students will compete as teams to create the most persuasive and fact-filled presentation about either pressurized cabins or supplemental oxygen systems. The presentation should include information about how the system works and why it is vital to a particular aircraft's mission/operation. Each presentation should take no longer than 3 minutes.

If short on time, direct students to only complete the first three steps in class. Consider asking students to complete the remaining steps as homework and then devoting a full class session to giving the presentations.

[DOK-L3: *Analyze*; DOK-L4: *Create*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Explanations show evidence of each of the following:
  - Accurate and detailed description of pressurization and/or oxygen systems
  - Thoughtful analysis of how these systems affect aircraft operation and safety
  - Accurate and persuasive supporting evidence for necessity in their aircraft's mission

- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points **Performance Levels**

9-10 A full understanding the lesson is demonstrated. The group: selects either pressurized cabins or supplemental oxygen systems for their topic and correctly describes how it works; chooses an aircraft and describes its intended mission; and records facts about their topic.

7-8 A sufficient understanding the lesson is demonstrated. The group: selects either pressurized cabins or supplemental oxygen systems for their topic and gives an adequate description of how it works; chooses an aircraft and describes its intended mission; adequately records facts about their topic.

5-6 An insufficient understanding of the lesson is evident. The group: selects their topic providing an insufficient description of how it works; chooses an aircraft and describes its intended mission; and provides insufficient documentation of facts about their topic.

0-4 A lack in understanding of the lesson is evident. The group: selects their topic providing incomplete or incorrect description of how it works; chooses an aircraft but incorrectly describes its intended mission; lacks documentation of facts about their topic.

GOING FURTHER

If time allows, direct students to complete the remaining steps of **Pressurization and Oxygen Systems Student Activity 3** in class.

Give students about 20 minutes to conduct research and prepare their presentations. Then, use the remaining time for each group to give their presentation to the class.

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **HS-PS2-6** - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
  - Science and Engineering Practices
    - Obtaining, Evaluating, and Communicating Information
  - Disciplinary Core Ideas
    - PS1.A: Structure and Properties of Matter
    - PS2.B: Types of Interactions
  - Crosscutting Concepts
    - Cause and Effect

- **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
  - Science and Engineering Practices
    - Asking Questions and Defining Problems
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.A: Defining and Delimiting Engineering Problems
    - ETS1.B: Developing Possible Solutions
  - Crosscutting Concepts
    - Systems and System Models

COMMON CORE STATE STANDARDS

- **RST.9-10.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **WHST.9-10.1** - Write arguments focused on discipline-specific content.
- **WHST.9-10.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- **WHST.9-10.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **WHST.9-10.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **WHST.9-10.9** - Draw evidence from informational texts to support analysis, reflection, and research.

REFERENCES

https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/09_phak_ch7.pdf
https://www.aopa.org/news-and-media/all-news/2016/september/pilot/oxygen-masks-101
https://www.aopa.org/news-and-media/all-news/1998/september/pilot/o2-issues
https://www.aopa.org/news-and-media/all-news/2008/february/pilot/turbine-pilot-pressure-pointers
Source of investigation results: https://www.skybrary.aero/index.php/B733,_en-route,_northwest_of_Athens_Greece,_2005