DANSE AVEC LES ONDES…

par Jean-Marie Clément

Préparation et Conduite des Grands Vols de Distance par exploitation des phénomènes dynamiques, pente, confluences, ondes et autres.

EN CLÔTURE :

Première Expédition Vélivole Française en Patagonie, 2002.
Allier tourisme et grands vols d'onde dans un site d'exception.
Voire même tenter des records!
Présentation, diaporama et récits de vols

Varese, 28/2/93,27/2/94, 5+12/2/1995, 28/1+4/12/96
Parma, 26/2/94
Thiene, 25/1/97
Borgo San Lorenzo, 14/2/99
Torino, 17/6/99

Ferrara 02/2000
Milano 13+20/02/2001
Toulouse 3/2/02
Colmar 23/3/03

AVANT-PROPOS

Ce document est un recueil de suggestions et d'idées personnelles de l'auteur, fruit de plus de quarante ans d'expérience et de recherche appliquée, ayant comme but l'intégration des connaissances théoriques que chaque pilote doit nécessairement avoir acquit avant de suivre cette formation et d'entreprendre de grands vols complexes avec vent fort.

Il est donc nécessaire d'avoir préalablement lu et assimilé les ouvrages suivants:

- Manuel du Pilote de Vol à Voile, SFACT, Cepaduès
- Meteorologia per il pilota di Volo a Vela, Plinio Rovesti
- Strechenflug, (La Course en Planeur) Helmut Reichmann
- "En planeur au-dessus des Alpes", SEIDEC, Chambourcy

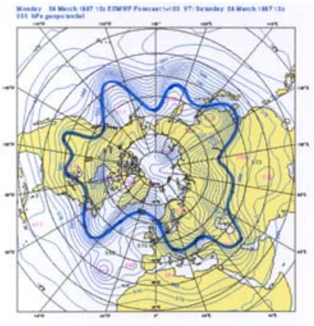
Et si possible avoir consulté:

- I Monti dal Cielo, Cesare Balbis, Priuli & Verlucca Editori
- En vol au-dessus des Alpes, Joachim Kalcreuth, Motorbuch Verlag.
- Che tempo farà, Edmondo Bernacca, Oscar Casa Mondadori
- Il Vento e il Tempo, Mario Giuliacci, Mursia.
- Sport Estremi dell'aria, Vicenzino Siani, Zanichelli (11/95)
- Prevedere il Tempo con Internet, Mario Giuliacci, Alpha Test.

PREMIERE PARTIE

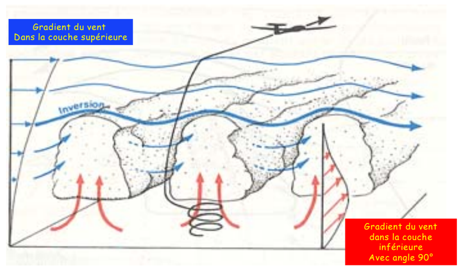
DYNAMIQUE = VENT + OBSTACLE (Visible ou non)

- **VENT SYNOPTIQUE, DE GRADIENT: DIFFERENCE DE PRESSION (GRADIENT) ENTRE DEUX ZONES**
  - Exploitation à l'échelle continentale: H et L
  - Le Vent, pourquoi ? Le Vent, sa prévision – Internet – Identification – Répétabilité
  - Exploitation du vent à l'échelle locale. Brise thermique, confluence, thermo-onde, convergences, friction de masses d'air. Interactions vent de gradient, brise et soleil. Blocages. Mouvements dynamiques locaux sur le bord d'une pente.
  - Le Vent, un autre Vent et le Soleil: la thermo-onde ou onde de convection
- **L'OBSTACLE PEUT ETRE FIXE (RELIEF) OU FLUIDE (VENTS, MASSE D'AIR)**
  - Rencontre entre brises de vallées convergentes
  - Confluence entre les brises de deux versants de la même crête quand les deux masses d'air ont des humidités différentes
  - Collision entre deux masses d'air en mouvement

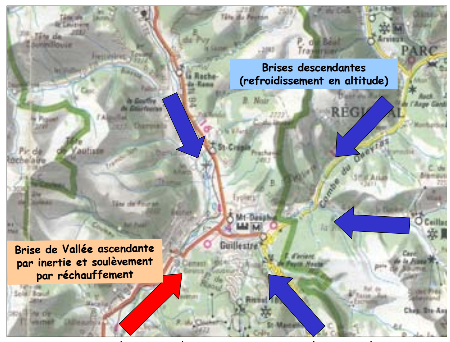


Prévision à 5 jours à 500 mb pour le 28 mars 1997

Vue du pole Nord



Situation théorique du développement d'onde de convection, appelée aussi thermo-onde, ou onde d'inversion Selon Kuttner, courtesy of OSTIV

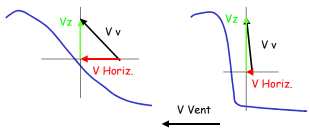


DEUXIEME PARTIE

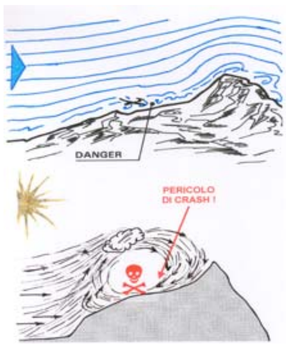
VOL DE PENTE APPLIQUE AU VOL DE DISTANCE

Sauf très rares exceptions (Pyrénées quelquefois) tout grand vol d'onde passe par une phase critique de vol de pente. Quelques conseils inédits qui pourront vous aider... Ou vous éviter le pire...

- **TYPES ET ZONES A EXPLOITER**



  - Importance de la verticalité de la paroi
    - Plus la paroi est verticale, plus faible est la composante horizontale du vent (dangereuse).
    - Plus la paroi est verticale, plus l'ascendance est forte et régulière et moindre est le risque de toucher les cailloux



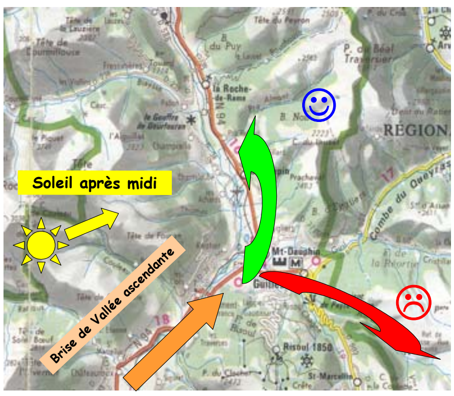
Le danger des faux plats sur les crêtes.

Typiquement: Serre de Montdenier

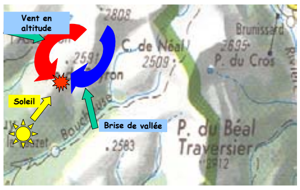
Courtesy of SFACT & Cesare Balbis

    - Les parois ondulées et inclinées présentent des dangers et n'offrent pas de montées régulières (ex. Clotinailles)
  - Attention aux faux plats, hauts plateaux

- **SENS DE ROTATION DE LA PENTE** (DANS L'HEMISPHERE NORD)
  - La loi de Coriolis s'applique selon le sens de rotation du vent sur la pente
    - Pente à rotation anti-horaire => facilite le mouvement ascendant
    - Phénomène amplifié par l'exposition au soleil en phase avec le vent



- **PRIORITES**
  - **<u>La théorie de "la pente à droite" ne vaut rien si on vous voit pas</u>.**
  - Problème de visibilité très réduite, limitée à un coté
  - Laisser le passage à ceux qui ont le soleil de face.
  - Autour d'un éperon rocheux



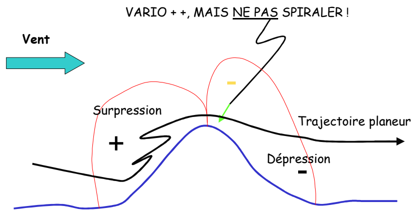
Danger autour d'un éperon rocheux, surtout avec le soleil de face (accident d'Helmut Reichman)

- **VITESSE**
  - Sur paroi verticale
  - Sur pente peu inclinée
  - Sur pente pour "avancer", non pour monter
  - Altitudes

- **DANGERS**

  - Câbles
  - Lumière rasante
  - Arbres, terrain accidenté
  - Franchissement de la ligne de crête, passage sous le vent
  - Franchissement d'un col contre le vent

Au passage du sommet, le variomètre indique une forte ascendance due à la dépression locale (effet Venturi)

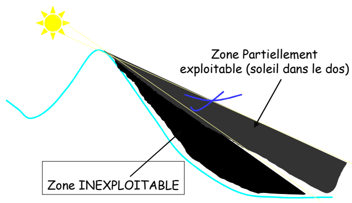


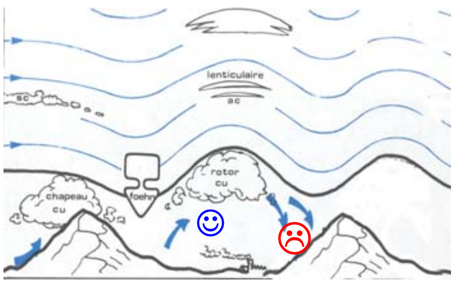
Danger variomètre au passage d'une crete vent arrière

- **FACTEURS NEGATIFS**

  - Descendance sur la pente, présence d'une pente au vent, opposition de phase
  - Activité thermique forte
  - Nuage de chapeau
  - Gradient de vent négatif ou rotation
  - Rotation du vent en altitude
  - Présence d'un faux plat à mi-pente
  - Pente isolée, convexe
  - Pente non perpendiculaire au vent

- <u>CONTRE-JOUR, LUMIERE RASANTE</u>. Mieux vaut une pente mal exposée au vent mais éclairée (Est-Ouest)





Pente en <u>opposition de phase</u> avec l'onde: se diriger tout de suite au centre de la vallée !

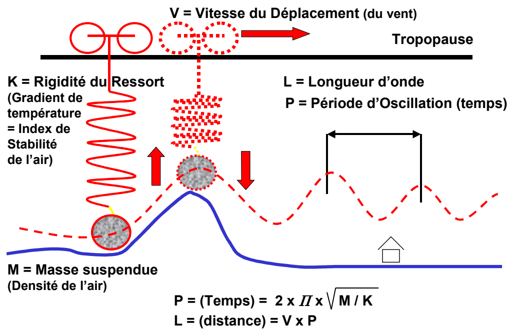
TROISIEME PARTIE

MECANISMES PHYSIQUES A LA BASE DE LA FORMATION D'UN SYSTEME ONDULATOIRE STABLE

- **COMMENT SE FORME L'ONDE**

  - **Lois physiques: Newton, Scorer**

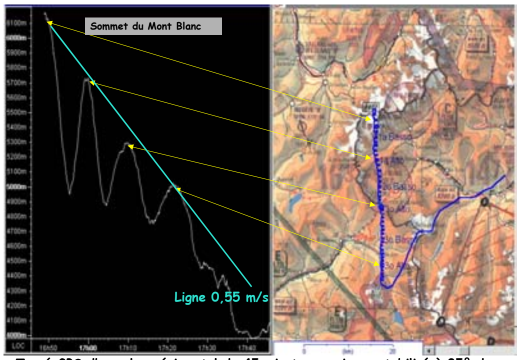
    L'onde de ressaut résulte de l'application de phénomènes physiques simples basés sur:
    - La loi de Newton (1660) F= m.g
    - La loi de Foucault (1850) $T = 2.\pi\sqrt{L/g}$
    - Les équations de Lyra (1943) et Queney (1948)
    - et surtout Scorer (1949), dont le paramètre (**L^2**) doit être décroissant avec l'altitude.



Similitude Mécanique de l'Onde Orographique de ressaut "positif"

  - **L'élément de déclenchement peut être positif ou négatif**
  - **Formation des turbulences de Haute Altitude**
  - **Vérification en vol de la théorie ondulatoire**

    Vol expérimental sous le vent du Mont Blanc. Conclusions.

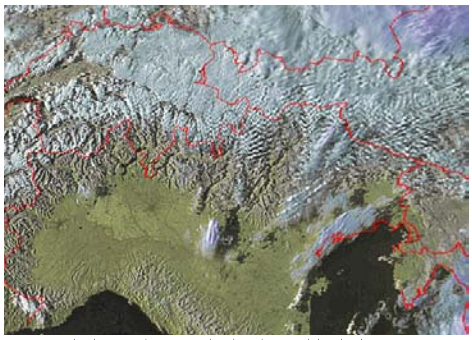


Tracé GPS d'un vol expérimental de 45 minutes en virage stabilisé à 35° dans un système ondulatoire du Mont Blanc (21/3/99)

- **CONDITIONS METEOROLOGIQUES NECESSAIRES**

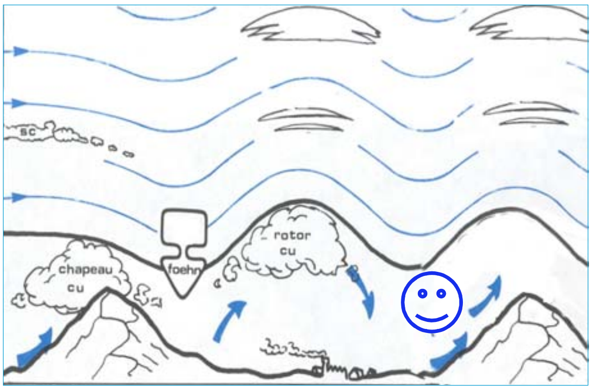
- Pas d'instabilité naturelle de la masse d'air
- Orientation de la crête (ou de la plaine)
- Gradient de vent positif
- Faible rotation du vent avec l'altitude

- **FACTEURS FAVORABLES A LA FORMATION DE L'ONDE**



Matérialisation des trains d'ondes, du Jura à la Slovénie (Sept 01)

- Air froid, stable, plus lourd. L'hiver est donc plus propice.
- Vent synoptique à courbure cyclonique
- Orographie en phase avec le ressaut
- Vallée profonde avec vent canalisé perpendiculaire au vent synoptique
- Pente au vent exposée à un facteur orographique local d'accélération
- Jet Stream (cirrus en "queue de cheval")
- Arête concave, «entonnoir», «cuiller»



Onde renforcée par une pente en phase

- **FACTEURS NEGATIFS POUR LA FORMATION DE L'ONDE**

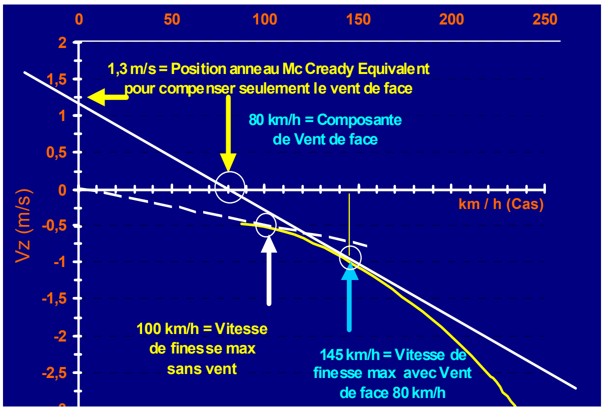
- Air chaud, même si seulement en altitude (arrivée de cirrus)
- Air humide, plus léger.
- Air instable dans les couches supérieures. Formation d'orages.
- Vent avec courbure anticyclonique: la divergence est favorable au mouvement descendant. Vents catabatiques, de chute (secteur E-NE)
- Orographie en opposition de phase avec le ressaut
- Orographie isolée, pente convexe
- Rotation du vent en altitude
- Gradient de vitesse du vent positif insuffisant
- Couvertures nuageuses étendues, arrivée d'un front
- Forte humidité à basse altitude, même sans nuage
- Pluie même si locale, brouillard

Cirrus en "queue de cheval", vus par dessus, et quelques lenticulaires et cirro-cumulus lenticularisés (photo NASA)

QUATRIEME PARTIE

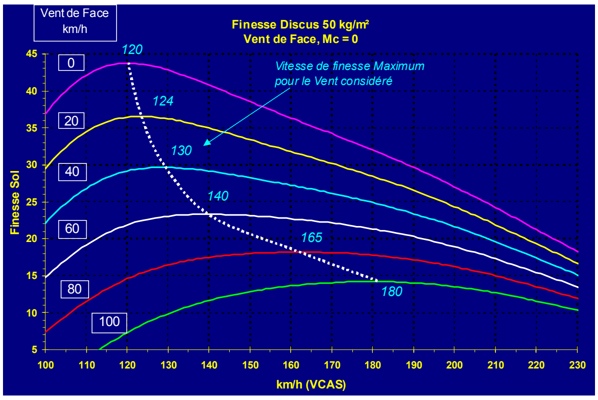
TECHNIQUES DE VOL, STRATEGIES DE VITESSE

- **LA THEORIE DE MAC CREADY NE S'APPLIQUE PAS**
- **A QUELLE VITESSE VOLER EN ONDE?**
- **FINESSE MAXIMUM VENT DE FACE**

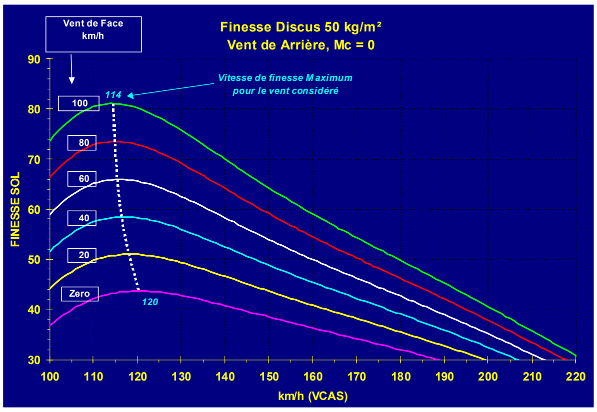


Polaire ASH 25E à 41 kg/m2, niveau mer, 80 km/h de face
Point de Finesse maximum

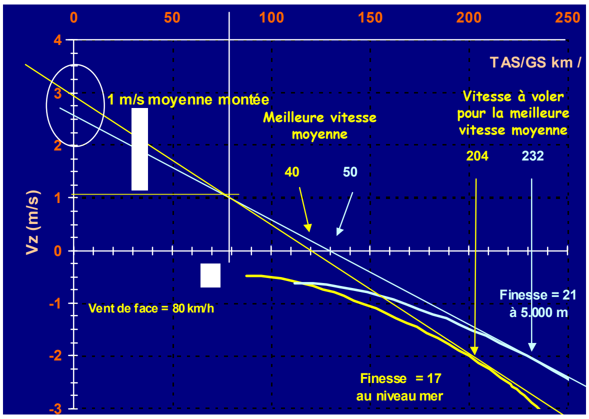
- **FINESSE MAXIMUM VENT**



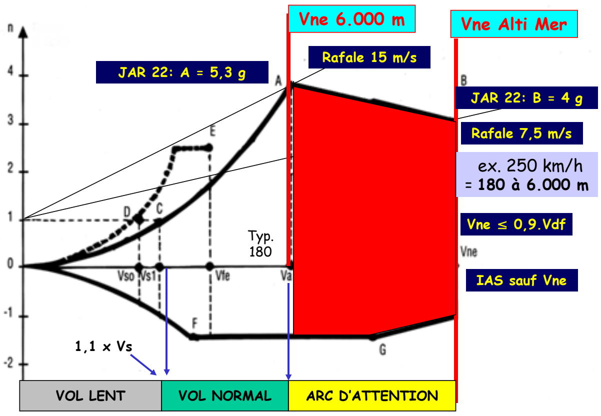
Influence du Vent en face sur la finesse maximum et vitesse correspondante, avec Mc Cready = 0 (pour arriver le plus haut possible)



Influence du Vent arrière sur la finesse maximum et sa vitesse correspondante, avec Mc Cready = 0 (pour arriver le plus haut possible)



ARRIERE



Exemple de domaine de vol et valeurs JAR 22

- **VITESSE DE CROISIERE MAXIMUM**
- **INFLUENCE DE L'ALTITUDE SUR LA FINESSE VENT DE FACE**
- **LIMITES STRUCTURELLES**
- **ENERGIE CINETIQUE (INERTIE):**
- **ON PEUT EXPLOSER LA MACHINE EN VOLANT "LEGALEMENT" A LA VA VENT ARRIERE ET EN FAISANT ½ TOUR VENT DE FACE SI TURBULENCE**
- **CHARGE ALAIRE: IMPORTANCE SUR LA SENSIBILITE AUX TURBULENCES**

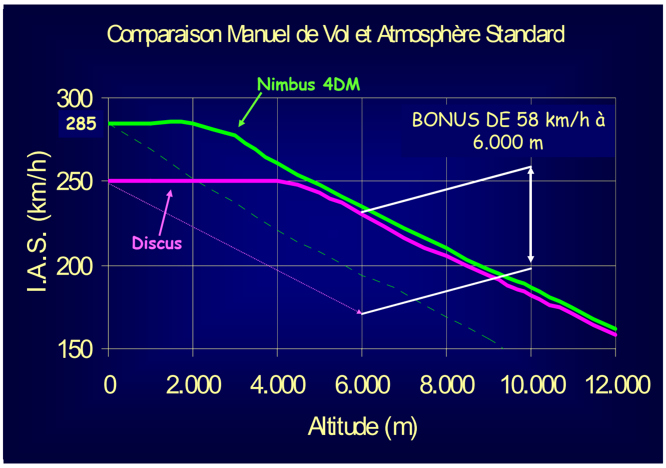
$$n_1 = n_2.\sqrt{P_2}\,/\,P_1$$

- **CONCLUSIONS:**

• A l'inverse du vol en thermique de plaine, c'est le plané vers la prochaine montée qui détermine le calage du Mc Cready.

• Compte tenu de l'effet altitude, il est impossible de voler aux vitesses conseillées par le calculateur s'il est calé sur la Vz moyenne réelle.

• Il est plus facile d'accrocher un nuage par dessus que par dessous, les Vz sont meilleures, le vol est plus confortable



Vne-IAS en Altitude: le Manuel de Vol peut réserver d'agréables surprises

• Il est préférable de rester dans un laminaire moyen (certain) que dans un rotor violent (incertain)

• Le calage est un compromis entre la force du vent et le risque de passer sous le laminaire

• Conserver ses forces et sa fraicheur pour une douzaine d'heures (qui veut voyager loin .....)

• Se rappeler que l'on perd 30% à 50% de ses capacités au bout de 10 heures en altitude, que les accrochages “délicats” sont à proscrire en fin de journée, et que la dernière heure est souvent difficile (froid, éblouissement, nuit au sol)

• Lors d'un grand vol de distance, il faut privilégier la continuité du vol sur la vitesse pure.

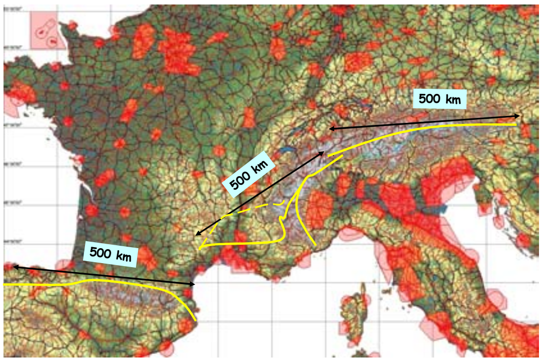
m/s	km/h	0	20	40	60	80	100
0	V	120	124	130	141	163	180
	Mc	0	0,2	0,4	0,7	1,3	2
	L/D	43	37	30	23	18	14
1	V	153	166	176	183	192	200
	Mc	1	1,3	1,7	2,2	3	x
	L/D	38	31	25	21	17	12
2	V	180	186	191	198	203	210
	Mc	2	2,4	3	x	x	x
	L/D	32	27	23	19	16	13

Tableau Vent de face / Mc Cready Equivalent / Finesse
Discus à 50 kg/m2, niveau mer

CINQUIEME PARTIE

STRATEGIES DE ROUTES AU SOL ET EN VOL

- **AVANT LE VOL – CHOIX DU DEPART.** Observations météo, Choix des ponts, Le remorqué, Vent, relief, fronts, images satellites.

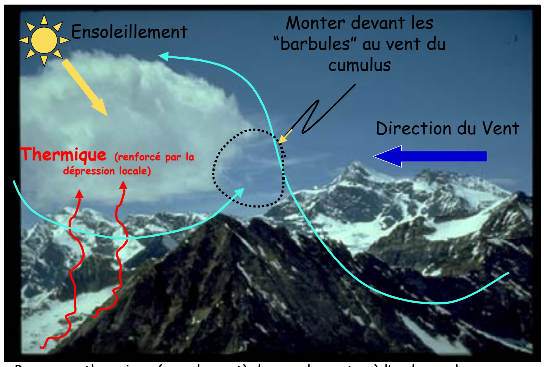


Routes classiques des grands vols d'onde dans les Alpes et les Pyrénnées au départ FR + IT

- **CHOIX DU CIRCUIT:** épouser le plus possible les formes des lignes de cretes orientées le plus possible perpendiculaire au vent

- **SOLUTIONS DE DEROUTEMENT** (pluie, brouillard, vent de travers, percée impossible). Infos fréquences.

- **LA MONTEE INITIALE, PASSER DE L'ENFER AU PARADIS, DU THERMIQUE A L'ONDE**

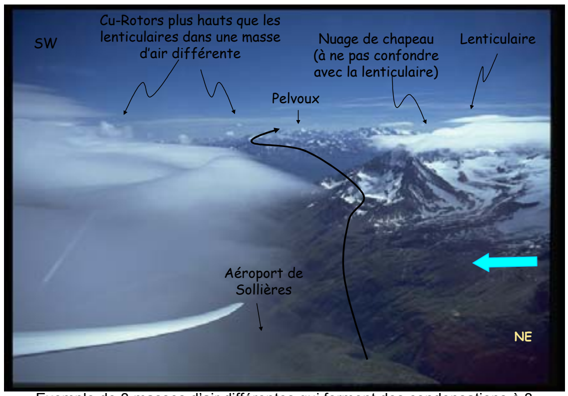


Passer en thermique (sous le vent) du cumulus-rotor à l'onde en phase avec la pente opposée au soleil

- **UN PASSAGE EN ONDE PEUT ETRE LA CLE DE REUSSITE D'UN VOL COMMENCE EN THERMIQUE ET PENTES**

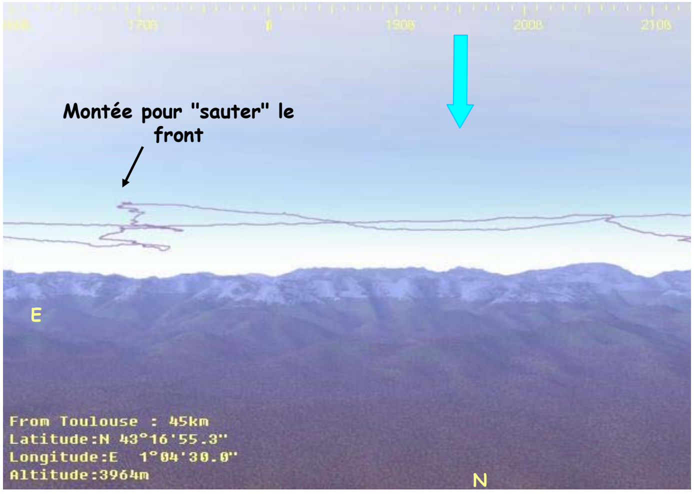
- **UN PASSAGE EN PENTE PEUT ETRE LA CLE DE REUSSITE D'UN VOL COMMENCE EN ONDE**

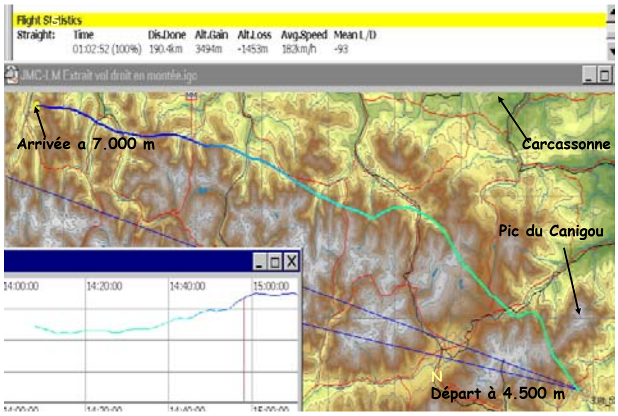
- **UNE FOIS EN LAMINAIRE, Y RESTER ET AVANCER LE PLUS VITE POSSIBLE SANS S'ARRETER**



Exemple de 3 masses d'air différentes qui forment des condensations à 3 niveaux différents et de différentes formes (1995, ASH25)

- **VOYAGER LE LONG DES "ROUTES ENERGETIQUES"**



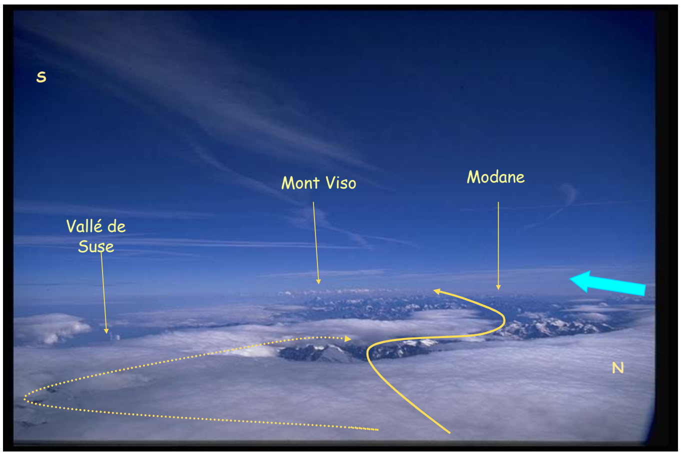


En absence totale de nuages, suivre la forme des sommets et le vario netto. Exemple de 190 km parcourus en 1 heure avec cette métode et en gagnant del'altitude
(29/11/00, Pyrénées, L. Moreau, Nimbus 4DM)

SIXIEME PARTIE

LES DANGERS SPECIFIQUES AU SOL ET EN VOL

- **SAUTER UNE COUCHE PARTIELLE, UNE ZONE DE HAUTS SOMMETS**
- **LA FERMETURE DE LA COUCHE NUAGEUSE**



Pour sauter la couverture dans la Vallée de Rhèmes vers Modane, il faut monter 1.000 m au dessus de ces nuages qui ne montrent aucun signe d'onde

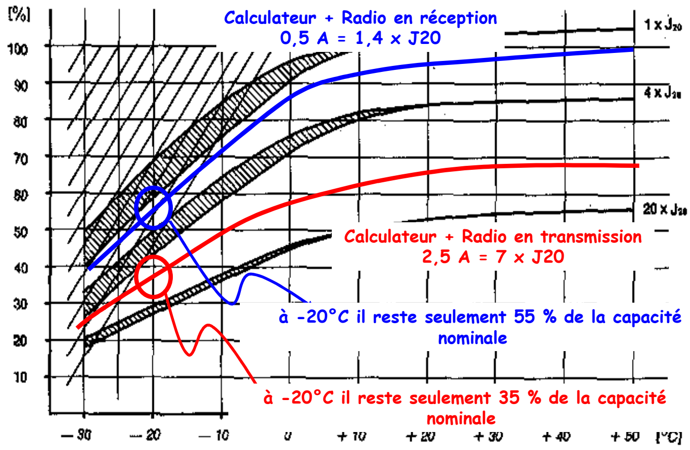
Quand le top remonte et se ferme, il vaut mieux ralentir et monter en s'enfuyant vers la lumière. Vent 230° 87 km/h, 4.200 m, netto +3 , IAS 130 km/h, gyros ON (1/12/00, H. Delort)

- **LES DANGERS SPECIFIQUES**
  - **La perte de l'orientation spatiale**

Le vol «on top» entre deux couches peut amener à la perte de l'orientation dans l'éspace, de toute façon la montée n'est pas au dessus, mais en avant, à ciel ouvert (accident d' Emilio Danesi)

  - **La condensation au sol sur les ailes et la verrière**

- **La glace, le givrage en vol**
- **La montre et la lumière**
- **Les batteries et la basse température**
- **Les autres utilisateurs de l'espace aérien**
- **Les espaces aériens contrôlés**



Batterie au gel DRYFIT de 7 AH: Variation de la capacité en fonction de la température. Pour les longs vols en altitude, il faudrait TRIPLER les batteries et les garder TOUJOURS en parallèle.

Jouir du soleil levant sur le Campo dei Fiori, mais impossible de voler sur la pente, invisible à contre-jour (18/3/00, avec A. Ferrero)

SEPTIEME PARTIE

ASPECTS PSYCHO-PHYSIQUES

PROTECTION DE LA SANTE

ASPECTS TECHNIQUES SPECIFIQUES

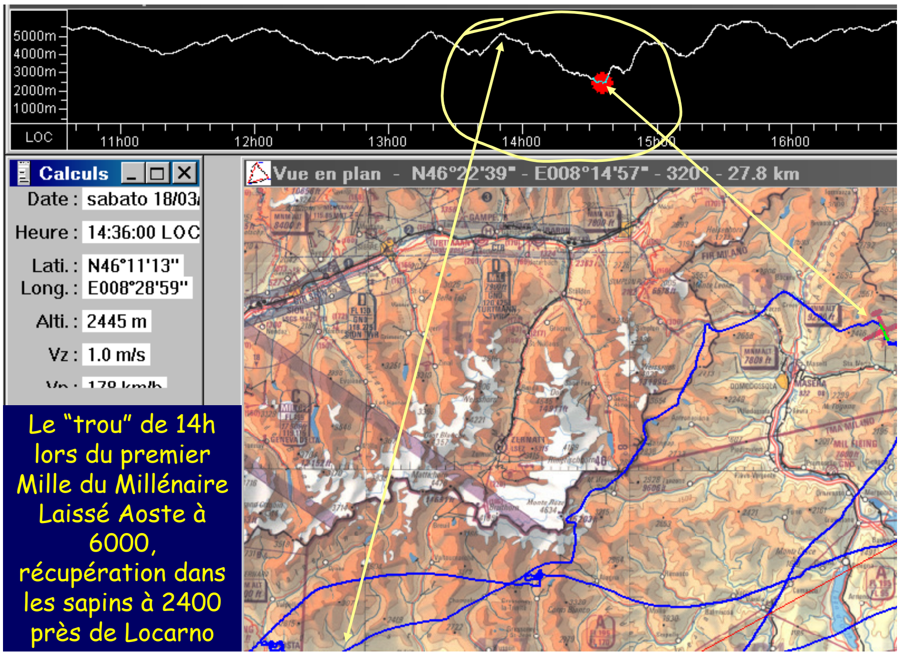
- **FACTEURS ATMOSPHERIQUES SIMPLES**
  - Le froid
  - Les rayons UVA
  - Le manque d'oxygène (hypoxie)

- **FACTEURS ATMOSPHERIQUES COMPLEXES**

  - **La basse pression (Dysbarisme):**
  - **Syndrome de décompression (DCS)**
  - **Interdiction de voler pendant 24 h suivant une séance de plongée.**
  - **Syndrome de la classe économique**
  - **Hygiène dentaire**
  - **Sphère ORL**
  - **Miction**
  - **Le métabolisme (biorythme) ("trou" de 14h)**

Aucune partie du corps ne devrait être exposée au soleil à haute altitude

Le système Mountain High offre une capacité de 12 heures à deux pilotes avec une petite bouteille de 4 litres. Ne pas oubliez les piles de rechange ! Mieux vaut l'alimententation de bord.



- **ASPECTS TECHNIQUES SPECIFIQUES**
  - **AU SOL**

    - Tout préparer la veille !
    - Ne pas courir pour ne pas suer
    - Contrôler oxygène, barographe et batteries deux fois
    - Bien bloquer tout ce qui est à l'intérieur avec des vis et des courroies pour qu'il puisse résister à un éventuel vol sur le dos
    - Tout essayer avant de monter à bord et tout laisser en marche
    - Utiliser le planeur avec la plus grande charge alaire possible = antigel, plein d'essence. Centrage avant.

  - **AU DECOLLAGE**

    - Les décollages peuvent être délicats, se préparer au pire: vent de travers, cisaillement, rotors en bout de piste
    - Aile haute au vent si travers fort
    - Condensation brutale à l'intérieur de la verrière pendant le roulage
    - Si vous êtes seul, quelqu'un doit être informé de votre tentative de décollage

- **LA MACHINE**
  - Contrôles spécifiques au sol, câbles, graisses
  - Contrôles périodiques pendant le vol: commandes, batteries, état des pilotes
  - Effet température / humidité sur le gelcoat. Ne pas nettoyer à l'eau. Cirer deux fois par an. Polyuréthane ?
  - Pression et débit d'oxygène
  - Traitement anti-buée de la verrière
  - Traitement anti-givre du bord d'attaque

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ANNEXES A LA CONFERENCE

SITES INTERNET UTILES ET

ARTICLES RELATIFS A :

- **SYNDROME DE DECOMPRESSION D'ALTITUDE (DCS)**
- **UTILISATION CORRECTE DE L'OXYGENE**
- **DANGERS DES RADIATIONS U.V.**

RECUEIL DE SITES INTERNET UTILES

METEO

- **Mon préféré** http://www.wetterzentrale.de/topkarten/fsfaxsem.html (choisir FAX, SEMBACH puis BRACKNELL)
- **Pour les passionnés de météo:** http://www.wetterzentrale.de/
- **Le plus rapide et complet pour METAR et TAF** (enregistrement obligatoire gratuit): http://www.avbrief.com/
- **La dernière image visible en haute définition** (il faut une **connexion rapide) =** ftp://ftp.dfd.dlr.de/put/wetterbilder/Central_Europe/image1.jpg
- **La dernière image IR** (qualité moyenne) http://www.sca.uqam.ca/sat_europe/ir_last_e.html
- **Tout et facile d'accès =** http://www.westwind.ch/
- **Idem Anglais =** http://www.weatheronline.co.uk/
- **Notre DF National =** http://df2.free.fr/
- **Les meilleures analyses et prévisions à tous les niveaux** (se configurer les pages selon ses goûts) http://grads.iges.org/pix/pix.html
- **Les meilleures prévis de 3 à 6 jours =** http://www.ecmwf.int/
- **Tous les satellites américains** = http://www.goes.noaa.gov/
- **Les plus belles images en très haute définition** (conn. rapide!)

http://home.t-online.de/home/wienzek/ ou http://www.wienzek.net

- **Animations splendides (conn. rapide)** http://www.sat.dundee.ac.uk/movie.html
- **US Air Force in Europe:** http://ows.public.sembach.af.mil/

EQUIPEMENTS SPECIAUX

- **Système de régulation électronique de l'oxygène** : http://www.mtn-high.com/

RAPPORTS ET ETUDES SCIENTIFIQUES

- **DRYDEN TECHNICAL REPORT SERVER** http://www.dfrc.nasa.gov/DTRS/
- **NASA TECHNICAL REPORT SERVER** http://techreports.larc.nasa.gov/cgi-bin/NTRS

- **LEE WAVES: BENIGN AND MALIGNANT. Wurtele & Al. (1993)** http://www.dfrc.nasa.gov/DTRS/1993/PDF/H-1890.pdf
- **WIND AND MOUNTAIN WAVE OBSERVATIONS** FOR THE PATHFINDER HAWAIIAN FLIGHT TEST OPERATION, Edward H. Teets, Jr. and Natalie Salazar (1999)http://www.dfrc.nasa.gov/DTRS/1999/PDF/H-2286.pdf
- **STRATOSPHERIC TURBULENCE MEASUREMENTS** AND MODELS FOR AEROSPACE PLANE DESIGN Ehernberger (1992) http://www.dfrc.nasa.gov/DTRS/1992/PDF/H-1865.pdf

BULLETINS MEDICAUX SPECIFIQUES

- **Federal Aviation Administration Office of Aerospace Medicine Civil Aerospace Medical Institute**

http://www.cami.jccbi.gov/AAM-400A/
En particulier:
http://www.cami.jccbi.gov/AAM-400A/Brochures/400altitude.html
http://www.cami.jccbi.gov/AAM-400A/Brochures/600Air-HFB.html

- **The Federal Air Surgeon's Medical Bulletin**

http://www.faa.gov/avr/aam/fasb597/archtoc.htm

- **HealthGate**

http://www.healthgate.com

- **Centers for Disease Control and Prevention (CDC)**

http://www.cdc.gov

- **US National Library of Medicine (NLM)**

http://nlm.nih.gov

INFOS SECURITE

- **DG Flugzeugbau GmbH .Safety Reports - Please Fly Carefully!** http://www.dg-flugzeugbau.de/index-e.html

Federal Aviation Administration

Office of Aerospace Medicine

Civil Aerospace Medical Institute

ALTITUDE-INDUCED DECOMPRESSION SICKNESS

Tiny Bubbles, BIG Troubles

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. DCS can occur during exposure to altitude (altitude DCS) or during ascent from depth (mining or diving). The first documented cases of DCS (Caisson Disease) were reported in 1841 by a mining engineer who observed the occurrence of pain and muscle cramps among coal miners exposed to air-pressurized mine shafts designed to keep water out. The first description of a case resulting from diving activities while wearing a pressurized hard hat was reported in 1869.

ALTITUDE-INDUCED DECOMPRESSION SICKNESS

Altitude DCS became a commonly observed problem associated with high-altitude balloon and aircraft flights in the 1930s. In present-day aviation, technology allows civilian aircraft (commercial and private) to fly higher and faster than ever before. Though modern aircraft are safer and more reliable, occupants are still subject to the stresses of high altitude flight-and the unique problems that go with these lofty heights. A century and one-half after the first DCS case was described, our understanding of DCS has improved, and a body of knowledge has accumulated; however, this problem is far from being solved. Altitude DCS still represents a risk to the occupants of modern aircraft.

Tiny Bubbles

According to Henry's Law, when the pressure of a gas over a liquid is decreased, the amount of gas dissolved in that liquid will also decrease. One of the best practical demonstrations of this law is offered by opening a soft drink. When the cap is removed from the bottle, gas is heard escaping, and bubbles can be seen forming in the soda. This is carbon dioxide gas coming out of solution as a result of sudden exposure to lower barometric pressure. Similarly, nitrogen is an inert gas normally stored throughout the human body (tissues and fluids) in physical solution. 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."

Trouble Sites

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

Table 1 lists the different DCS types with their corresponding bubble formation sites and their most common symptoms. "The bends" (joint pain) account for about 60 to 70% of all altitude DCS cases, with the shoulder being the most common site. Neurologic manifestations are present in about 10 to 15% of all DCS cases with headache and visual disturbances being the most common symptoms. "The chokes" are very infrequent and occur in less than 2% of all DCS cases. Skin manifestations are present in about 10 to 15% of all DCS cases.

Medical Treatment

Mild cases of "the bends" and skin bends (excluding mottled or marbled skin appearance) may disappear during descent from high altitude, but still require medical evaluation. If the signs and symptoms persist during descent or reappear at ground level, it is necessary to provide hyperbaric oxygen treatment immediately (100% oxygen delivered in a high-pressure chamber). 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.

Facts About Breathing 100% Oxygen

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 between 18,000 and 43,000 ft. However, oxygen prebreathing has to be continued. without interruption with inflight 100% oxygen breathing to provide effective protection against altitude DCS. Furthermore, it is very important to understand that breathing 100% oxygen only during flight (ascent, enroute, descent) does not decrease the risk of altitude DCS, and should not be used in lieu of oxygen prebreathing.

Although 100% oxygen prebreathing is an effective method to provide individual protection against altitude DCS, it is not a logistically simple nor an inexpensive approach for the protection of civil aviation flyers (commercial or private). Therefore. at the present time it is only used by military flight crews and astronauts for their protection during high altitude and space operations.

Table 1. Signs and symptoms of Altitude Decompression Sickness.

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 aggrevates the pain. • Pain can occur at altitude, during

		the descent, or many hours later.
NEUROLOGIC	Brain	• Confustion 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 for twitching
CHOKES	Lungs	• Burning deep chest pain (under the sternum) • Pain is aggravated by breathing • Shortness of beath (dyspnea) • Dry constant cough
SKIN BENDS	Skin	• Itching usually around the ears,

		face, neck arms, and upper torso • Sensation of tiny insects crawling ove 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)

PREDISPOSING FACTORS

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. who have not been SCUBA (Self Contained Underwater Breathing Apparatus) diving. Individual exposures to altitudes between 18,000 ft. and 25,000 ft. have shown a low occurrence of altitude DCS. Most cases of altitude DCS occur among individuals exposed to altitudes of 25,000 ft. or higher. A US Air Force study of altitude DCS cases reported that only 13% occurred below 25,000 ft. The higher the altitude of exposure, the greater the risk of developing altitude DCS. It is important to clarify that although exposures to incremental altitudes above 18,000 ft. show an incremental risk of altitude DCS, they do not show a direct relationship with the severity of the various types of DCS (see Table 1).

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. 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 liter) 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.

Scuba Diving Before Flying

SCUBA diving requires breathing air under high pressure. Under these conditions, there is a significant increase in the amount of nitrogen dissolved in the body (body nitrogen saturation). The deeper the SCUBA dive, the greater the rate of body nitrogen saturation. Furthermore, SCUBA diving in high elevations (mountain lakes), at any given depth, results in greater body nitrogen saturation when compared to SCUBA diving at sea level at the same depth. Following SCUBA diving, if not enough time is allowed to eliminate the excess nitrogen stored in the body, altitude DCS can occur during exposure to altitudes as low as 5,000 ft. or less.

WHAT TO DO WHEN ALTITUDE DCS OCCURS

- Put on your oxygen mask immediately and switch the regulator to 100% oxygen.
- Begin an emergency descent and land as soon as possible. Even if the symptoms disappear during descent, you should still land and seek medical evaluation while continuing to breathe oxygen.
- If one of your symptoms is joint pain, keep the affected area still; do not try to work pain out by moving the joint around.
- Upon landing seek medical assistance from an FAA medical officer, aviation medical examiner (AME) military flight surgeon, or a hyperbaric medicine specialist. Be aware that a physician not specialized in aviation or hypobaric

medicine may not be familiar with this type of medical problem. Therefore, be your own advocate.

- Definitive medical treatment may involve the use of a hyperbaric chamber operated by specially trained personnel.
- Delayed signs and symptoms of altitude DCS can occur after return to ground level whether or not they were present during flight.

THINGS TO REMEMBER

- Altitude DCS is a risk every time you fly in an unpressurized aircraft above 18,000 feet (or at lower altitude if you SCUBA dive prior to the flight).
- Be familiar with the signs and symptoms of altitude DCS (see Table 1) and monitor all aircraft occupants, including yourself, any time you fly an unpressurized aircraft above 18,000 ft.
- Avoid unnecessary strenuous physical activity prior to flying an unpressurized aircraft above 18,000 ft. and for 24 hrs. after the flight.
- Even if you are flying a pressurized aircraft, altitude DCS can occur as a result of sudden loss of cabin pressure (inflight rapid decompression).
- Following exposure to an inflight rapid decompressions do not fly for at least 24 hrs. In the meantime, remain vigilant for the possible onset of delayed symptoms or signs of altitude DCS. If you present delayed symptoms or signs of altitude DCS, seek medical attention immediately.
- Keep in mind that breathing 100% oxygen during flight (ascent, enroute, descent) without oxygen prebreathing prior to take off does not prevent the occurrence of altitude DCS.
- Do not ignore any symptoms or signs that go away during the descent. In fact, this could confirm that you are actually suffering altitude DCS. You should be medically evaluated as soon as possible.
- If there is any indication that you may have experienced altitude DCS, do not fly again until you are cleared to do so by an FAA medical officer, an aviation medical examiner, a military flight surgeon, or a hyperbaric medicine specialist.
- Allow at least 24 hrs. to elapse between SCUBA diving and flying.
- Be prepared for a future emergency by familiarizing yourself with the availability of hyperbaric chambers in your area of operations. However, keep in mind that not all of the available hyperbaric treatment facilities have personnel qualified to

handle altitude DCS emergencies. To obtain information on the locations of hyperbaric treatment facilities capable of handling altitude DCS emergencies, call the Diver's Alert Network at (919) 684-8111.

For More Information

If you are interested in learning more about altitude DCS, as well as the other stressors that may affect your performance and/or your health during flight. we encourage you to enroll in the Physiological Training Course offered by the Aeromedical Education Division (Airman Education Programs) at the FAA Civil Aerospace Medical Institute in Oklahoma City. A similar course is also available at US military physiological training facilities around the country through an FAA/DOD Training Agreement. For more information about any of these courses, call us at (405) 954-4837.

Medical Facts for Pilots

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Federal Air Surgeon's Medical Bulletin

Oxygen Equipment and Aviation: It's a Real Gas

Basic use and design of typical oxygen equipment

J.R. Brown

From the very first moment that human beings began to ascend into the atmosphere, it was understood that we had one major disadvantage: *Humans do not belong in the sky*. Our brain allows us to develop the technology to compensate for our physiological shortcomings so that we may venture into new and dangerous environments.

The major obstacle to journeying into the heavens has always been the inevitable drop in atmospheric pressure and the subsequent lack of oxygen to support the body's needs.

If you want to fly to high altitude, you must compensate for either the lack of atmospheric pressure or for the corresponding drop in the partial pressure of oxygen.

It is much better to compensate for the atmospheric pressure drop through the use of pressurized cabins. This puts aviators at an altitude (typically 8,000 feet) where the physiological problems of high altitude flight are left well outside the cabin.

However, most general aviation aircraft do not have the capability to pressurize their cabin. So the only way these pilots can compensate is to breathe supplemental oxygen. Since almost 60% of the 639,000 pilots in this country are in the general aviation category, the chances are good that, at one time or another, they may use and have questions concerning oxygen equipment.

The intent of this article is to describe the basic use and design of typical oxygen equipment. If you or the pilots that you examine have specific questions concerning a particular oxygen delivery system, they should be directed to the manufacturer of that equipment.

Oxygen delivery systems consist of three basic components:

- the storage system,
- delivery systems, and
- the oxygen mask.

Oxygen Storage Methods

There are several ways that oxygen can be stored aboard the aircraft. It can be stored either as a gas, liquid, or a solid. Each method has both advantages and disadvantages. Gaseous oxygen can be found in three various forms: ***aviator's breathing oxygen***, ***medical grade oxygen***, and ***industrial*** (***welder's) oxygen***.

For oxygen to be considered *aviator's breathing oxygen*, it must meet stringent criteria. First, it must be 99.95% pure oxygen with no colors, odors, or taste. And secondly, it must be dry. The dryness of the oxygen is very important in that, with colder temperatures associated with high altitude, any moisture in the oxygen would freeze and play havoc with the oxygen regulator. Medical and welder's grade oxygen do not meet the criteria of aviator's grade.

When medical grade oxygen is bottled, it may contain anywhere from 1 to 5% water vapor, and welder's oxygen contains impurities that may be harmful if inhaled. It is apparent that ABO (aviator's breathing oxygen) is the only safe way to supply gaseous oxygen to the aircraft.

Gaseous oxygen affords the pilot advantages over the other various storage methods: It is the most economical, and it has a very low rate of maintenance.

Of course, with the advantages come the disadvantages. ABO cylinders are very bulky and heavy, which can bring about a substantial weight and space penalty. Another disadvantage lies in the fact that you are dealing with compressed 100% oxygen. By nature, this brings about a potential fire hazard, especially when there is a petroleum product present. Another problem, if the filler valve was accidentally broken off the bottle, it would allow the oxygen to rapidly escape, propelling the bottle much like a missile.

To escape the problems of storing ABO in an aircraft, a liquid oxygen (LOX) system can be used. LOX is a pale blue liquid that is stored at a critical temperature of -297°F. As long as it stays at this temperature, it will remain as a liquid, but if the temperature rises above critical, the liquid will immediately convert into a gas (a process known as *boiling*).

This action accounts for the major advantage that LOX has over ABO. The boiling creates an 860 to 1 expansion ratio. In other words, 1 liter of LOX will expand into 860 gaseous liters of ABO. This will afford a 5 to 1 space savings, and a 3 to 1 weight savings over ABO. The major disadvantage of LOX is expense. It is expensive to install and to maintain this system. Also, the cold nature of LOX poses potential harm if it comes in contact with exposed skin.

The expense of LOX may cause an aviator to look for other ways to store oxygen onboard the aircraft. If that's the case, then sodium chlorate candles may be a viable option. Through a chemical chain reaction, NaClO3 thermally decomposes into sodium chloride (salt), iron oxide (a core of iron wool is located in the candle and acts as a catalyst for the chemical reaction), and oxygen. The oxygen is delivered to the user through the bottom of the candle into an oxygen mask.

The advantage that sodium chlorate has over ABO stems from a 600 to 1 expansion ratio. This will save weight and space on the aircraft, as well as eliminating the potential problems of storing a compressed gas. A major disadvantage of this system is once the candle is ignited it will continue to burn and can't be stopped until the chemical is completely exhausted. Another disadvantage of this system is that it emits a great amount of heat, which, of course, is a potential fire hazard.

The final system to be discussed may be the system of choice for aviation in the future. It is called the molecular sieve. It works on the principle of taking air, just like we are breathing, and routing it over a series of chemical beds that are designed to absorb and retain nitrogen.

Once the nitrogen has been removed from the air, the major gas that is left is oxygen. The oxygen is then sent to a storage tank and is available for crew and passenger use. The military has been using this system for many years and has enjoyed a very good track record. This system has also been portabalized and employed for therapeutic oxygen use.

The molecular sieve system has only a couple of disadvantages. First, the best percentage of oxygen that can be attained is about 98%, with the remainder being argon. But the biggest disadvantage is its initial expense. This tends to discourage the general aviation community; therefore it has not been accepted as it has in the military.

Delivery Systems

So far, we have discussed ways to store and supply oxygen to the aircraft. Next, we need to examine how this oxygen can be delivered from the source to the user. Currently, oxygen can be delivered in three fashions:

- continuous flow
- diluter demand
- pressure demand

The continuous flow system is the most simple and economical to use. A continuous flow system works just as the name implies, it delivers a continuous flow of oxygen to the user. The oxygen flows from the source until the system is shut-off or until the oxygen supply has dwindled.

The advantage of this delivery system lies in the cost. It is the most economical system to employ. Most of the portable oxygen systems that aviators rent at a local FBO use the continuous flow method. When the oxygen leaves the tank, it flows out at a certain rate. This rate is usually expressed in liters per minute. The higher you fly, the greater the flow rate must be. For example, if you are flying unpressurized at 25,000 feet, your minimum flow rate delivered to the mask needs to be 2.5 liters per minute. This flow rate, with a proper mask fit, will ensure there is enough oxygen being delivered to the user to maintain an alveolar pO_2 of approximately 100mm (sea level equivalency). By using various flow plugs, a pilot can ensure a proper flow rate depending upon the altitude.

The downside of a continuous flow system is its waste of precious oxygen. First, we only need oxygen when we demand it. To demand oxygen, we simply inhale. To stop the demand, we pause and then exhale. But with a continuous flow system, the oxygen continues to flow, regardless of what phase of respiration we are in. This is a waste of oxygen.

Additionally, most continuous flow systems deliver only 100% oxygen. Breathing 100% oxygen at any altitude below 34,000 feet is wasteful. For example, breathing 64% oxygen at 25,000 feet unpressurized, will create an alveolar pO_2 of approximately 100mm (sea level equivalency).

But, if you breathe 100% oxygen at 25,000 feet, you are essentially wasting 36% of your supply. These two problems were in mind when the diluter demand system was created. This system saves oxygen two ways: First, it gives oxygen in the proper percentages, depending on the altitude. Second, it gives oxygen only on demand (on inhalation).

If an aviator desires to fly above 34,000 feet and maintain a proper alveolar oxygen level, then a pressure demand system should be used. This system is identical to the diluter demand system with one major difference: it delivers 100% oxygen under positive pressure. Positive pressure is described as a forceful (positive) flow of oxygen into the trachea, alveoli, and blood.

Most people are not comfortable with positive pressure breathing because it disrupts the normal breathing cycle. Normally, inhalation is an active process. The diaphragm must actively drop and the intercostals must contract to allow the lungs to expand and let the air enter. But with positive pressure breathing, inhalation does not have to be very active. A slight inhalation is all that is needed to fill the lungs. Under normal conditions, when we exhale the diaphragm and the intercostals relax to squeeze the expired air from the lungs. But because of the forceful flow of oxygen continually pushing oxygen into the lungs, you must exhale forcefully. The force of the exhalation must be greater than the force of the positive pressure coming in. If an aviator is not careful to breathe with a proper pressure breathing cycle, hyperventilation can be a real possibility.

In my experience as an instructor in the altitude chamber, I have found that, if students inhale slightly, pause for a second, and then forcefully exhalejust hard enough to allow the breath to leave the maskthey rarely hyperventilate. It takes much practice to master this technique.

Oxygen Masks

Thus far, we have discussed various ways to store, supply, and deliver oxygen to the user. Next, we need to look at the final component of an oxygen delivery system, and that is the mask.

The FAA recognizes two categories of oxygen mask: *quick-don* and *non quick-don* type.

To be a quick-don mask, it must be able to be donned with one hand over prescription glassesin five seconds or less. If the mask fails to meet this standard, it is considered to be a non quick-don mask.

Another consideration is that the mask must be able to function with the breathing regulator that you are using. In other words, if you have a diluter demand mask and pressure demand regulator, the two are not compatible. Some masks have the oxygen regulator mounted on the mask. This is a real convenience for aircraft that have limited space in the cockpit.

No matter how good the mask may be, it can be rendered useless if it does not fit properly. Most oxygen masks are sold as universal-fitting. That is, one size fits all, no size fits right. Even so, it is important to stop as many leaks as possible.

Another issue that needs to be addressed is that of beards. Heavy beards can create a separation between the mask and the face. This is an invitation for oxygen leaks that could rob the body of needed oxygen.

Oxygen Equipment Inspection

Once you are in possession of an oxygen delivery system, you must ensure that it functions properly. By conducting inspections before and while using the oxygen equipment, potential problems can be avoided.

A successful approach that the US Air Force has used for many years is to have their pilots conduct a PRICE check. PRICE is both a mnemonic and a checklist that helps pilots and crewmembers to inspect oxygen equipment.

Pressure - Ensure there is enough oxygen pressure and quantity to complete the flight.

Regulator - Inspect the oxygen regulator for proper function. If you are using a continuous flow system, make sure the right flow plug is on the mask

Indicator - Most oxygen delivery systems indicate an oxygen flow through the use of flow indicators. Flow indicators may be located on the regulator or within the oxygen delivery tube. Every time the oxygen mask is donned, the flow indicator should be checked. This will let you know if you have oxygen flowing to the mask.

Connections - Ensure that all connections are secured. This includes oxygen lines, flow plugs, and the mask.

Emergency - Have oxygen equipment standing by and ready to go for those emergencies that call for oxygen (hypoxia, decompression sickness, smoke and fumes, and rapid decompressions).

Oxygen equipment is your first line of defense against the enemies of safe flight at high altitude. Knowing your oxygen equipment and its limitations will go a long way towards making us all much safer aviators.

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ULTRAVIOLET RADIATION HAZARD
by
Guy Ford Byars

Exposure to ultraviolet radiation (UV) generated by the sun poses serious health risks. We as pilots can be exposed to a great deal of UV throughout our lives. This article will detail what UV is, why it is particularly bad for pilots, and what we can to do to reduce our exposure to it.

What is UV and why it is harmful

The sun emits a wide spectrum of electromagnetic radiation, including infrared, visible, and ultraviolet. Based on its wavelength in nano-meters (nm) the UV reaching the earth can be categorized into ultraviolet A (UVA; 320nm - 400nm) and ultraviolet B (UVB; 290nm - 320nm). The intensity of UVA orUVB reaching the earth is subject to numerous variables, including time of day, altitude above sea level, scattering by atmospheric substances . . . etc. Depending on these variables, UVA exposure can exceed that of UVB by 10 to 1,000 fold. During the early morning and late afternoon, UVB irradiance is comparatively small, whereas significant UVA levels may be encountered throughout the day.

UV poses very serious health risks. There is extensive medical evidence that UV causes several forms of skin cancer. Both Basal cell carcinomas, the most common skin cancer, and Squamous cell carcinoma, a more dangerous form of skin cancer, are directly related to long term UV radiation exposure.

UVA and UVB are quite different, yet both are damaging. UVB is the primary cause of both sunburn and skin cancer. UVA plays a role in skin cancer because it increases the carcinogenic effectsof UVB. While UVA doesn't cause sunburn as quickly as UVB, UVA penetrates deeper into the skin causing a much more damaging burn. UVA also contributes to a wide variety of other medical problems including blood vessel and DNA damage. UVA has been consistently linked to skin changes associated with aging, such as skin wrinkling and sagging.

Skin cancer, in which UV exposure plays an important role, is the most common form of cancer. Unfortunately, the number of cases of skin cancer has increased more than 50% in the past decade. More important to us is the increasing number of pilots, who after 30+ years in the aviation, are now having repeated surgery for removal of facial skin cancers. Therefore, it is imperative for everyone, especially pilots, to consider ways to minimize exposure to UV.

Pilots have high UV exposure

By the very nature of aviation, pilots are exposed to a great deal of sunlight. In order to fly we must be outdoors. Also, we in sport aviation usually fly when the weather is nice and sunny and stay outside at fly-ins from early in the morning until dark. To make matters worse, many home builders and sport pilots use
bubble canopies which expose them to a lot of sun but provide no protection against it. Since there is less atmosphere to screen the sun at higher altitudes, the damaging effects of the sun are compounded by 4% for each 1000ft above sea level. (Figure 1). Given that in order for us to pursue aviation we expose ourselves

to a great deal of sunlight, what can we do to reduce our health risk from UV? There are many effective ways. Sunscreens, clothing, sunglasses, and UV filtering films all are effective in reducing UV exposure. I will discuss each one and try to clear up some common misunderstandings.

Sunscreens

The single most important thing to remember about sunscreens is to USE THEM! You must follow the instructions provided with the sunscreen and reapply them as directed. Sunscreens can not protect you unless you use them!

The effectiveness of sunscreens is usually rated by a sun protection factor (SPF). This gives an indication of how many times your natural sunburn protection the sunscreen will provide. It is easy to misinterpret these SPF factors. A sunscreen with SPF 15 will block 93% of UVB while one with SPF 50 will block only 5% more. Also, the SPF is only an indication of the protection against the UVB. It gives no information whatsoever about the sunscreen's ability to protect against UVA. Indeed, the majority of sunscreens available today, even those with SPF factors as high as 45, provide little or no protection in the UVA wavelengths. High SPF sunscreens without UVA protection can be dangerous. They prevent sunburn which allow people to stay out in the sun longer, thus exposing themselves to large amounts of UVA.

Several sunscreen products have been recently introduced which effectively block both UVA and UVB. The most effective is a brand called "PHOTOPLEX" (available at pharmacies). This isn't the only one which is effective against UVA. Many new products are being introduced. Be aware that while most sunscreens will advertise that both UVB and UVA are blocked, a sunscreen need only block as little as 1% of the UVA in order to claim UVA protection. The effective UVA sunscreens can be identified by the term "Broad Spectrum", or by a separate UVA screen factor.

Hats

Over 70% of the hats sold in this country last year were the common "baseball" type. This is unfortunate because the baseball hat does not provide adequate protection from UV. This is a very important point that we all need to be aware of. While the baseball hat does cover your head (essential for those with thin hair), forehead and nose, it provides no protection for your ears, neck and cheeks. One of the most common places for skin cancers to occur is on the cheek, a place which the baseball hat does not cover. Instead of the baseball hat, you should wear a broad brimmed hat. Both cowboy hats and pith helmets are hard to beat.

Sunglasses

Not only does your skin suffer from the effects of UV, but your eyes do too. Eye damage, caused by UV, can easily be prevented by the use of high quality sunglasses. Most all sunglasses are now sold with information about their UV blocking abilities. High quality sunglasses will state that both UVB and UVA up to 400nm are filtered. Avoid cheap sunglasses which just claim to "Block UV rays". They may only block a small amount of UVB, yet still allow significant UVB and UVA to enter.

Automotive Glass

We receive a great deal of UV exposure through the driver's window of our cars. This is clearly demonstrated by the fact that drivers in countries with left hand drive cars have a higher incident of skin cancer on the left side of their faces. While drivers in countries with right hand drive cars have a higher
incidence on the right side of their face. Therefore, it is important to do all we can to reduce UV exposure while driving. Automotive glass very effectively blocks UVB, but not UVA. Therefore while you might not get sunburned through glass, the cancer causing UVA still comes through. The easiest way prevent this is to apply a UV protection film to the driver's side window of your car. You can install this film yourself, or have an auto customization shop do it. It is not necessary to apply a "smoked" or tinted film in order to obtain UV protection, there are clear films available which will do this quite well. I highly recommend a clear film made by the Madico company sold under the name CLS-200-X Since it is clear you won't be able to tell it is on the window, but It still provides 100% protection against both UVA and UVB. This will also help prevent your car's interior from deteriorating. The film can be purchased from MADICO 64 Industrial Parkway, Woburn MA 01888 (800)-225-1926, (617)-935-7850

Plexiglas Canopies

A common misconception about Plexiglas canopies is that they will adequately protect you from the sun. They don't. Plexiglas will only provide protection in the UVB wavelengths. Thus, while you might not sunburn as badly through Plexiglas, you are still exposed to UVA. As with sunscreens, since the UVB burning wavelengths are blocked, one might stay out in the sun longer, thus being exposed to a great deal of UVA. While the blue tinted canopies look nice and might help you feel cooler, they provide no additional UV filtering.

Applying films to Plexiglas canopies.

I have been researching the use of films applied to canopies to protect the pilot from UV. Again the Madico CLS-200-X can be used for this purpose. Figure 2 shows how the UV filter compares with clear Plexiglas. While the graph does show that Plexiglas provides protection to UVB and some UVA, it still allows
significant UVA to be transmitted. This UVA exposure is especially bad for pilots because it increases with altitude .

Let me describe some of the limitations of applying film to Plexiglas. Most UV films were designed to be applied to flat window glass. They come with a pressure sensitive adhesive on one side which is used to bond them to the window glass. The film can be applied to flat Plexiglas and to Plexiglas curved in a single direction, a cylinder for example. However these films are not pliable enough to be applied to canopies with compound curves. Therefore, their use on canopies is limited. However, if your aircraft has flat side windows, like the Piper Pawnee for example, then you might consider it.

One important note about Plexiglas. According to the manufacturers, Plexiglas will produce gasses as it ages. If a film is bonded to it, then those gasses can become trapped between the film and Plexiglas causing bubbles to form. However, I have several test specimens of film bonded to Plexiglas which are over two years old and have not shown this problem. If you do try this, then do some testing yourself first and make sure you can easily replace any Plexiglas panels if they show signs of bubbling.

Plexiglas Dyes

In my opinion, applying film to Plexiglas is not the ultimate solution. The best long term solution is to have the manufacturer dye the Plexiglas while it is being made. I have done some experiments using clear dyes which were made for the eyeglass industry to block UV in glasses. They showed that Plexiglas can be dyed to filter out all UV and still remain clear. These experiments were limited because the dyes are very expensive and the Plexiglas must be heated to over 180F for the dye to be absorbed. At these temperatures Plexiglas becomes soft and a canopy which has already been formed could easily be ruined.

While dying Plexiglas is not feasible for the individual, it would seem like an easy process while it is being manufactured. It is up to us to inform the Plexiglas manufacturers that canopies with UV protection is a serious concern. Given the information we now have on the damaging effects of UV, we must
make the manufacturers aware of the necessity of such canopies.

Recommendations
In summary, the following four measures will help reduce your UV exposure:

1) Always use a sunscreen. Do not be mislead by high SPF numbers. Only sunscreens which state that they are "BROAD SPECTRUM" provide protection throughout the entire UV spectrum. PHOTOPLEX is the most effective sunscreen in the UVA wave lengths available today.

2) Wear as much clothing as practical. Always wear a large hat outside the cockpit and at least a tennis hat while flying. Throw those baseball hats away and get a hat which will provide protection for your entire head and neck.

3) Have a clear UV film applied to the windows of your car. This is relatively inexpensive, but will reduce UV exposure while driving. It will also prevent car interiors from deteriorating.

4) Inform the canopy manufacturers and Plexiglas suppliers that a canopy with complete UV protection is important to you. If you would be willing to pay extra for such a product, then certainly make that point known.

It is imperative that we protect ourselves from UV on a daily basis throughout our lives. By starting now, one stands a good chance of avoiding the skin cancer surgery that many long time pilots are now requiring.

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