

High Altitude Training

Ground Training Syllabus

Simcom by CAE | Phoenix BAT

GROUND SCHOOL

4.5 Hours

MODULES

2 + Knowledge Check

REGULATORY BASIS

14 CFR § 61.31(g)

Course Description

This course delivers the ground training required by 14 CFR § 61.31(g) for pilots operating pressurized aircraft with a service ceiling or maximum operating altitude above 25,000 ft MSL. It is presented in two modules – **High Altitude Physiology** and **High Altitude Operations** – followed by a knowledge check and instructor endorsement. The physiology module addresses the human limits of the high altitude environment; the operations module addresses aircraft performance, aerodynamics, automation, and threat management above FL250.

Terminal Objectives

- Recognize the causes, symptoms, and progression of hypoxia, hyperventilation, decompression sickness, and trapped gas disorders, and state the correct corrective action for each.
- State the time of useful consciousness for a given altitude and describe how it drives the response to a loss of pressurization.
- Describe how cabin pressurization works, how it fails, and the immediate crew actions on failure.
- Explain high altitude aerodynamics – L/D_{MAX} , speed stability, coffin corner, crossover, optimum and maximum altitude – and determine the aircraft's cruise altitude capability.
- Identify the weather, icing, automation, and human factors threats that lead to unintentional slowdowns and upsets at altitude.
- Apply the correct recovery technique for an approach to stall and for a fully developed stall at high altitude, prioritizing angle of attack reduction over altitude retention.

MODULE 1 High Altitude Physiology			2.0 Hours
LESSON	TOPIC	KEY ELEMENTS	
1	High Altitude Basics	• The atmosphere as an operating environment: ambient pressure, temperature, and weather. • Oxygen remains ~21% of the atmosphere at all altitudes – hypoxia at altitude results from reduced barometric pressure, not reduced oxygen concentration.	
2	Hypoxia	• Definition: oxygen deficiency sufficient to impair the brain and other organs. • Causes: insufficient differential pressure to drive oxygen into the blood; changes in the partial pressures of oxygen and carbon dioxide. • Symptoms: shortness of breath, euphoria, dizziness, nausea, reduced visual acuity. • Progression by altitude – night vision degrades as low as 5,000 ft; other effects usually absent below 12,000 ft; tunnel vision and cyanosis above 15,000 ft. • Loss of corrective and protective action in 20–30 min at 18,000 ft and 5–12 min at 20,000 ft, followed by unconsciousness. • Recovery on oxygen is rapid (improvement in ~15 seconds). A paradoxical short-lived increase in symptoms is possible – do not stop oxygen. • Prevention: heed factors that reduce altitude tolerance, enrich inspired air with oxygen, maintain a safe cabin pressure altitude.	

LESSON	TOPIC	KEY ELEMENTS
3	Time of Useful Consciousness	- TUC table from 20,000 ft (30+ min) through 40,000 ft (15–20 sec). - Relationship between TUC, rate of decompression, and the time available to don a mask and initiate a descent.
4	Oxygen and Pressurization	VIDEO "Flying and Hypoxia" · slide 14 15:21 - Two means of prevention: increase the ratio of oxygen, or increase the pressure. - Oxygen – provides greater concentration of available O₂, but does not prevent evolved gas problems and does not hydrate lung tissue. - Pressurization – prevents evolved gas problems and bodily discomfort, maintains lung function, and never runs out. - How it works: bleed air fills and compresses the cabin; cabin altitude is controlled by the outflow valve. - Failure modes: leaks or sudden failure of the pressure vessel, structural failure of windows/doors/fuselage, bleed air failure, outflow valve malfunction. - Crew response: don oxygen mask, descend without delay, then reevaluate the flight (fuel burn, maintenance, diversion).
5	Hyperventilation	- Blowing off CO₂ faster than the body produces it; the body requires CO₂ to function normally. - Primary cause in crewmembers is emotional – fear, anxiety, stress. - Symptoms overlap with hypoxia and the two can occur together; increased breathing rate is an early compensatory response to hypoxia. - Treatment: slow the breathing rate, talk out loud, breathe into a bag.
6	Decompression Sickness	VIDEO "Altitude Induced Decompression Sickness" · slide 21 11:15 - Liberation of nitrogen bubbles in the body due to reduced atmospheric pressure. - Symptom groups: bends, skin effects, chokes, neurological symptoms. - Predisposing factors: altitude, duration of exposure, exercise, re-exposure, age, body weight. - Flying after SCUBA – at least 12 hours after a dive not requiring controlled ascent, and at least 24 hours after a dive requiring controlled ascent, for flight altitudes up to 8,000 ft; at least 24 hours after any dive for flight above 8,000 ft. Altitudes are actual flight altitudes AMSL, not cabin altitude.

LESSON	TOPIC	KEY ELEMENTS
7	Trapped Gas – Ear and Sinus Block	VIDEO “Trapped Gas” · slide 44 10:06 • Middle ear equalization: the Eustachian tube vents on ascent; on descent the pilot must actively equalize by swallowing, yawning, tensing throat muscles, or the Valsalva maneuver. • Ear block – congestion holds the Eustachian tube closed; produces severe pain and hearing loss lasting hours to days, with possible eardrum rupture or middle ear infection. • Sinus block – frontal or maxillary; occurs most often during descent; excruciating pain, aching upper teeth, possible bloody nasal discharge. • Prevention: do not fly with an upper respiratory infection or nasal allergic condition. Sprays and drops give inadequate protection, and oral decongestants carry side effects that impair pilot performance.
8	Rapid and Explosive Decompression	• Rapid decompression – the lungs can decompress faster than the cabin (e.g., loss of a window or door). • Explosive decompression – the lungs cannot exhale fast enough and expanding gas can cause lung damage. • Do not hold your breath in either event. • Secondary effects: reduced hypoxia and DCS onset times, flying debris, wind blast, lowered temperature. • Case study – Aloha Airlines Flight 243.

LESSON	TOPIC	KEY ELEMENTS
1	Overview and Training Goals	• High altitude defined for training purposes as any altitude above FL250. • NTSB recommendation: pilots must thoroughly understand the airplane's performance capabilities, limitations, and high altitude aerodynamics. • Where the operational envelope is reduced – stay alert, recognize and confirm the situation, avoid large control movements, and be smooth with pitch and power.

LESSON	TOPIC	KEY ELEMENTS
2	High Altitude Aerodynamics	• V_{MO} / M_{MO} and the “barber pole”; how the indication moves with altitude. • Coffin corner – convergence of stall speed and V_{MO}; turbulence loading can stall the aircraft and recovery can overspeed it. • $L/D_{MAX} (V_{MD})$: the front side of the drag curve is speed stable; the back side (region of reverse command) is unstable – decreasing speed increases drag, which further decreases speed. • Crossover altitude – where a given CAS and Mach represent the same TAS; above it, speeds are referenced to Mach. • Optimum altitude and its sensitivity to weight, cost index, speed mode, and temperature. • Maximum altitude as the lowest of certified (structural), thrust-limited, and buffet/maneuver-limited altitude. • The amber band – 1.3g / 40° bank margin to buffet, constant with temperature; it gives no indication of thrust limits and does not guarantee level flight is sustainable at that speed. • Optimum climb speed deviations – improper use of vertical speed modes is the primary cause of slow speed events during climb.
3	Maneuvering and Handling at Altitude	• Thrust-limited vs. buffet-limited: most turbine aircraft are thrust limited at altitude, especially in a turn. • Bank angle protection is available in LNAV but lost in HDG SEL; select a routine 10–15° bank limit for cruise. • Recovery from airspeed decay – reduce bank, increase thrust to MCT, descend. • Weight and balance effects: aft loading reduces longitudinal stability and can severely impede stall recovery; the problem is magnified at altitude. • Mach tuck and Mach buffet – critical Mach number, shock wave formation, aft movement of the center of pressure.
4	Stalls at High Altitude	• A wing can stall at any airspeed, any altitude, and any attitude – attitude has no relationship to aerodynamic stall. • Know the difference between approach-to-stall recovery and stall recovery; the techniques are not the same. • Stall characteristics: heavy buffeting, lack of pitch authority, lack of roll control, inability to arrest descent rate, usually with continuous stall warning. • The elevator is the primary pitch control – not thrust. Reduce angle of attack and trade altitude for airspeed. • Stall recovery is the priority; altitude recovery is secondary and is initiated only after positive recovery. • Swept wing turbojets may stall at a reduced angle of attack at altitude due to Mach effects.

LESSON	TOPIC	KEY ELEMENTS
5	High Altitude Threats – Weather	• Icing, clear air turbulence, convective and wake turbulence, mountain wave, high level windshear, thunderstorms. • Jet stream velocities and boundary windshear can produce severe turbulence and substantial airspeed decay. • Recovery requires increasing thrust or decreasing angle of attack, and may require trading altitude for airspeed to accelerate off the back side of the power curve. • Preflight and enroute: review forecasts, significant weather charts, and turbulence plots; monitor trends and update weather in cruise.
6	High Altitude Threats – Icing	• Know anti-ice equipment limitations, AFM requirements, and SAT temperature limits. • Thermal anti-ice bleed penalty – reduced available thrust and increased fuel consumption; the aircraft may be unable to hold cruise speed or altitude. • Ice accretion increases weight and drag; the aircraft may exhibit stall onset before stick shaker activation. • Automation can mask icing effects – autopilot may trim to a stall and then disconnect with a large out-of-trim or rolling moment. • There are no reliable rules of thumb for icing speeds; maintain an adequate margin above stall.
7	Flight Techniques and Automation	• PFD airspeed tape and trend vectors show speed margins but do not indicate whether adequate thrust is available. • Automation in cruise will increase thrust to the selected limit and then raise pitch to hold altitude while speed decays – select MCT, and if speed still decays, the only option is to descend. • Act before excessive airspeed loss: pitch down in a mode that keeps thrust at maximum; if the aircraft is not responding, take over manually and re-engage once stabilized. • Vertical Speed mode prioritizes the commanded rate over speed – as a general guideline VS should not be used for climbing at high altitude. In descent, excessive rates can drive an overspeed. • RVSM and traffic considerations during a large altitude deviation – turn off course, avoid large bank angles, monitor TCAS, advise ATC.
8	Human Factors and Upsets	• Startle factor – unexpected stall warning, dynamic buffeting, and large attitude changes, especially with the autopilot engaged. • Low speed buffet mistaken for high speed buffet, prompting an incorrect reduction in airspeed. • Reasons for delayed recovery: concern for occupant safety after large control inputs, prior training that emphasized minimum altitude loss, anxiety over altitude deviations and ATC, limited recent manual handling at altitude, and underestimating the altitude loss required.

MODULE 2 High Altitude Operations			2.0 Hours
LESSON	TOPIC	KEY ELEMENTS	
9	Additional Considerations	- Multi-engine flameout – prompt recognition, immediate recall items and checklist, manual pitch down to establish windmill relight airspeed; driftdown may be required above 30,000 ft. Autopilot/autothrottle disconnect and electrical indications are recognition cues. - Core lock – differential contraction after an abnormal thermal event seizes the core. If spools indicate zero RPM, establish best L/D_{MAX} rather than windmill speed and consider forced landing options. - Turbine rollback – uncommanded thrust loss with reduced N1 and rising EGT; causes include moisture, icing, fuel control faults, disrupted airflow at high AOA, and mechanical failure.	

Course Media

All course video resides in the High Altitude Physiology deck and its runtime is included in the Module 1 allocation below. If the videos are instead assigned as pre-work, Module 1 reduces to 1.5 hours and the course total to 4.0 hours.

VIDEO	SLIDE	PRESENTED IN	RUNTIME
"Flying and Hypoxia"	14	Module 1, Lesson 4	15:21
"Altitude Induced Decompression Sickness"	21	Module 1, Lesson 6	11:15
"Trapped Gas"	44	Module 1, Lesson 7	10:06
Total video runtime	—	—	36:43

Training Time Allocation

COMPONENT	DURATION	NOTES
Module 1 – High Altitude Physiology	2.0 hours	Includes 36:43 of course video
Module 2 – High Altitude Operations	2.0 hours	No video; instructor-led
Knowledge check and endorsement	0.5 hours	Written check, review, logbook entry
Course total	4.5 hours	Ground training only

Knowledge Check and Endorsement – 0.5 Hours

Instructor-led review and written knowledge check covering both modules. On satisfactory completion the authorized instructor endorses the pilot's logbook or training record for the ground training required by § 61.31(g)(1).

Associated Flight / Simulator Training – § 61.31(g)(2)

The ground training above does not by itself satisfy § 61.31(g). The following flight training is accomplished in the applicable full flight simulator during the aircraft-specific course.

REQUIRED FLIGHT TRAINING	WHERE ACCOMPLISHED
(i) Normal cruise flight operations above 25,000 ft MSL	Simulator – cruise at or above FL250; energy state monitoring, speed and thrust margins, bank angle limiting.
(ii) Proper emergency procedures for simulating rapid decompression without actually depressurizing the aircraft	Simulator – pressurization failure and rapid decompression; mask on, crew communication, checklist discipline.
(iii) Emergency descent procedures	Simulator – emergency descent to a safe altitude, ATC coordination, terrain and traffic considerations.

High Altitude LOFT

An industry-recommended LOFT scenario familiarizes the crew with a high altitude slowdown and approach to stall. Crews recover at the **first** indication of an impending stall. The exercise is not intended to train a full stall or an actual upset, and may be adapted to the specific aircraft.

§ 61.31(g)(1) Ground Training Compliance Matrix

REQUIRED SUBJECT	COVERED IN
(i) High-altitude aerodynamics and meteorology	Module 2, Lessons 1–3, 5–6
(ii) Respiration	Module 1, Lessons 1–2, 5
(iii) Effects, symptoms, and causes of hypoxia and other high-altitude sicknesses	Module 1, Lessons 2, 5–7
(iv) Duration of consciousness without supplemental oxygen	Module 1, Lesson 3
(v) Effects of prolonged usage of supplemental oxygen	Module 1, Lesson 4
(vi) Causes and effects of gas expansion and gas bubble formation	Module 1, Lessons 6–7
(vii) Preventive measures for eliminating gas expansion, gas bubble formation, and high-altitude sickness	Module 1, Lessons 4, 6–7
(viii) Physical phenomena and incidents of decompression	Module 1, Lessons 4, 8
(ix) Any other physiological aspects of high-altitude flight	Module 1, all lessons

Completion Standards

- Attendance at both modules in their entirety.
- Satisfactory score on the written knowledge check.
- Ability to correctly state the immediate action items for a loss of pressurization and for a high altitude stall.
- Instructor endorsement entered in the logbook or training record per § 61.31(g)(1).

References

- [14 CFR § 61.31 – Type rating requirements, additional training, and authorization requirements \(eCFR\)](#)
- Simcom courseware: 01 – High Altitude Physiology, Revision Original 09/21
- Simcom courseware: 02 – High Altitude Operations, Revision Original 09/21
- FAA-H-8083-3 Airplane Flying Handbook; AC 61-107; Airplane Upset Recovery Training Aid