TB–263 TECHNICAL BULLETIN

Rev-0

PIA - HIGH ALTITUDE SKYDIVING OPERATIONS - BEST PRACTICES GUIDELINES

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HASO – Mission Statement

"High-altitude skydiving offers many unique challenges with increased risk. The goal of PIA is to improve the safety of this activity through research and education. "PIA's Best Practices Guidelines" provide basic considerations that are critical to jumper survival while allowing industry the latitude to improve available technology and procedures."

Purpose

The purpose of this document is to communicate a set of best practices in order to lower the risk associated with sport high-altitude skydiving operations. For the purposes of this document, High Altitude Skydiving Operations (HASO) are defined as those jump operations initiated at altitudes at or above 14,000 ft. MSL and up to 22,000 ft. MSL. These altitudes were chosen to cover the range that most drop zones will ascend to when offering high-altitude jumps. A separate section will be developed to cover altitudes above 22,000 ft. MSL. It is understood that there will be some overlap between the information presented in this document and the document that covers 22,000 ft. MSL and higher. The recommendations in this document are for jumps where the planned canopy opening altitude is at or just slightly above what is considered the normal opening altitude for the specific activity planned.

Introduction

Humanity is constantly evolving to lower risks through training and technological innovation. Every time a person leaves the ground, there is a risk of severe injury or death. As skydiving evolves, participants seek to expand the envelope of current activities with sometimes fatal results. As industry experts, the authors of this report are putting forth their current knowledge and experience with the goal of mitigating the risks associated with high-altitude operations, and thus hopefully lead to a lower incidence of injuries and fatalities. Hundreds of pages of FAA and military documents have been reviewed and distilled down to create these *Best Practices Guidelines.*

This report is intended to be a living document that will be updated as the industry and sport adapts to new technologies and training methods. It is not meant to be a comprehensive guide, but instead to be a source of knowledge for those who wish to take part in this activity. The reader is encouraged to seek additional resources and secure every available technology and training opportunity that will minimize the risk of high-altitude jumping. A list of reference materials is provided at the end of this report and the reader is encouraged to learn more about safe oxygen use and related activities.

High-altitude skydiving is risky. All parties involved must understand and acknowledge that there is a significant risk of injury or death, even when all precautions are taken. There is no technology in existence today that can guarantee a successful jump, and everyone who chooses to participate in this activity must be fully aware that human life is at risk, and that the risk increases exponentially with altitude. When the risk increases to a point where it cannot not be mitigated the operation must cease. Assessing and mitigating risk is only a part of the equation. The ability to recognize one's own individual limitations, the limitations of the equipment being used, and knowing when to choose not to jump is critical to increase the odds of a successful outcome.

Definitions

AED - Automated External Defibrillator

AGL – Above Ground Level

Aircraft Safety Officer (ASO) – The individual(s) onboard the aircraft who monitor each person onboard and manage the use of all oxygen-related equipment, to include aircraft-mounted and jumper worn oxygen systems. The Aircraft Safety Officer shall remain with the aircraft following the departure of the jumpers.

AINDS – Aviation-Induced Neurological Decompression Sickness

Bail-Out / Jumper-worn oxygen system – Typically consists of a mask and hose that connects to the regulator and oxygen bottle

CAMI – Civil Aerospace Medical Institute

CFR – Code of Federal Regulations (new term that replaces "FAR")

CPR - Cardiopulmonary Resuscitation

DCS – Decompression Sickness

Diluter Demand Regulator – A system which at certain altitudes provides breathing gas consisting of oxygen diluted with cabin air in order to prevent hypoxia while also conserving oxygen.

FAR – Federal Aviation Regulations - Replaced by the term "CFR" (Code of Federal Regulations)

HASO – High Altitude Skydiving Operation

Hemoglobin - The protein in red blood cells that transports oxygen from the lungs throughout the body and carbon dioxide from the tissues back to the lungs.

Hypoxia – A decrease in oxygen delivered to tissues to a point that bodily functions are compromised.

Jump Bottle – A supplemental oxygen supply worn by a jumper

Metered Orifices – A device used to control the flow rate or average velocity of gas flowing in a pipe

MSL – Mean Sea Level

Nasal Cannula - A device used to deliver supplemental oxygen to a person; consists of a tube which splits into two prongs which are placed in the nostrils. Not designed for use above 18,000 ft. MSL.

Onboard Oxygen – An oxygen system mounted in the aircraft, either permanently or temporarily, to provide oxygen to the occupants of the aircraft during flight above 10,000 ft. MSL.

Oxygen Mask – A device used to transfer breathing oxygen gas from storage to the lungs. Oxygen masks, for the purposes of this document, cover the nose and mouth.

Oxygen Saturation – The percentage of hemoglobin in blood that is bound with oxygen

Perfusion – The passage of fluid through the blood vessels to an organ or a tissue

Pulse Oximeter – A medical device that uses a sensor to indirectly measure oxygen saturation of blood (SPO2) and pulse rate.

SPO2 - The saturation of arterial blood with oxygen as measured by pulse oximetry, expressed as a percentage.

Safety Culture

Safe jump operations begin with the culture of the organization conducting the jump. From large organizations operating multiple turbine aircraft to the smaller Cessna drop zones, every organization must evaluate their equipment, training, procedures, techniques, and capabilities with a culture and goal of conducting jump operations as safely as possible.

General Considerations

1. The FAA oxygen requirements in unpressurized aircraft for pilots and aircrew are different than for jumpers and others in the aircraft.

   Under Part 91 Operations, the FAA allows pilots to engage in flights up to 30 minutes long at altitudes above 12,500 ft. MSL and below 14,000 ft. MSL without requiring the use of supplemental oxygen.

   14 C.F.R. § 91.211 states that:
   § 91.211 Supplemental oxygen
   (a) General. No person may operate a civil aircraft of U.S. registry –

(1) 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; (2) 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; and (3) At cabin pressure altitudes above 15,000 feet (MSL) unless each occupant of the aircraft is provided with supplemental oxygen.

2. For any flight above 15,000 ft. MSL jumpers must be provided with supplemental oxygen. The best practice would be for the jumpers to use the oxygen provided. Each person involved in high-altitude parachute operations is encouraged to become familiar with high-altitude physics, oxygen systems, and human physiology associated with exposure to high altitudes, and to communicate this information to all involved parties.
3. Multiple grades of oxygen are available. Consistent with FAA guidance with regard to concerns of regulator malfunction due to ice formation, Aviator Breathing Oxygen (ABO) is the grade of oxygen recommended for parachuting applications.
4. Each drop zone and HASO is unique, yet all should have specific plans in regard to safety considerations and risk. The following items are recommended minimum formal planning requirements at the organization level: Aircraft Maintenance, Oxygen Equipment Maintenance, Emergency Response, Airspace Coordination, On-board Aircraft Safety, Overall Mission and Safety, and Team Training.
5. Altitude chamber hypoxia training is available from multiple sources including the FAA, US military and private corporations. It is considered best practice that all personnel involved in HASO will receive altitude chamber training prior to participating in high-altitude operations.
6. Risk at altitude increases with time spent and activity level at altitude. The operational plan should include maximum permitted times at altitude, which if reached should cause immediate decent to a safe altitude and evaluation for the potential of-the planned jump's continuation.
7. Due to communication constraints, unique risks of high-altitude exposures, the potential for rapid deterioration of cognition at altitude and other factors it is recommended that the operations plan for each high-altitude drop allows that every participant has the ability to call for immediate termination and decent to safe altitude at any time. There should be multiple agreed upon methods for communicating this termination decision including voice, hand and arm signals, light signal or other methods which should be easily recognized by all personnel in the aircraft.
8. It is recommended that all personnel who will be exposed to high altitude have appropriate medical clearance for their role, which at a minimum would be a current FAA Class III medical certificate or equivalent medical examination.
    1. If there have been any significant medical changes since the last FAA medical certificate was issued people should not participate in high-altitude operations until cleared by an appropriate medical authority.
    2. An operation and safety briefing should be conducted with all participants at the start of the HASO. At a minimum the briefing should include the following elements:
        - i. Overall outline for the HASO
        - ii. Physiology and medical risks
        - iii. Oxygen system design and operation
        - iv. Abort criteria and authority
        - v. Ground and onboard medical response plan
        - vi. Opportunity for all participants to ask questions

Personnel Considerations

HASO team composition will vary based on many factors including maximum altitude, aircraft used, weather conditions, jump discipline employed, experience of team members, location of drop zone, etc. Recommended best practices regarding team composition may include considerations and planning for pilots, jumpers, medical responders, oxygen safety personnel, and ground personnel.

Pilots

1. Must meet all FAA requirements for the planned HASO.
2. Should be qualified and current in the aircraft and all other procedures involved in the planned HASO.
3. The pilot in command has ultimate responsibility for the control of the aircraft and thus the altitude associated risks for all personnel. The pilot in command can terminate the flight or decrease to safer altitude at any time for safety or other considerations.

Jumpers

1. A mission safety briefing should be conducted with all jump, aircrew, and support personnel prior to jump operations.
2. Ground training appropriate to the jump altitude should be conducted prior to the first jump at high altitude, recurrent training on an annual basis and before high-altitude jumps are made.
3. This training may incorporate drop zone-specific information and thus the jumper should receive training specific to the procedures and equipment at each different drop zone.
4. Discipline-specific (i.e.; tandem, wingsuit, individual freefall) briefings should be conducted for all high-altitude jumps.
5. Preparation and inspection of jumper oxygen gear integration with the harness/container system used must be performed by qualified personnel.
6. Jumpers must be briefed and should demonstrate awareness of HASO related emergency procedures, equipment limitations, etc.
    a. When an accidental canopy deployment occurs upon exit, will the jumper be able to safely descend to a no-oxygen-required altitude?
    b. Generally, with increasing altitude, parachutes open in less time resulting in higher opening forces.
    c. High-altitude deployments may exceed the maximum speed and structural strength of main and reserve parachutes and the harness/container system.
    d. High-altitude deployments may expose the jumper to very high opening forces, possibly resulting in injury or death.
    e. When a high-altitude deployment is intended after exiting an aircraft, to reduce opening forces, it is recommended to deploy 5 to 7 seconds after exit.
7. All personnel involved must be aware of additional risks associated with high-altitude jumps including parachute system altitude limitations, oxygen system operation and limitations.
8. The jumper may be unable to help themselves due to hypoxia and other causes.
9. Equipment modifications should only be made in consultation with the manufacturer and must be thoroughly briefed and understood by the staff and jumpers onboard.

10. Emergency procedures may have to be modified and rehearsed to account for any equipment modifications and the HASO environment.
11. For flights between 14,000 ft. - 18,000 ft. MSL and any time oxygen will be used during the flight:
    a. Ground training on the proper use and fit of the onboard oxygen system and aviation physiology review should be accomplished.
    a. Specific review of where to stow masks or nasal cannulas after they are removed in order to minimize entanglement issues during exit should be accomplished.
    b. Review procedures for hypoxia, DCS, trapped gas expansion issues and when to stop using the onboard system prior to exit.
    c. Review hand commands that might be used instead of voice commands due to use of oxygen mask related communication difficulties.
    d. For jump operations above 18,000 ft. MSL, masks must be used.
    e. It is recommended that facial hair not be present when using masks. (Refer to AC120-43 – The Influence of Beards on Oxygen Mask Efficiency)
    f. The expected temperatures at altitude should be taken into account and appropriate clothing worn, with consideration of electrically heated clothing and covering of all exposed skin.
    g. An evaluation of participant physical condition, O2 saturation baseline at ground level and gear check should be made for all HASO participants.
    h. All parachute equipment used on high-altitude jumps should be inspected by a rigger to ensure airworthiness and to minimize the risk of a premature deployment.
    i. The harness/container systems should be packed tightly to ensure wind blast from various angles is not likely to open the container, the pin protection flaps or the main riser covers. The main deployment handle, cutaway handle and reserve handle must be secure in their respective locations.
    j. Review inflight emergency procedures and identify any differences from normal procedures.
    k. Review the procedures for problems with the oxygen system. Procedures include confirming the oxygen flow, the correct use of the mask or cannula, and swapping defective equipment.
    l. Review use of Pulse Oximeter.
    m. Review the procedures on how to communicate with the ASO while on oxygen.
    n. Each jumper should be assigned a “Buddy,” a jumper seated in sight of and near to them. The pair keeps watch on each other for any indication that there is a problem with their oxygen supply, hypoxia or DCS.
12. For flights above 18,000 ft MSL and below 22,000 ft MSL all of the above, plus the following:
    a. Medical certification (FAA - Class 3 or equivalent)
    b. If demand regulators of any type are used, provide ground training on the function and use of the regulators and masks.
    c. Confirm that the masks being used are compatible with the oxygen system used.
    d. Oxygen masks must be properly attached to the mask restraint system on the jumpers head and then individually fit and leak tested.
    e. If jumper worn oxygen systems are used, train everyone onboard on their operation and the procedure used when switching from the onboard system to the jumper worn oxygen system.

f. Review in-flight emergency procedures for aircraft-related problems and oxygen system-related problems including emergency exit procedures when connected to the onboard system.
g. Review breakoff altitude, opening altitude and loss of range of vision when using an oxygen mask and larger than normal goggles in freefall.
h. The temperatures and equipment use for high-altitude parachute operations can lead to icing of goggles. Consideration should be given to the use of backup altimeters that do not rely on jumper vision.
i. Review how unfamiliar equipment (i.e.; thicker gloves) can affect dexterity during normal deployment, EPs and canopy control.
j. Recognize how the consequences of a premature deployment at higher altitude can differ significantly from lower altitude deployments due to airspeed, temperature, winds aloft, canopy ride time, locating a safe landing area and other variables.
k. Recognize that once in-aircraft supplementary oxygen is removed, decompensation occurs rapidly and exponentially as altitude increases.

Medical Personnel

1. Best practice would include medical personnel with appropriate high-altitude physiology training and familiarity with the specific oxygen life support equipment used onboard the aircraft.
2. At a minimum, medical personnel that can conduct appropriate first responder duties must be available on the ground.
3. Minimum training for medical personnel includes First aid, Basic Life Support training including CPR and AED use, recognition and treatment of altitude disorders including hypoxia, DCS, hyperventilation.
4. Emergency Medical Services (EMS) must be on-site or within a reasonable emergency response time.
5. EMS personnel and should be briefed and ready to recognize and respond to altitude related medical conditions to include the importance of administration of the highest percentage oxygen possible to altitude-related casualties and transport of DCS patients at lowest altitude possible.
6. EMS must have the ability to contact the closest hyperbaric treatment facility that will be operational and staffed on the day of the HASO in order to consult with the facility personnel and notify them of the incident.
7. Every person participating in the HASO must have familiarity with the medical response plan. The medical personnel and aviation safety officer are responsible for formulation and verification of response plan details to include verification of closest hyperbaric treatment chamber capability and activation process.
8. The medical response plan should include at least one individual on the aircraft who is currently certified in Basic Life Support and familiar with all emergency response equipment and procedures in the medical response plan.
9. In-aircraft emergency treatment/resuscitation should be simulated/drilled by relevant staff to appreciate the complexities of attempting this on a jumper wearing a parachute harness, jumpsuit with extra clothing, mask and helmet while possibly attached to another jumper in a confined space.

Aircraft Safety Officer

The ASO will be responsible for the safety of the personnel on the aircraft. The ASO should develop a safety plan and a briefing for all participants. The ASO must be able to terminate the HASO at the first sign of an unsafe condition.

ASO Minimum Requirements:

1. Must have prior experience with multiple operations at the jump altitude planned.
2. Must possess the appropriate medical certifications (such as a FAA-Class 3 Medical) to perform their duties across all stages of flight.
3. Should use a suitable mask (not a nasal cannula) at all altitudes.
4. For flights above 18,000 ft. MSL, recommended to have successfully received high-altitude training, such as the FAA CAMI High-Altitude Chamber Training Program.
5. Must have a hose and mask donned and connected at all times above 10,000 ft. MSL.
6. Must have a backup system readily available in case of primary system malfunction.
7. Must be able to reach every location of the aircraft while connected to the primary oxygen system.
8. Must remain with the aircraft at all times, thus ensuring the safety of the pilots and remaining crew or jumpers after the jump.
9. Must be able to continue safe flight of the aircraft in the event of pilot incapacitation, such as coordinating with the co-pilot or taking control of the aircraft for single-pilot operations.
10. Must be able to relay emergency information to ground personnel without depending on the pilot. (Access to the aircraft radio without sitting in a pilot's seat.)

Ground Staff

1. It is recommended that there be a ground safety officer who has full knowledge of and appropriate authority to coordinate an emergency response.
2. The ground crew must have a plan to coordinate with alternate airports/drop zones in the event an emergency precludes a landing at the expected location.
3. Must have the ability to communicate with the aircraft at all times.
4. Must be able to track the aircraft and monitor the flight path to detect an anomaly, and if necessary communicate with air traffic control.
5. Must have the authority to direct an immediate termination of activities and return to a safe condition.

Equipment Considerations

Equipment most appropriate for a HASO will vary based on multiple considerations including maximum altitude aircraft used, weather conditions, jump discipline employed, experience of team members, location of drop zone, etc. Recommended best practices regarding equipment may include considerations and planning for aircraft, oxygen systems, physiology monitoring system, communications system, medical equipment, and a video recording system.

General

1. High altitudes can cause equipment malfunction or failure through pressure, temperature or other effects.
2. All equipment used in HASO should be tested and approved at the altitudes of the operation.

Aircraft

1. The planned HASO must not exceed the aircraft service ceiling.
2. The aircraft must be equipped with an onboard oxygen system with the capability of supplying a regulated source of oxygen to each person that is appropriate to prevent hypoxia at the maximum altitude for the planned flight.
3. If the aircraft is re-pressurized during any portion of the flight, care must be taken to ensure that the rate-of-change in cabin altitude at no time during the flight will cause activation of parachute automatic activation devices.

Parachute Equipment

1. Ensure the equipment is suitable for the intended jump - (weight, airspeed and altitude limitations)
2. In the absence of high altitude opening data for parachutes, aircraft true airspeed must be used for parachute deployment speed limitations.
3. Evaluate any modifications and how they might perform at higher altitudes and speeds.
4. Evaluate the performance of the canopies and consider the risk of an inadvertent opening and evaluate the procedures to mitigate risk.
5. Evaluate the jumper’s emergency procedures for the planned jump and modify accordingly to minimize the risk. (i.e.; delay the reserve opening, which may be the desirable option at higher altitudes.)

Oxygen System

1. The oxygen system should provide a sufficient reserve to support 20 minutes of flight in addition to the expected flight plan, and whatever additional time is required to descend at normal rates to 10,000 ft. MSL.
2. If the flight is below 18,000 ft. MSL, nasal cannula can be used.
3. If at or above 18,000 ft. MSL, nasal cannula is not appropriate and masks that cover the nose and mouth must be used.
4. If a diluter demand regulator is used and the flight is at or above 18,000 ft. MSL and up to 22,000 ft. MSL, it should be able to provide 100% oxygen for use in pre-breathing for 30 minutes below 16,000 ft. MSL, and for the rest of the flight. The volume of gas carried must be great enough to support the pre-breathe time, the planned flight time and a 20 minute reserve.
5. The masks and hoses used should be designed and approved for use with the regulators being used.
6. Oxygen storage cylinders should be easily accessible and secured so that they cannot shift during takeoff, flight and landing.
7. The feed lines and manifolds should be designed to allow for the appropriate flow of oxygen needed to supply the ports in each main line and each line providing oxygen to an individual. This can be

accomplished through the use of properly sized metered orifices or a variable flow regulation device(s) placed at or near the distribution point or in each line between the attachment to the main line and the end where the nasal cannula or masks are located.

8. Oxygen supply lines should have a means to regulate the flow to each individual user.
9. Oxygen regulators should automatically regulate the pressure to the manifold as the altitude increases and the cylinder pressure drops. If the regulator used does not automatically adjust for altitude then an ASO must be assigned to appropriately adjust the regulator.
10. Oxygen hoses will be securely located and placed so they can be easily accessed while not causing a trip or entanglement hazard.
11. The hoses for each person should be long enough so every person can remain on oxygen in all anticipated locations inside the aircraft.
12. The material used to construct the O2 regulator and distribution system should be designed to be compatible with 100% oxygen and cleaned for use with oxygen at the factory, or before use.
13. Each individual hose for nasal cannula and masks should have a flow indicator so that the flow of oxygen can be confirmed at all times.
14. The portions of each cannula or mask that are in contact with the user should be sanitized between uses with a medically appropriate and oxygen safe sanitization product.
15. Commonly used hose materials for intermediate and low pressure hoses, used in a constant flow system, are polyethylene, silicon and PVC.
16. Hoses and connectors used for connection to high pressure cylinders, need to be designed for high pressure applications.
17. The aircraft must carry appropriate spare nasal cannulas and or masks which can be rapidly employed at altitude in the event of equipment failure.
18. A backup system should also be in place and readily accessible to everyone in the aircraft. This system should provide an appropriate volume of oxygen and ports for cannula or masks to supply everyone in the aircraft with oxygen to allow for a normal descent from the maximum altitude to 10,000 ft. MSL.
19. Recommendations for oxygen pre-breathing to reduce risk of DCS are based on the assumption that the oxygen system used during the pre-breathe period is supplying 100% oxygen to all personnel. The oxygen system used must be capable of providing 100% oxygen or the risk reduction assumptions associated with the pre-breathe period are not valid and DCS risk will be increased.

Physiology Monitoring System

1. Everyone in the aircraft should be able to have oxygen saturation monitored by an individual familiar with altitude physiology and the challenges of pulse oximetry monitoring.
2. Best practice would be the use of FDA approved devices for continuous real time pulse oximetry monitoring with data recording of everyone in the aircraft for the duration of the operation.

Communication System

1. Oxygen systems needed for life support can cause significant degradation of voice communications.

2. A communications plan which works in conjunction with the particular oxygen system being used is essential to maximize safety.
3. Best practice would be for continuous voice communications capability for all personnel on the aircraft for the duration of the operation.
4. If voice communications are not practical then backup communications plans should at a minimum include ready access to written communications for all personnel, which can be accomplished with dry erase white boards or paper tablets.

Medical Equipment

1. The aircraft must be equipped with an emergency response kit to include: Protective equipment for providing first aid / CPR, barrier mask or bag mask with capability to add supplemental oxygen supply, spare pulse oximeter, paramedic shears, separate portable oxygen supply able to deliver 100 % oxygen to treat DCS and/or hypoxia during flight.
2. When an automatic external defibrillator (AED) is available in the aircraft, and be aware of the manufacturer's recommended maximum altitude for use. Additionally, users may not hear the verbal commands.

Video System

1. Given the prevalence of small inexpensive video cameras it is considered best practice to have multi-view video recording of the entire HASO.
2. The video should be used in debriefing in order to facilitate system and safety improvements in future iterations of the HASO.
3. Efforts should be made to include time and altitude references in the video recordings.

Operational Considerations on Jump Day

Pre-Flight Activities

1. Pre-flight activities are generally the responsibility of the ASO and/or lead jumper.
2. Ensure oxygen system functionality and adequate oxygen supply for the planned HASO.
3. Ensure the oxygen system is installed correctly and is secured within the aircraft.
4. P.R.I.C.E check
    a. **P** – Check **Pressure** in oxygen cylinder
    b. **R** - Check the **Regulator** function
    c. **I** - Turn on the oxygen system and check the flow **Indicator** to ensure that oxygen is coming out of each cannula or mask.
    d. **C** - Check all the **Connections** in the system to ensure they are correctly closed and secure
    e. **E** - Ensure that the **Emergency** backup oxygen equipment is functioning properly and is ready for use
5. Ensure proper hose connection, routing, identification and compatibility.

   a. It is best practice to mark both ends of each distribution hose with individual identifiers to speed accurate tracing of hoses during normal checks or when there is a system problem during use.
   b. Colored zip ties either individually or with multiple colors works well. Tape can age quickly and degrade some hose material, its use is not advised.
6. Verify emergency equipment is on the aircraft and at the landing zone is functional and ready for use.
7. Verify proper 100% oxygen pre-breathing activities for all personnel have begun with sufficient time to accomplish pre-breathing requirements per guidelines.
   a. Cited references recommend 30 minutes of 100% oxygen pre-breathing be completed below 16,000 ft MSL for flights above 18,000 ft. MSL and up to 22,000 ft. MSL.
8. Verify appropriate clothing and thermal protection is worn by all aircraft occupants. Consider frostbite risk for exposed skin and use of electrically heated clothing.
9. Verify proper parachute equipment configuration and donning. Ensure AADs are properly configured and suitable to the operation. Ensure all handles are stowed and properly secured.
10. Ensure EMS is on-site and ready to respond.
11. Contact the pre-determined hyperbaric treatment chamber to notify that you will be conducting high-altitude operations and confirm that they will be able to provide emergency treatment that day.
12. Review winds aloft and compute exit point for jumpers. Ensure that jumpers will be able to exit and land within the operational area, without penetrating airspace outside the approved range.

Climb to Altitude

1. At 10,000 ft. MSL during daytime flights or 5,000 ft. MSL for nighttime flights – All aircrew must start the use of supplemental oxygen if not already started.
2. ASO will verify proper oxygen functionality for all occupants and inform pilot of status.
   a. Failure of an oxygen system major component will necessitate aborting the flight.
   b. The primary components and issues to consider include: Large O2 leaks in the primary system due to regulator, line disconnect or failure, or activation of a “Blow-Out Plug”
   c. The use of backup systems at this stage to continue the ascent is improper.
3. The ASO ensures everyone onboard the aircraft starts use of the oxygen system when directed. All jumpers must continue to use the onboard oxygen system until directed otherwise by the ASO or lead jumper just prior to exit.
4. The ASO monitors the oxygen supply and consumption rate throughout flight.
5. The ASO continuously verifies status of pilot, ideally using built-in verbal communication system.
   a. On jump run the ASO ensures that everyone continues to use the onboard oxygen delivery method until it needs to be removed just prior to exit according to the oxygen plan.
6. The ASO ensures oxygen hoses are properly stowed after removal by the jumper to allow clear access to the door.

Jump, Freefall, Canopy and Emergency Procedures

1. After exit, maintain situational awareness to keep track of other jumpers who may be having problems with physiological issues or altitude related gear issues.

2. Altitude awareness may be affected due to longer freefall time.
3. Take into consideration that at higher altitudes freefall speeds increase and may affect formation flying.
4. During all phases of the skydive, consider increased risk of hypoxia affecting your or other's judgement and flying.
   a. An important consideration on big-way skydives when potentially hundreds of other canopies are in the air and all are converging to land.
5. All personnel must be aware of their emergency procedures (EPs). Review, update and rehearse EPs to ensure minimum time is lost to respond during an emergency.
   a. EPs may very well change to accommodate for the high-altitude environment.

Post-flight Analysis and Reporting

1. Instruct everyone to check into a central meet location after landing to confirm all jumpers have returned safely.
2. Collect information from all jumpers with regard to:
   a. Any issues with the onboard oxygen system.
   b. Any signs or symptoms of hypoxia or DCS recognized in themselves or seen in others.
   c. If needed, activate EMS and/or start treatment for potential DCS with 100% oxygen.
3. Anyone with any complaint should be evaluated by trained medical responder.
4. Personally evaluate your physical condition prior to any further high-altitude jumps.
5. A thorough debrief and evaluation of all available video footage.
6. Human Factors – Document any reported or observed performance errors that may be related to hypoxia-induced lethargy, such as free fall collisions, sloppy formation docking, low main deployments, botched emergency procedures, canopy collisions/near misses, low hook turns, landing injuries, etc.)

7. Best practice guidelines recommend not to exceed:
   a. Aircrew/Pilots/ASO: Three (3) flights per 24 hour period at 18,000 - 22,000 ft. MSL.
      i. Additional flights may be made when all personnel breathes supplemental oxygen on each flight, commencing at 12,500 ft until the aircraft has descended below 12,500 ft.
      ii. Pulse/ox readings should be recorded on the ground and at the maximum planned altitude. Ground readings of 94% or lower, recommend terminate future flights until the PO2 levels rise to 96% or higher.
      iii. DZs based significantly above sea level should seek expert medical advice on what their flight profiles should be.

   b. Tandem Instructors: Five (5) flights per day at 15,000 – 18,000 ft. MSL.
      i. Additional jumps may be made when the instructor breathes supplemental oxygen on each flight, commencing at 12,500 ft until the oxygen supply system is removed and stowed prior to jump run.

ii. Pulse/ox readings should be recorded on the ground and at 3,000 ft below the intended exit altitude. Ground readings of 94% or lower, recommend terminate future flights until the PO2 levels rise to 96% or higher.
iii. DZs based significantly above sea level should seek expert medical advice on what their jump profiles should be.

c. AFF Instructors & Repeat Students: Five (5) flights per day at 15,000 – 18,000 ft. MSL.

i. Additional jumps may be made when the jumpers breathe supplemental oxygen on each flight, commencing at 12,500 ft until the oxygen supply system is removed and stowed prior to jump run.
ii. Pulse/ox readings should be recorded on the ground and at 3,000 ft below the intended exit altitude. Ground readings of 94% or lower, recommend terminate future flights until the PO2 levels rise to 96% or higher.
iii. DZs based significantly above sea level should seek expert medical advice on what their jump profiles should be.

Summary

High Altitude Skydiving Operations (HASO) are risky. All parties involved must understand and acknowledge that there is a significant risk of injury or death, even when all precautions are taken. The PIA intends that this technical bulletin describe best practices in order to reduce risk associated with HASO. The current version of this technical bulletin was formulated with input from multiple experts with experience in high-altitude operations and is limited to jump altitudes less than 22,000 feet MSL. It is a living document that will be updated as the industry and sport adopts new technologies, procedures and training methods. It is not meant to be a comprehensive guide, but instead to be a source of knowledge for those who wish to take part in this activity. The reader is encouraged to seek additional resources and secure every available technology and training opportunity that will minimize the risk of high-altitude jumping.

Reference Materials and Documents

1. Oxygen Equipment Use in General Aviation Operations. Federal Aviation Administration Report OK-09-439. https://www.faa.gov/pilots/safety/pilotsafetybrochures/media/oxygen_equipment.pdf
2. 14 CFR Part 135.89 Pilot requirements: Use of Oxygen
3. FAA AC105-2E Sport parachuting
4. FAA AC-120-43 The influence of beards on oxygen mask efficiency
5. FAA AM-400-95/2 Altitude Induced Decompression Sickness
6. FAA AM400-91/1 Hypoxia
7. FAR Part 91.2.11

8. USAF Manual 11-409 High Altitude Airdrop Mission Support Capability Program
9. 14 CRF Part 105 Parachute Operations
10. USPA SIM 6-7: High Altitude and Oxygen Use
11. FAA Airman Information Manual, Medical Facts for Pilots, 8-1-2 Hypoxia, https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap8_section_1.html#:~:text=For%20optimum%20protection%2C%20pilots%20are,above%205%2C000%20feet%20at%20night
12. FAA Pilot Safety Brochure Hypoxia, https://www.faa.gov/pilots/safety/pilotsafetybrochures/media/hypoxia.pdf

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