High Altitude Descent Course and Study Guide

New Zealand Parachute Industry Association Limited

NZPIA

For parachutists intending to make parachute descents from altitudes above 13,000 feet AMSL.

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INTRODUCTION

A High Altitude descent can be a safe descent, if all standard procedures are followed and a few additional precautions and best practices are taken into account.

For the purposes of this course, a High Altitude descent is defined as any planned parachute descent from between 13,000 and 20,000 feet Above Mean Sea Level (AMSL), from an unpressurised aircraft.

The NZPIA High Altitude Course does not specifically address descents from above 20,000 feet AMSL or descents from pressurised aircraft.

Regulations

The CAA rules pertaining to High Altitude descents are:

CAR Parts 91.209, 91.531 and 91.533 – Pilots and operators should familiarise themselves with these Rules parts; and

CAR Part 105.27 – Parachutists should familiarise themselves with this Rule part, which states:

(a) Each person making a parachute descent from an unpressurised aircraft shall –

(1) when between altitudes of 10 000 and 13 000 feet for longer than 30 minutes, use supplementary oxygen until immediately prior to exiting the aircraft; and

(2) when between altitudes of 13 000 and 20 000 feet, use supplementary oxygen until immediately prior to exiting the aircraft.

(b) *Refers to pressurised aircraft*.

(c) Each person making a parachute descent from altitudes above 13,000 feet shall have satisfactorily completed a training course, for High Altitude descents, conducted by a parachute organisation.

(d) *Refers to descents from above 20,000 feet*.

This High Altitude Descent Course meets the provisions of CAR 105.27(c) above and is a prerequisite for all parachutists prior to undertaking planned descents from above 13,000 feet AMSL. The course must be administered by an NZPIA Instructor or another person authorised by the NZPIA to do so.

Administration

Prior to undertaking their first High Altitude descent, all parachutists are required to carry out the following:

- Study the material in this study guide
- Pass a test on the material in this study guide – pass rate of 70%
- Receive a briefing from an NZPIA Instructor, or another person authorised by the NZPIA to do so, covering the following points at a minimum:
  - Use of oxygen equipment
  - Communication signals to be used on the flight
  - Emergency procedures
  - The briefing should include practice with the equipment

Successful completion of this course is indicated by a passing grade on the NZPIA High Altitude exam. Exam results and dates are recorded on the NZPIA website, and NZPIA recommends that candidates print a copy of their result and keep it with their logbook.

The NZPIA also recommends that the Course Assessor who administered the (successful) course and exam endorses this in the candidate's parachutist's logbook or training record, and signs and dates the endorsement.

Tandem Pairs – Passenger Briefing:

Every NZPIA Tandem Master undertaking a descent with a tandem passenger from above 13000ft AMSL must ensure that their passenger has received an appropriate briefing. *[CAR 115.205]*

The briefing should cover, as applicable –

- The increased safety risks associated with descents from higher altitudes;
- Use of oxygen equipment;
- Signs and Symptoms of hypoxia;
- Signs and symptoms of Decompression Illness
- Communication signals to be used on the flight.

The briefing can be in any format (e.g. verbal, written, pictorial, audio/visual or any combination thereof), but must be appropriate to the type of descent.

IMPORTANT NOTICE

High Altitude skydiving is an activity with inherent risks that could result in injury or death.

Safety can be enhanced with proper training, preparation, appropriate equipment, and other precautions. This Course contains some of the knowledge and practices that, in the opinion of the NZPIA, will promote the safe enjoyment of high altitude skydiving, but does not guarantee the safety of any party.

This document is not a textbook in aviation medicine, but rather a key point guide for skydivers.

Each skydiver and drop zone operator has the responsibility to exercise basic safety practices and perform whatever actions are necessary to not cause unnecessary risk to him/herself or other people.

NZPIA makes no warranties as to the completeness of the information set out in this document, nor does it claim to present all risks and possible outcomes of high altitude skydiving.

RISKS OF HIGH ALTITUDE PARACHUTING

There are a number of factors which increase the safety risks on a High Altitude descent, compared with descents from below 13,000 feet AMSL, such as reduced air pressure, temperature and oxygen; stronger winds; and higher freefall speeds. The likelihood and severity of the risks increase significantly with increases in altitude.

Some of the safety considerations are –

1. Gases expanding in the body due to decreased air pressure can lead to physical injury or severe discomfort (page **Error! Bookmark not defined.**).
2. Hypoxia brought on by reduced oxygen due to reduced air pressure can lead to impaired judgment and/or performance, even unconsciousness or death (page **Error! Bookmark not defined.**).
3. Lower air temperatures can adversely affect a person's ability to carry out safety-critical tasks, due to reduced mobility and dexterity (page **Error! Bookmark not defined.**).
4. Repeated exposure to the above physiological effects of altitude can rapidly lead to fatigue, or injury (Page 5) which in turn can lead to impaired performance. These physiological risks also have a cumulative effect, i.e. the effects of exposure get worse on each jump.
5. Freefall drift, or canopy drift in the case of a premature deployment, can result in skydivers landing in hazardous or isolated terrain (page **Error! Bookmark not defined.**).
6. A premature deployment at a high altitude presents many and varied risks (page **Error! Bookmark not defined.**):
   - The longer time it takes to descend to an oxygen-rich altitude increases the risk of hypoxia;
   - The longer time in a low-temperature environment increases the risk of impaired performance brought on by cold;
   - More drift will be experienced, as an open canopy will be significantly more affected by the upper winds than a person in freefall, leading to increased risk of an unsafe landing area;
   - A high-speed or terminal deployment in the thinner air can lead to physical injury;
   - A high-speed or terminal deployment in the thinner air may compromise equipment.
   - With an increased fallrate as calculated in true airspeed (Not indicated/skydivers freefall speed) the operating limits as dictated by the equipment manufacturers may be exceeded.
7. Extra equipment considerations create a risk of overlooking safety-critical tasks due to distraction.

The higher the altitude, the more likely the risk factors and the more severe the potential consequences. NZPIA considers any jump from higher than 16,500 feet AMSL to be in the "higher risk" category and recommends extra precautions be taken.

As with all aspects of parachuting, High Altitude descents are made safer through –

- Appropriate training
- Suitable equipment
- Pre-planning, including what to do in case of an emergency
- Good judgement

N.B. *The NZPIA cannot manage these risks for you. This training course is designed to inform and educate, but as with all skydives, every skydiver is responsible for knowing and understanding the risks they take, and putting into place appropriate measures to minimise risks to themselves and others they are skydiving with.*

It is not possible to come up with one universal procedure that is appropriate for all parachutists in all scenarios. Parachutists are therefore encouraged to read these guidelines and use their judgement when developing their own personal High Altitude safety procedures.

AIR PRESSURE

The Atmosphere

The atmosphere is an envelope of gases surrounding the earth which supports all life by providing breathing gases. It also maintains survivable temperatures, provides weather patterns, protects us from solar radiation, and allows the transmission of sound.

Near sea level, due to the weight of the atmosphere above, gas molecules are tightly packed together. At higher altitudes, there is less weight of atmosphere pressing down from above, allowing the gases to expand. This means that air pressure is greater at sea level than at altitude.

At 18,000 feet, the pressure of the atmosphere is half what it is at sea level, so a given amount of gas will double in volume. The percentage of oxygen remains constant, at 21%, but the volume of o2 molecules we inhale with each breath is about 50% of what it is at sea level. We can therefor conclude that every breath we take at altitude without supplementary oxygen has the effect of removing O2 saturation from our brains, and then muscles.

Trapped Gases

Whenever there is a drop in air pressure, any gas which is trapped will tend to expand. Put another way, there will be an increase in pressure differential across the wall of whatever is trapping it. This can cause pain or discomfort, or even physical injury if not properly managed.

Relieving the trapped gas will reduce this pressure difference.

Gas can be trapped in four spaces in the human body: lungs, gut, middle ear and sinuses.

Lungs

Since the lungs are open to the atmosphere and gas (air) is always moving in and out with breathing, there is no noticeable effect on the lungs due to gas expansion. Participants should continue to breathe in and out normally on the way to altitude to maintain the pressure balance in the lungs.

Gut

The gut (digestive tract) is that tube starting with the mouth and ending with the anus. It is over 10 metres long and contains a variable amount of air. The expansion of gas in the gut at normal skydiving altitudes causes few problems, since gas can escape through one end of the tube or the other.

Middle Ear

There are three parts to the ear: The outer ear consists of the ear canal and eardrum; the middle ear contains gas and some small bones; and the inner ear contains the organs of hearing and balance.

The middle ear is the part we're most concerned with because it's filled with gas. A soft walled tube, called the Eustachian tube, connects the middle ear to the back of the throat, allowing changes in pressure in the middle ear.

In an ascending aircraft, the gas in the middle ear expands gradually, opens the tube and escapes into the back of the throat, so the pressure stays the same on both sides of the eardrum.

As the skydiver descends, the gas contracts rapidly and the first effect of this is it closes the Eustachian tube. This means we need to do something to allow some gas into the middle ear before beginning our rapid descent. Most people swallow, wiggle their jaw or yawn – each of these movements opens the Eustachian tube slightly and allows some gas to re-enter the ear from the throat, equalizing the pressure.

A more effective way of clearing the ears is what is called the *Valsalva* manoeuvre: blocking your nose and blowing gently into your closed mouth forces air up the Eustachian tube into the middle ear. This is best done with the head tipped back to straighten the tube, and the blow should be sustained rather than forceful. An alternative method is the blocking of the nose and swallowing.

If you have a cold, hay fever or sore throat, the Eustachian tube can be swollen and/or obstructed. This may make it difficult to clear your ears.

The problem only occurs on descent. If ear-clearing manoeuvres are unsuccessful, then as the gas contracts first the eardrum bows inwards causing pain and diminished hearing. Then with further constriction, blood vessels lining the inner ear can become swollen and eventually can burst, causing bleeding into the middle ear. Occasionally the eardrum can burst. Therefore it is very important to equalise pressure in the Eustachian tubes on the ascent to altitude.

<u>Sinuses</u>

The sinuses are gas-containing cavities in the skull, located on either side of the nose (behind the cheeks) and above the nose (behind the forehead).

Each sinus is connected to the nose through a very narrow, rigid tube. If the tube to the nose is obstructed because of a cold, hay fever or sinusitis, it can cause pressure pain either on ascent or descent. The pain can be severe, and may be felt in the cheek, forehead, between or behind the eyes or in the upper teeth.

Clearing the ears usually doesn't help but decongestants can. It is very risky to skydive if you have a cold or congestion or any feeling of pressure in the sinuses. It is also very risky to skydive while on some medications, so seek a doctor's advice before attempting a High Altitude skydive under any of these circumstances.

<u>Teeth</u>

Teeth do not normally contain gas but can in two situations. First, a poorly done filling may have gas trapped underneath it. The expanding gas can cause pain or even eject the filling.

Second, if there is decay around the root of a tooth the bacteria can produce gas. This gas expands at altitude causing pressure on an already painful area, but the pain often disappears after landing.

Altitude Induced Decompression Sickness.

Decompression sickness (DCS) describes 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.

Altitude DCS became a commonly observed problem associated with high-altitude balloon and aircraft flights in the 1930s.

When the body is exposed to decreased barometric pressures (as in flying an unpressurized aircraft to altitude, or during a rapid decompression), the nitrogen dissolved in the body comes out of solution. If the nitrogen is forced to leave the solution too rapidly, bubbles form in different areas of the body, causing a variety of signs and symptoms. The most common symptom is joint pain, which is known as "the bends."

Although bubbles can form anywhere in the body, the most frequently targeted anatomic locations are the shoulders, elbows, knees, and ankles.

Neurological DCS, "the chokes," and skin bends with mottled or marbled skin lesions (see Table 1) should always be treated with hyperbaric oxygenation. These conditions are very serious and potentially fatal if untreated.

DCS Type	**Bubble Location**	**Signs & Symptoms (Clinical Manifestations)**
BENDS	Mostly large joints of the body (elbows, shoulders, hip, wrists, knees, ankles)	• Localized deep pain, ranging from mild (a "niggle") to excruciating. Sometimes a dull ache, but rarely a sharp pain. • Active and passive motion of the joint aggravates the pain. • Pain can occur at altitude, during the descent, or many hours later.
NEUROLOGIC Manifestations	Brain	• Confusion or memory loss • Headache • Spots in visual field (scotoma), tunnel vision, double vision (diplopia), or blurry vision • Unexplained extreme fatigue or behavior changes • Seizures, dizziness, vertigo, nausea, vomiting and unconsciousness may occur
	Spinal Cord	• Abnormal sensations such as burning, stinging, and tingling around the lower chest and back • Symptoms may spread from the feet up and may be accompanied by ascending weakness or paralysis • Girdling abdominal or chest pain
	Peripheral Nerves	• Urinary and rectal incontinence • Abnormal sensations, such as numbness, burning, stinging and tingling (paresthesia) • Muscle weakness or twitching

CHOKES	Lungs	• Burning deep chest pain (under the sternum) • Pain is aggravated by breathing • Shortness of breath (dyspnea) • Dry constant cough
SKIN BENDS	Skin	• Itching usually around the ears, face, neck arms, and upper torso • Sensation of tiny insects crawling over the skin • Mottled or marbled skin usually around the shoulders, upper chest and abdomen, accompanied by itching • Swelling of the skin, accompanied by tiny scar-like skin depressions (pitting edema)

Factors contributing to increased risk to DCS

Altitude

There is no specific altitude that can be considered an absolute altitude exposure threshold, below which it can be assured that no one will develop altitude DCS. However, there is very little evidence of altitude DCS occurring among healthy individuals at altitudes below 18,000 ft. AMSL who have not been SCUBA diving.

Repetitive Exposures

Repetitive exposures to altitudes above 18,000 ft. within a short period of time (a few hrs.) also increase the risk of developing altitude DCS.

Rate of Ascent

The faster the rate of ascent to altitude, the greater the risk of developing altitude DCS. The advances in faster climbing skydiving aircraft increases the risk. An individual exposed to a rapid decompression (high rate of ascent) above 18,000 ft. has a greater risk of altitude DCS than being exposed to the same altitude but at a lower rate of ascent.

Time at Altitude

The longer the duration of the exposure to altitudes of 18,000 ft. and above, the greater the risk of altitude DCS.

Age

There are some reports indicating a higher risk of altitude DCS with increasing age.

Previous Injury

There is some indication that recent joint or limb injuries may predispose individuals to developing “the bends.”

Ambient Temperature

There is some evidence suggesting that individual exposure to very cold ambient temperatures may increase the risk of altitude DCS.

Body Type

Typically, a person who has a high body fat content is at greater risk of altitude DCS. Due to poor blood supply, nitrogen is stored in greater amounts in fat tissues. Although fat represents only 15% of an adult normal body, it stores over half of the total amount of nitrogen (about 1 litre) normally dissolved in the body.

Exercise

When a person is physically active while flying at altitudes above 18,000 ft., there is greater risk of altitude DCS.

Alcohol Consumption

The after-effects of alcohol consumption increase the susceptibility to DCS.

Mitigation of risk of DCS

One of the most significant breakthroughs in altitude DCS research was the discovery that breathing 100% oxygen before exposure to a low barometric pressure (oxygen prebreathing), decreases the risk of developing altitude DCS. Oxygen prebreathing promotes the elimination (washout) of nitrogen from body tissues. Prebreathing 100% oxygen for 30 minutes prior to initiating ascent to altitude reduces the risk of altitude DCS for short exposures (10-30 min. only) to altitudes above 18,000ft AMSL.

Preventing Trapped Gas Problems

- Skydive only when healthy
- Do not self-medicate
- See a doctor if ill
- Equalise pressure (clear the ears) frequently on ascent, and on descent if necessary.
- Pre-breath 100% oxygen for 30 minutes prior to ascending higher than 18 000ft AMSL.

Do not skydive if you have any of these –

- Cold, flu, hay fever, sinus infection
- Diarrhoea, vomiting
- Headache
- Hangover
- Injuries

Always do a pre-flight check on yourself to ensure you are fit to fly. Also brief tandem passengers on these possible discomforts, and monitor their wellbeing throughout the ascent and descent.

OXYGEN

The Requirement for Oxygen

All humans need oxygen to remain alive, but the body cannot store significant reserves of oxygen so a constant supply is needed. The cells with the greatest requirement for oxygen in the body are those of the brain and eye, so these are the tissues that will show the first signs if the oxygen supply is reduced.

Oxygen reaches the body's cells through a complicated process called gas exchange. At higher altitudes, the reduced air pressure means that less oxygen molecules are pushed through the membrane of the lungs into the blood. There are a number of reasons why the amount of oxygen arriving at the cells might be further diminished –

- If the lungs are diseased
- If the membrane is thickened due to illness or infection
- If the blood has decreased haemoglobin (e.g. anaemia)
- If the cells are already impaired in function (as with alcohol impairment)

Hypoxia

The condition of having insufficient oxygen to function properly is known as hypoxia. It is a reduced supply of oxygen to vital tissues, with the potential to severely hinder a person's ability to make safe decisions and perform safety-critical tasks quickly and effectively.

During the climb to altitude, the pressure of the air surrounding the skydiver begins to decrease as soon as the climb begins. However, the available oxygen in the blood stream does not start to drop substantially until 10,000 feet AMSL. If flight is at or below 10,000 feet AMSL, the healthy skydiver should not be affected significantly by hypoxia, but it can still be a risk (see Factors Affecting Tolerance to Hypoxia, next page).

Above 10,000 feet AMSL, extra oxygen is required to prevent adverse effects of oxygen-deficiency (hypoxia).

Hypoxia can be very subtle in its onset and may not be noticed easily by the skydiver. An added danger of hypoxia is that, because the brain itself is not working properly, it may take some time before the skydiver recognises that s/he is not well.

Hypoxia effects are somewhat like alcohol impairment, in that the affected person thinks they're fine when actually they're not. Obviously, this can be very dangerous, as it combines a feeling of well-being with poor judgement and a lack of self-criticism.

Furthermore, the effects of oxygen deficiency are cumulative, so a skydiver may make one or more High Altitude descents with no ill-effect, but be badly affected on a later descent. This is especially dangerous in the event of a premature deployment; the longer time under canopy at a high altitude would compound the cumulative effects of altitude already being felt.

Participants doing multiple High Altitude descents in a day may make use of a pulse oximeter to ensure sufficient oxygen in the blood throughout the jump day. This does not mitigate all risk and all pulse oximeters are not created equal.

There are many factors that influence the accuracy of pulse oximeters: Light, temperature, movement, rate of breath and even pigment colour of skin can affect a reading.

Hyperventilation increases peripheral oxygenation while decreasing brain oxygenation. At 13 000ft AMSL, a healthy skydiver's saturation should be about 85%. Hyperventilation can bring the oximeter reading up to 96% -but brain oxygen saturation falls to about 55%, which rather decreases the ability to be an interesting, well-rounded, skilled skydiver with good judgment. There is a risk of creating hypoxia-induced euphoria when hyperventilating to raise oximeter readings.

Signs and Symptoms of Hypoxia

Due to the gradual and subtle onset of hypoxia, it is very important to monitor yourself and others for signs and symptoms. Be aware that you might notice someone else's diminished function or wellbeing before they do, and you should be prepared to intervene if they are not able to make safe decisions for themselves. Also bear in mind that someone else might have to intervene on your own behalf, if you unknowingly fall victim to the effects of hypoxia.

Signs of Hypoxia **(What to look for in others)**	**Symptoms of Hypoxia** **(What to feel for in yourself)**
• Euphoria • Cyanosis (Blu or grey fingers, nails, lips, around eyes) • Confusion • Cough • Nausea and vomiting • Rapid breathing • Sweating • Severe hypoxia can lead to loss of consciousness, seizures or convulsions, or coma.	• Euphoria or a sensation of dissociation from self • Headaches • Fatigue or tiredness • Breathlessness or shortness of breath • Palpitations may be seen in the initial phases of hypoxia. As hypoxia progresses, the heart rate may quickly fall. • Light-headedness • Nausea and vomiting • Cyanosis • Confusion, memory loss and cognitive problems • Disorientation and uncoordinated movement

Factors Affecting Tolerance to Hypoxia

- Amount of altitude (higher up = higher risk)
- Time spent at altitude
- Temperature (cold)
- Fatigue
- Exertion
- Repeated exposure
- Illness
- Some prescription medications
- Smoking
- Drugs / alcohol
- Hangover

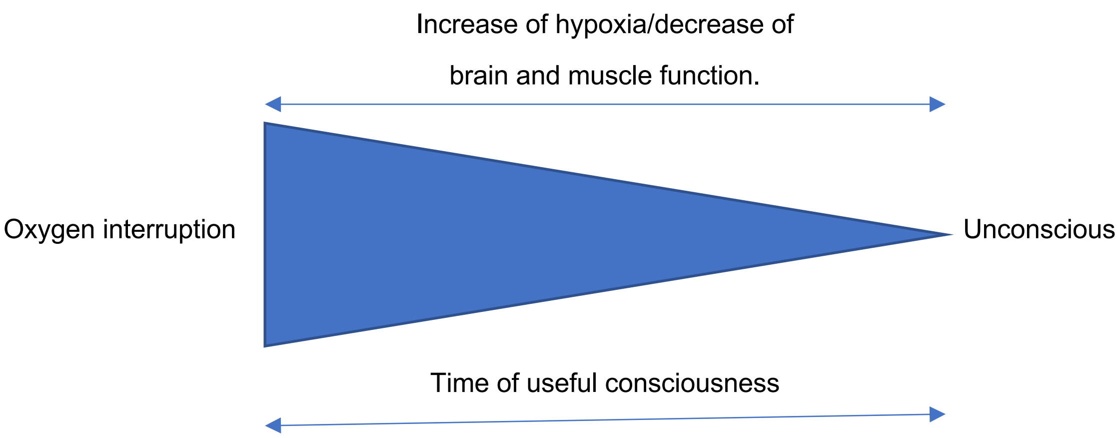
Treatment of Hypoxia
Immediately supply the affected person with oxygen from an oxygen supply source and descend the aircraft to below 10,000 feet AMSL.

Oxygen Paradox

If somebody suffering from severe hypoxia is given oxygen to breathe, often the symptoms will get suddenly worse rather than better. This is called the **Oxygen Paradox***.* It is due to a momentary reflex constricting the arteries to the brain, caused by the sudden increase in oxygen in the blood stream. During this period, the oxygen should <u>not</u> be removed. Encourage the person to keep breathing deeply and the symptoms will soon improve.

Times of Useful Consciousness

When a skydiver starts to become hypoxic, there is a limited timeframe in which they can recognise the symptoms and act before they become too hypoxic to be able to remedy the situation on their own. The effect of this deterioration can best be described as illustrated below:



The study to establish TUC figures were designed to illustrate how important it is for aircrew to put on their own oxygen equipment before helping others. The term was intended to illustrate the time to reach such a hypoxic state that you cannot make the decision to save your own life anymore. Prior to that point, useful consciousness was deemed a state where the candidate could follow a simple emergency command. We have all seen the safety briefing on aircraft telling us to “put on your own mask before helping children”. This study is where that safety concept came from.

Without doing personal tests in a hyperbaric chamber to establish individual time of useful consciousness, it is inappropriate to use as an indicator for a safe amount of time a skydiver can solve complex problems at altitude without supplementary oxygen.

HYPERVENTILATION

Overview

Breathing rate is controlled by the level of carbon dioxide (CO_2) in the bloodstream. CO_2 is acidic, so if CO_2 levels rise, the bloodstream becomes more acidic. This stimulates the breathing centre in the brain to increase breathing rate, to try to reduce the amount of CO_2.

Breathing is usually automatic. In certain situations, however, we can breathe more quickly and/**or more deeply** when we don't need to. This is called hyperventilating, or over-breathing, and results in the level of CO_2 dropping too much.

Simply put, hyperventilating causes too much carbon dioxide to be blown out of the lungs on exhalation. The resulting reduction in blood acidity causes recognisable symptoms.

Symptoms of Hyperventilation

- Rapid breathing (over-breathing)
- Dizziness
- Seeing spots
- Flushed skin
- Sweating
- Feeling of anxiety
- Chest tightness
- Tingling in the hands, feet and face
- Cramps in the hands

Causes of Hyperventilation

- Fear
- Pain
- Anxiety; excessive worry
- Motion sickness
- Being startled by something
- Excessive heat
- Hypoxia (page **Error! Bookmark not defined.**)

In skydiving, the most common cause is usually anxiety in inexperienced jumpers, but taking slow deep breaths at altitude without supplementary oxygen can have the same ill effect.

Hypoxia is also a common cause of hyperventilation, because when short of oxygen, the brain responds by increasing the rate and depth of breathing in an attempt to improve the oxygen supply. Often the first symptom of hypoxia is dizziness brought on by hyperventilation.

Treatment of Hyperventilation

When over-breathing occurs, the treatment is to make a conscious effort to slow down the breathing, *but not to stop breathing and not to take deep breaths.*

Breathing into a rolled-up newspaper or paper bag, if one is available, can help build up levels of carbon dioxide in the lungs again. Reassurance also works well, along with calm explanation of what is happening. Symptoms will resolve quickly once normal breathing is resumed.

If there is any doubt at all as to whether the skydiver is over-breathing or suffering from hypoxia, it must always be assumed that it is ***hypoxia.*** This should be treated immediately by administering oxygen or descending the aircraft to a lower altitude.

Giving someone who is hyperventilating 100% oxygen to breathe will not harm them. On the other hand, telling someone who is hypoxic to just slow down their breathing could be fatal.

TEMPERATURE

Temperature decreases with altitude—by about 2 degrees Celsius per 1,000 feet, although this varies depending on weather patterns.

For example, this means that if the air temperature at sea level is +15°C, the average outside air temperatures at various altitudes are approx.:

5,000 feet	+5°C
10,000 feet	-5°C
15,000 feet	-15°C
20,000 feet	-20°C

The effects of cold can set in during the climb to altitude, and can be exacerbated by long periods of sitting in the aircraft with little movement. This can make moving around in the aircraft more difficult, especially with bulky clothing on. Pre-exit tasks and exit procedures may be more difficult/awkward as a result.

Temperatures at 15,000 to 20,000 feet AMSL can be expected to be well below freezing year-round, and with a 200 KM/h wind chill, frostbite can occur under these conditions. Also, mobility and dexterity can be severely limited by the cold.

All exposed skin should be covered by wind-proof clothing for the duration of the freefall, however be aware that bulky clothing can also limit mobility and dexterity. Locating handles by touch may be difficult, and stiff or numb fingers may have difficulty grasping/pulling handles, loosening straps under canopy, etc.

The effects of cold will be exaggerated in the event of a premature deployment at a high altitude, as you will be up there for longer. Prolonged exposure to the cold may affect a skydiver’s ability to carry out emergency procedures.

SPOTTING

Wind speed and direction at higher altitudes will vary from what they are on the ground. When calculating the exit spot, always take into account –

- Wind speed and direction at exit altitude:

  Winds aloft are usually stronger than surface winds, so parachutists will drift farther horizontally in freefall than they would at lower altitudes in the same amount of time.
- Wind speed and direction between exit and opening heights:

  Both speed and direction of upper winds can vary greatly at different altitudes, so freefall drift distance and direction may change throughout the descent.
- The type of jump:

  In addition to winds aloft, the type of jump will also affect horizontal distance travelled during the descent. Longer freefall time equates to more drift; the amount of surface area presented to the wind affects the amount of drift; and obviously tracking or angle flying will have a big effect on the amount of ground covered during the skydive.

  All of this will affect not only where a person will land, but also where they will open. Extreme care must be used when planning the jumps, to ensure no one is directly above or below another person/group at opening time.
- Possible consequences of a premature opening at a higher altitude:

  The potential for higher wind speeds at higher altitudes means a parachutist may have less control over the speed and direction of their canopy flight; and the longer canopy flight time at the mercy of a strong wind can take a skydiver far from the intended landing area and/or over hazardous terrain/obstacles.

  All parachutists should take into account the terrain between the exit point and the landing area and have a plan for what to do in case of an unplanned opening at any time during the descent. This is especially important if there are significant hazards nearby, e.g. mountain range, large body of water, power station, etc.

Parachutists should also ensure that the jump organiser has an effective emergency situation action plan that takes all these factors into account.

OTHER CONSIDERATIONS

Communication

Communication in the aircraft will be limited by the wearing of oxygen masks. All parachutists should establish and agree on a method of communication in the aircraft that does not require removal of oxygen masks. For example, any combination of the following may be helpful –

- Hand signals
- Bells or other sounds
- A small tablet or whiteboard for written communication.

Whatever method(s) of communication are used, all participants and crew on the load should know and understand the signals to be able to effectively communicate. At a minimum, a signal is needed for –

- When to get ready for exit
- When to remove oxygen
- In the case of tandem passengers, that they are ready to jump
- Something's wrong
- The jump is delayed or called off

Malfunctions / Emergencies

- As discussed earlier in this document, the risks of a premature deployment are many and varied. However, these will be compounded in the event of a malfunction of a prematurely deployed canopy,

  E.g. an accidental deployment of the main which subsequently malfunctions; an out of sequence deployment which results in a horseshoe malfunction; or a deliberate deployment of the main in response to a collapsed drogue in tow, which subsequently malfunctions.
- Response time and the ability to perform emergency procedures may be compromised by the cold or cumulative effects of multiple High Altitude jumps.
- Remember also that thinner air means higher-speed malfunctions, e.g. spinning mains, and higher-speed freefall collisions.
- All parachutists, and especially tandem masters, should have a plan for dealing with freefall emergencies and practice it often on the ground.

Effects of a High-Speed or Terminal Opening

Terminal velocity will be higher at higher altitudes due to the thinner air. Canopy descent rate will also be higher, but not as dramatically. Put another way, as altitude increases, so does the difference in speed between freefall speed and canopy flight speed.

This means that a terminal opening at a high altitude will result in higher G-forces than those experienced at lower altitudes, and can result in injuries as a result of the greater opening shock. This risk is exaggerated in the case of a freefly-terminal opening.

This risk is also exaggerated in the case of a tandem-terminal opening. It is important that Tandem Masters get a drogue or canopy out before tandem-terminal velocity is reached at higher altitudes, to prevent injury to themselves and/or their passengers.

It is also possible that the equipment could be damaged by the extra force during a high speed or terminal opening. All parachutists should know the certified limits of their equipment and ensure procedures are in place to stay within these limits, including in the event of an emergency situation.

In the absence of high-altitude opening data for parachutes, aircraft true airspeed must be used for parachute deployment speed limitations. As an example, an aircraft flying at 18 000ft AMSL at an indicated airspeed of 80 Knots, has a true airspeed of around 114 knots due to the lack in air pressure. Similarly, a skydiver falling at an indicated terminal velocity of 200km/h at 16 000ft AMSL has a true airspeed of some 270km/h, possibly exceeding the operating limits of the equipment used.

All parachutists should select equipment appropriate to the planned descent. Tandem Masters (and Operators) should consider the use of a larger drogue, where provided for by the manufacturer, to reduce drogue-fall speed and thus minimise opening shock.

Special Considerations for Wingsuiters

Wingsuiters must be aware that extra altitude will radically increase their glide time. This naturally also increases the risks of hypoxia, prolonged exposure to cold and the possibility of an off-PLA landing.

- Wingsuiters should be especially mindful of the effects (and cumulative effects) of hypoxia. Since their descent angle is shallower, they will potentially spend much more time in the oxygen-depleted environment on each descent, increasing the risk of becoming cognitively impaired during the freefall.
- Wingsuiters should also be especially mindful of the effects of the cold. Since their descent angle is shallower, they will potentially spend much more time in below-freezing temperatures on each descent, which could hinder their ability to carry out deployment and/or emergency procedures quickly and effectively.
- Wingsuiters should take into account all the terrain between their exit point and the landing area, and have a plan for what to do in case of an unplanned opening at any time during the descent. This is especially important if there are significant hazards nearby, e.g. mountain range, large body of water, power station, etc.

PRE-JUMP PLANNING AND PREPARATION

Administrative Requirements

- Completion of this course is a pre-requisite for all parachutists prior to making a descent from higher than 13,000 feet AMSL.

- Refer to the NZPIA Documents, Standards and Procedures Manual (latest revision) for other NZPIA requirements.
- Refer to Civil Aviation Rule Part 105 (latest revision) for CAA requirements.

Equipment

Personal Equipment

- Warm clothing and gloves are recommended, preferably windproof.
- An altimeter is required, and an audible altimeter is strongly recommended.
- AADs are mandatory on all High Altitude descents.
- Harnesses and canopies should be selected with consideration of their placarded speed/weight limits and the loadings (weight and Gs) likely to be encountered on the descent.
- All equipment should be checked thoroughly before each descent, paying particular attention to security of pins, handles and bridles, to reduce the risk of an accidental premature opening.
- Parachutists should only use equipment they are familiar with.

Oxygen Equipment

For all flights above 13,000 feet AMSL, supplemental oxygen for continuous use must be available for every person on board *[CAR 91.533].*

- Each participant, including tandem passengers, must have their own oxygen dispensing unit (cannula or mask), but all can be on one system.
  - The NZPIA recommends masks as opposed to cannulas above 16,500 feet AMSL, to ensure sufficient oxygen is taken. Cannulas only feed oxygen to a person's nose, so if that person is talking and breathing through their mouth, they will not get the full benefit of the oxygen flow. Cannulas are not appropriate above 18 000ft AMSL.
  - Masks with exhalation ports in the side are specifically designed to allow the correct amount of carbon dioxide to be released when the user exhales. Using a mask that fits poorly (too big/small/too much facial hair) or blocking those ports in any way is contrary to ensuring the system is working as designed and the user may not receive the required amount of oxygen or expelling the required amount of CO_2.
- It is recommended that the pilot have his/her own mask on a separate oxygen system.
- It is recommended that someone other than the pilot also has access to the main valve opening and closing the oxygen supply.
- Each participant, including tandem passengers, must be briefed on the use of the oxygen equipment to be used in the aircraft prior to the descent. The briefing should include practice in using the equipment.
- Always handle oxygen bottles with extreme care.

- Oxygen is extremely flammable: Never allow smoking or naked flames within three metres of an oxygen bottle.
- Certain oils, when mixed with pure oxygen, can spontaneously ignite.
  - Never allow 100% oxygen that is flowing under pressure to come in contact with oil, grease or dust. Make sure that there is no grease on your hands before turning the bottle on and that masks are clean and free of dirt.
  - Wipe away any make-up or lotions from the area of the mouth and nose before donning an oxygen mask.

Preparation / Pre-Jump Procedures

- Ensure any required approvals have been obtained, e.g. Airways.
- Ensure the jump organizer has a plan in place to deal with emergencies and off-PLA landings.
- Ensure there is a trained First-Aider on duty, in case of a medical event.
- Calculate the exit spot, exit order and exit separation based on winds aloft data and the types of jumps to be carried out.
- Depending on the height of the jump and the equipment to be used on ascent, it may be appropriate for parachutists to "dirt-dive" the jump from aircraft loading through to exit, to familiarize themselves with the extra equipment and procedures involved and to minimize associated risks (e.g. distraction, difficulties with communication, etc.).
  - Practice communication in the aircraft with masks on.
  - Ensure vision is not overly restricted by the oxygen mask.
  - Practice all pre-exit activities while wearing the clothing and equipment that will be worn on the jump, including as applicable –
    - Fastening, removing and stowing restraints (for self and tandem passenger);
    - Donning, removing and stowing oxygen masks (for self and tandem passenger);
    - Donning helmets and goggles;
    - Turning on cameras;
    - Passenger hook-up procedures;
    - Opening the door;
    - Handles and harness checks;
    - Stacking the exits;
    - Un-stowing and re-donning oxygen masks in the case of a go around or aborted jump (for self and tandem passenger).
  - Practice should continue until the entire sequence can be carried out by all on board smoothly and efficiently. Once masks are removed, any unnecessary use of energy will deplete oxygen reserves, so it's important to be able to be able to carry out all tasks with a minimum of exertion.
- Consider nominating one person (or one person and a back-up person) on each load to be the loadmaster, to monitor the oxygen system, watch for symptoms of hypoxia and DCS within the group, and coordinate the exits.
- A thorough equipment check should be carried out prior to loading the aircraft, including all oxygen and skydiving equipment.

Ascent and Climb-Out Procedures

- Participants and pilot should put on their masks and begin breathing oxygen by 10,000 feet AMSL.
- Breathing should be normal steady breaths in and out throughout the ascent. Do not hold breath.
- All participants should stay on oxygen for as long as possible, only removing their masks when told to do so by the pilot or loadmaster. People exiting later in the exit order should keep their oxygen masks on until after the earlier groups have exited.
- In the event of a go-around, oxygen masks should be re-donned with oxygen flowing until the aircraft is ready for the drop.
- In the case of an aborted jump (i.e. one or more people decide not to jump, or the jumps are called off), participants who are remaining with the aircraft must stay on oxygen until the aircraft has descended to below 10,000 feet AMSL.
- Prior to exiting, always do a handles check and a check of the passenger connections (if applicable). Have a buddy check your pins and closing flaps if possible, before moving into the doorway.
- Be aware that unnecessary time in the door is increasing the time you (and everyone waiting to exit after you) spend in an oxygen-deprived environment. This is especially important with big groups, multiple groups, and/or groups stacking exits in the door.