GLIDING NEW ZEALAND INCORPORATED

ADVISORY CIRCULAR AC 3-07

CARRIAGE & USE OF OXYGEN

This is an uncontrolled document when printed

1 Introduction

1.1 This Advisory Circular provides guidance on the carriage and use of oxygen in gliders (reference CAR 91), identification and charging of cylinders, and general safety precautions when handling oxygen equipment.

1.2 Gliding clubs and commercial operators based at sites where altitudes in excess of 10,000 feet are achieved, and where oxygen systems have been installed in Club or commercial gliders, must provide appropriate oxygen training to any person prior to undertaking flight above 10,000 feet.

1.3 It is strongly recommended that a 2-seat glider is not taken above 18,000 feet unless each occupant is capable of flying the glider alone as pilot-in-command under the conditions of the day.

1.4 Responsibility: A Mountain High EDS system is not treated as a fixed part of the airframe. This means that the pilot-in-command (and not the glider engineer) is fully responsible for ensuring that the EDS system is compliant and airworthy, and checked before each flight.

1.5 All operating instructions and limitations specified by the manufacturer of the oxygen equipment must be complied with. There is to be no substitution of any component of the system with a part not specified by the original manufacturer (unless a modification has been approved by an acceptable authority). For EDS units this means (for example):

- only Mountain High connecting tubing and cannulae may be used
- use the specified battery type (Duracell alkaline or equivalent - not Lithium)
- bottle pressure must not drop below 300 psi (EDS units need 300 psi to function)
- the length of the cannula or mask tubing is unchanged from original

2 General Rules on Use of Oxygen

2.1 All persons in a glider are required to use supplemental oxygen during any time that the glider is being operated above 13,000 feet AMSL and during any period of more than 30 minutes that the glider is being operated between 10,000 feet and 13,000 feet AMSL.

2.2 Every glider operated at altitudes above 13,000 feet AMSL (or for more than 30 minutes between 10,000 feet and 13,000 feet AMSL) must be equipped with a means of indicating to the pilot-in-command the amount of oxygen available and whether oxygen is being delivered.

2.3 Oxygen used in gliders must be of Aviation Oxygen Standard, which is gaseous oxygen with a minimum purity of 99%, maximum moisture of 0.0056 grams per cubic meter, and nil carbon monoxide. (The extreme dryness is to avoid the possibility of water freezing in the system at high altitudes.)

2.4 Pilots intending to operate above 25,000 feet AMSL should take special care to ensure that an adequate supply of oxygen is available, including some form of back-up system, such as an additional constant-flow mask independent of an EDS unit.

3 Responsibilities of the Operator, Glider Engineer and Pilot-In-Command

3.1 The Operator of a glider equipped with oxygen is responsible for ensuring that all required inspections and maintenance are carried out within the specified intervals, and that persons carrying out such maintenance are qualified to do so. Also, that equipment has not been not modified, nor parts substituted, without the appropriate certification.

3.2 A Glider Engineer (Class 2-4) is responsible for ensuring the oxygen bottle is within its required pressure testing period, is securely mounted in the airframe, and that any permanently-attached metal plumbing and fittings are serviceable, including pressure gauges and regulators in the instrument panel or permanently attached to the airframe.

3.3 The Pilot-in-Command (PIC) of a glider in which oxygen is to be used is responsible for all parts of the system that are not permanently attached to the airframe. This includes plastic tubing, connectors, portable electronic devices (eg EDS units), dry-cell batteries and electrical connections, masks and cannulae.

3.4 The PIC should be aware of known equipment failures, which include battery failure, tubing falling out of connectors, kinks in tubing, EDS units concealed in side pockets where warning lights are not visible, oxygen level indicators installed out of view and wind noise in the cockpit masking audible alarms.

4 Guidance for Passengers and Trainee Pilots (up to 18,000 feet)

4.1 Gliders flying above 10,000 feet would normally be flying in mountain wave, where additional risks exist, such as strong winds, turbulence, cloud, freezing temperatures and high terrain. These elements are normally addressed in "Alpine Pilot" training.

4.2 Notwithstanding 4.1 above, there are occasions where a passenger in a glider could safely experience high-altitude flight (above 10,000 feet but not above 18,000 feet) provided such passenger had received adequate training in the use of supplemental oxygen. Such training should include:

- why supplemental oxygen is needed above 10,000 feet (eg. Appendix A)
- normal operation of the oxygen system in the aircraft
- how to respond to the apnea alarm (breathe regularly through the nose)
- actions to be taken in the event of a malfunction or emergency

4.3 In a tandem 2-seat glider (where the pilot-in-command is unable to physically assist the passenger) it is recommended that, prior to launch, the canula is fitted to the passenger and the dispensing unit set to automatically turn on at a preset altitude. Also that the passenger alarms are audible or visible to the pilot-in-command, and that all tubing is firmly connected and smoothly routed without kinks.

4.4 EDS units used for passenger flights should have sufficient battery capacity remaining for the expected duration of the flight, so there is no possibility of the battery failing in flight. The pilot-in-command must recognise the low-voltage alarm from the passenger EDS unit.

4.5 If the passenger is not fluent in English, or has a medical condition which could be aggravated by reduced air pressure, additional caution should be exercised.

5 Guidance For Flight Between 18,000 feet - 25,000 feet

5.1 At 18,000 feet altitude there is only half the air pressure at sea level, and pressure continues to reduce significantly with increasing altitude. This means that the breathing environment rapidly becomes more pernicious and additional precautions are required.

5.2 In the USA (and in the EDS literature) an oxygen mask is required above 18,000 feet. There are different views on this requirement. One view is that in the USA all airspace above 18,000 feet is Class A and a different set of rules apply. Another view is that a cannula has proved adequate up to about 25,000 feet, provided that the pilot maintains awareness of his/her breathing style and breathes steadily and consistently through the nose.

5.3 Blood-oxygen levels can be monitored with an inexpensive device called a pulse oximeter, which clips over a fingertip and uses an infrared beam to measure oxygen levels in the blood. Use of this type of instrument is advised at these altitudes.

5.4 If a pilot persists with a cannula above 18,000 feet but happens to slow his breathing, hold his breath, or breathe through his mouth - all surprisingly easy to do - there will be reduced oxygen uptake. Even mild anxiety - such as might arise at a difficult part of the flight - will cause an involuntary change in the pilot's breathing pattern, such as shallow mouth breathing. Talking and eating in flight can also reduce the effectiveness of a cannula.

5.5 The pilot needs to be totally familiar with the operating instructions and limitations of the equipment at these altitudes. The section in the EDS manual on auto-compensation needs to be well understood. In addition, it would be wise to acquire some understanding of the physiology of the human respiratory system.

5.6 Check every few minutes that your oxygen system is operating normally. Be aware of your passenger and even pilots in other gliders. A slurred voice on the radio, long periods of silence, euphoria, risky behaviour . . . could all be a signal of mild hypoxia.

6 Guidance for Flight Above 25,000 feet

6.1 A healthy, young military pilot has a time-of-useful-consciousness (TUC) at 25,000 feet of 3-6 minutes. An aging, sedentary pilot under moderate stress would have significantly less time. This highlights the hazard of flight without oxygen in this region of the atmosphere.

6.2 Plenty of flight experience at lower altitudes is advised before flying at these altitudes.

6.3 A close-fitting mask is mandatory at this altitude.

6.4 An independent back-up supply of oxygen, and a means of rapidly changing over in flight, is strongly advised when contemplating flight at this altitude. Even if a fault is detected promptly there would be insufficient time to descend to a recovery altitude without loss of consciousness.

APPENDIX A What Every Pilot Should Know About Oxygen

This summary has been extracted from the Mountain High EDS O2D1-2G Operating Manual. It is strongly recommended that the entire document is downloaded from the MH web site and studied.

What Is Air?

The air surrounding us is a mixture of gases consisting of 78% nitrogen and 21% oxygen. The remaining 1% is made up of argon, carbon dioxide, and traces of rare gases.

What Is Oxygen?

Under normal conditions, pure oxygen is a colorless, tasteless, odorless, non-combustible gas. It is the most important single element in our universe.

Why Is Oxygen So Important?

Although it will not burn alone, oxygen supports combustion - in fact, without oxygen there can be no fire. Oxygen, therefore, is not only necessary for the burning of combustible materials, but it is also absolutely essential to support the process of "vital combustion" which maintains human life. Although a person can live for weeks without food or for days without water, he or she dies in minutes if deprived of oxygen. The human body must have oxygen to convert fuel (the carbohydrates, fats, and proteins in our diet) into heat, energy, and life. The conversion of body fuels into life is similar to the process of combustion; fuel and oxygen are consumed, while heat and energy are generated. This process is known as "metabolism."

Where And How Do We Normally Obtain Our Oxygen?

At each breath we fill our lungs with air containing 21% oxygen. Millions of tiny air sacs (known as "alveoli") in our lungs inflate like tiny balloons. In the minutely thin walls enclosing each sac are microscopic capillaries, through which blood is constantly transporting oxygen from the lungs to every cell in the body. Because the body has no way to store oxygen, it leads a breath-to-breath existence.

How Much Oxygen Does The Human Body Need?

The rate of metabolism, which determines the need for and consumption of oxygen, depends on the degree of physical activity or mental stress of the individual. A person walking at a brisk pace will consume about four times as much oxygen as he or she would when sitting quietly. Under severe exertion or stress, he or she could be consuming eight times as much oxygen as at rest.

What Happens If The Body Does Not Receive Enough Oxygen?

When the body is deprived of an adequate oxygen supply, even for a short period, various organs and processes in the body begin to suffer impairment from oxygen deficiency. This condition is known as "hypoxia." Hypoxia affects every cell in the body, but especially the brain and the body's nervous system. This makes hypoxia extremely insidious, difficult to recognize, and a serious hazard, especially for flight personnel.

What Are The Effects Of Hypoxia?

Hypoxia causes impairment of vision (especially at night), lassitude, drowsiness, fatigue, headache, euphoria (a false sense of exhilaration), and temporary psychological disturbance. These effects do not necessarily occur in the same sequence nor to the same extent in all individuals, but are typical in average persons who are affected by hypoxia.

When And Why Must We Use Extra Oxygen?

Supplementary oxygen must be used to enrich the air we breathe to compensate for either a deficiency on the part of the individual or a deficiency in the atmosphere in which we are breathing. A person may have a respiratory or circulatory impairment which reduces the ability of the body to utilize the 21% oxygen in the air. For such a person, supplementary oxygen must be administered by an oxygen tent or by oxygen mask to enrich the inhaled air. The total volume of oxygen in each inhalation is then so much greater than normal that it compensates for the individual's own physical inability to utilize normal atmospheric oxygen. When we ascend in altitude, a different condition is encountered: a condition in which the individual may be perfectly normal, but in which there is an oxygen deficiency in the atmosphere and supplementary oxygen must therefore be used.

Does The Percentage Of Oxygen In The Air Change With Altitude?

No, the ratio of oxygen to nitrogen in the composition of air does not change. The 21% of oxygen in the air remains relatively constant at altitudes up to one hundred thousand feet.

Why Must We Use Extra Oxygen When We Ascend In Altitude?

The blanket of air which surrounds our planet is several hundred miles thick, compressible, and has weight. The air closest to the earth is supporting the weight of the air above it and, therefore, is more dense - its molecules are packed closer together. As we ascend in altitude, the air is less dense. For example, at 10,000 feet, the atmospheric pressure is only two-thirds of that at ground level. Consequently, the air is less dense, and each lung full of air contains only two thirds as many molecules of oxygen as it did at ground level. At 18,000 feet the atmospheric pressure is only one-half of that at ground level. Although the percentage of oxygen is still the same as at ground level, the number of molecules of oxygen in each lung full is reduced by one-half. As we ascend, there is a progressive reduction in the amount of oxygen taken into the lungs with each breath, and a corresponding decrease in the amount of oxygen available for the bloodstream to pick up and transport to every cell in the body. To compensate for this progressive oxygen deficiency, we must add pure oxygen to the air we breathe in order to maintain enough oxygen molecules to supply the metabolic needs of the body.

At What Altitudes Should Oxygen Be Used?

In general, it can be assumed that the normal, healthy individual is unlikely to need supplementary oxygen at altitudes below 8,000 feet. One exception is night flying. Because the retina of the eye is affected by even extremely mild hypoxia, deterioration of night vision becomes significant above 5,000 feet.

Between 8,000 and 12,000 feet, hypoxia may cause the first signs of fatigue, drowsiness, sluggishness, headache, and slower reaction time. At 15,000 feet, the hypoxic effect becomes increasingly apparent in terms of impaired efficiency, increased drowsiness, errors in judgment, and difficulty with simple tasks requiring mental alertness or muscular coordination. These symptoms become more intensified with progressively higher ascent or with prolonged exposure.

At 20,000 feet, a pilot may scarcely be able to see, much less read, the instruments. His or her hearing, perception, judgment, comprehension, and general mental and physical faculties are practically useless. The pilot may be on the verge of complete collapse. Therefore, the availability and use of supplemental oxygen is recommended on daytime flights where altitudes above 8,000 feet are contemplated.

How Can You Tell When You Need Oxygen?

You can't - therefore, oxygen should be used before it is needed. The most dangerous aspect of hypoxia is the insidious, "sneaky" nature of its onset. Because the effects of hypoxia are primarily on the brain and nervous system, there is a gradual loss of mental faculties, impairment of judgment, coordination, and skill - but these changes are so slow that they are completely unnoticed by the individual who is being affected.

Actually, a person suffering from mild or moderate hypoxia is apt to feel a sense of exhilaration or security, and may be quite proud of his or her proficiency and performance although he or she may be on the verge of complete incompetence. Because hypoxia acts upon the brain and nervous system, its effects are very much like those of alcohol or of other drugs which produce a false sense of well-being. There is a complete loss of ability for self-criticism or self-analysis.

Some people believe that a pilot can detect his or her need for oxygen by noting an increase in breathing rate, an accelerated heartbeat, and a slight bluish discoloration (cyanosis) of the fingernails. However, by the time these symptoms develop, the individual is more likely to be mentally incapable of recognizing these signs. The person may even decide that he or she has always wanted blue fingernails! Even while "spiraling" out of control, the individual may be convinced (if conscious at all) that he or she is doing this deliberately and enjoying it immensely.

Are All Individuals Equally Affected By Hypoxia?

No, they are not. Just as there is a variation among individuals in their ability to tolerate heat, cold, or alcohol, some people can tolerate without apparent effect a degree of hypoxia which would have noticeable effects on others who are more susceptible to the lack of oxygen. There is no way to measure and predict hypoxia tolerance because it can be affected by physical condition, fatigue, emotion, tobacco, alcohol, drugs, diet and other factors.

The individual who has flown at 14,000, 16,000, or 18,000 feet without oxygen and survived has no idea how close he or she may have been to disaster. The person may believe that all this talk about oxygen need, if true at all, does not apply to him or her. Such a belief may some day be fatal.

Why Not Use Oxygen Intermittently For Short Periods?

If one is at an altitude where there is an oxygen deficiency, intermittent use of oxygen would only temporarily alleviate the hypoxic effects during the period in which oxygen is being used. Because of the insidious nature of hypoxia, a person already mildly hypoxic is very unlikely to even think of using oxygen equipment, either intermittently or otherwise.

It is true that occasional use of oxygen for five or ten minutes (even at altitudes below 8,000 feet) can act as a "refresher" to relieve the effects of mild hypoxia, cigarette smoke, apprehension, or other factors. Also, the use of oxygen for five or ten minutes before the termination of a flight (even though the entire flight may have been flown at less than 8,000 feet) can be an excellent tonic to put the pilot in his or her best mental and physical condition for the approach procedures and landing maneuvers.

http://www.mhoxygen.com/index.php/component/attachments/download/676

APPENDIX B Charging oxygen cylinders – general safety precautions

B.1 As a general rule, oxygen cylinders should not be completely discharged; otherwise condensation and consequent internal corrosion may occur.

B.2 Before charging an oxygen cylinder, check the markings for charging pressure (service or filling or working pressure) and the date on which it was last hydrostatically tested – see Appendix C.

B.3 Before charging, cylinders and valves should be inspected to ensure that no contaminants are present, particularly oil or grease.

B.4 High pressure oxygen may cause or intensify fire and must be kept away from heat and open flames. Transport cylinders should be mounted securely on a portable cart or laid on their sides with chocks during storage or decanting.

B.5 Compressed gas cylinders can contain a lot of stored energy, so incorrect handling may cause ignition, sudden pressure increase and catastrophic rupture. Many materials normally non-flammable will burn fiercely in an oxygen-rich environment. ***Valves should always be cracked open slowly.***

B.6 Cylinders will naturally heat up during charging, so slow decanting from the transport cylinder supply is not only safer but will result in the maximum amount of oxygen decanted from a given charging pressure.

B.7 Extreme care must be taken not to overcharge cylinders. Persons carrying out the charging process should be specifically trained to do so.

Pressure Conversion Factors

Lb/in^2 (psi)	MPa	Bar
1,000	6.8948	68.948
1,800	12.4	124
1,900	13.1	131
2,000	13.8	138
2,100	14.5	145
2,200	15.2	152
2,300	15.9	159

APPENDIX C Testing and Marking of Oxygen Cylinders

Testing

Testing of oxygen cylinders must be done by a laboratory approved by Worksafe New Zealand, and a cylinder must not be charged unless it has been so tested within 10 years, unless the cylinder is more than 40 years old, in which case the test must be within 5 years.

Fibre-wrapped light aluminium or composite cylinders must have been tested within 3 years.

Gliding NZ form TECH-11 may be used to identify the cylinder to the testing laboratory so that it is treated as coming under the jurisdiction of the CAA.

Marking

Cylinder permanent markings contain a lot of information. This is stamped on the cylinder shoulder (or on a permanently attached ring or plate for cylinders not having a thickened shoulder) and requires some knowledge to interpret. The information relevant to charging is the last test date and the charging or working pressure.

Decoding of Markings

An example of a manufacturer's original cylinder marking, with decoding, follows:

Transport Canada Spec for Al alloy → TC-3ALM
Service Pressure → 153BAR
Manufacturer → CATALINA

TC-3ALM153BAR CATALINA

DOT-3AL2216BH014586M4002 03 Ⓒ 02 ② M22

- DOT-3AL: US DOT Spec For Al alloy
- 2216: Service Pressure psi
- BH014586: Serial Number
- M4002: Manufacturer
- 03 02: Test date at time of manufacture March 2002
- Ⓒ: Independent test lab mark (unique)
- ②: Oxygen use
- M22: Manufacturer's Part No for 22 ft^3

An example of marking by an approved testing laboratory, with decoding follows:

Test date – May, lab mark, 2014 Dry gas

Water Capacity 3.94 kg (litres)

Tare Weight 3.67 kg

Test Pressure 25.5 MPa

APPENDIX D - Summary of oxygen-related incidents

D.1 Omarama, unknown date: An experienced NZ pilot had reported "feeling hypoxic" while using an EDS system. The unit seemed to be operating normally and pulses of oxygen could be heard every time a new in-breath commenced. Upon investigation it was found that a non-standard cannula had been used, with six external ridges running along the connecting tube, presumably to prevent kinking. Such a cannula would have been satisfactory when connected to a fitting which went up the inside of the tube. But the EDS connector was designed to grip on a tube with a smooth and fairly rigid external surface. Although this cannula was gripped well enough by the connector the oxygen pulses mostly leaked out around the fitting - in between the ridges that ran along the tube - and very little went through the cannula.

D.2 Chos Malal, Argentina, November 2004: Two NZ pilots were test-flying a brand-new 2-seat self-launching glider, complete with a new factory-fitted EDS oxygen system. While climbing in strong wave at about 15,000 feet each pilot noticed and commented on his physical symptoms - one had developed a headache and the other reported a loss of colour vision. After some discussion it was decided to select the emergency mode (R/M), in which a half-second pulse of oxygen would be delivered at the start of each in-breath, regardless of altitude. The hypoxia symptoms quickly vanished. The under-delivering units were returned to the manufacturer and exchanged. The pilots concluded that even new EDS units needed to be constantly monitored to ensure they were performing correctly.

D.3 Omarama, 19 Dec 2017: The PIC of a 2-seat glider became unconscious at 22,000 feet after the cannula became disconnected from the EDS unit. The passenger - an experienced glider pilot - took control and descended the glider while flying towards an airfield. At about 17,500 feet the PIC recovered consciousness and was able to reconnect the oxygen line. The flight ended with a normal landing. Further investigation revealed that a non-standard cannula had been used, and the tubing diameter was insufficient to ensure a strong grip in the connector. All non-standard cannulae were subsequently discarded and replaced with ones supplied by Mountain High.

E. Informally-reported incidents

E.1 Battery failure occurred at 17,000 feet without any warning. Backup batteries were in the glider and were quickly replaced. Operator now replaces batteries at the start of the spring season.

E.2 Various battery connector failures, ranging from corroded or poorly adjusted terminals to a broken connecting wire. Sometimes the event happened in flight, in which case no alarms were activated. Just nothing.

E.3 Cannula tubing became kinked after moving items around behind the pilot's head, at an altitude of 18,000 feet. EDS alarms were activated but it took a few minutes to sort out.

E.4 Oxygen bottle rated to 1800psi was over-filled to 2200psi. The burst-disk (safety valve) failed at 14,000 ft - an explosion followed by a loud hissing sound for 20 seconds. Bottle located right behind control linkages. Pilot checked controls then descended promptly.