CIMP
COMMISSION INTERNATIONALE MÉDICO-PHYSIOLOGIQUE
FAI CIMP

President Juergen K Knueppel MD FS

- FAI Medico-Physiological Commission (CIMP)
  - (one of the oldest FAI Technical Commission; >100 years)
  - Human Factors, Medical Regulations
  - Medical Emergency Issues, Anti Doping

- Anti Doping, TUE (waivors), ADAG
  - National Olympic Committee Training
  - Select IGC AD ambassadors

- ICAO / EASA Oxygen: Carriage & Use Issue!
Oxygen Delivery Systems, MWP Klaus Ohlmann, Mount Everest
8800 m, 29,000 ft – 1 Febr 2014

Ohlmann
Basics of Hypoxia in Gen Aviation

easa  Medical Expert Group Meeting
Reference: ICAO Manual of Civil Aviation Medicine (Doc 8984)

Juergen K Knueppel MD
Flight Surgeon

President FAI-CIMP
Medical Commission, World Airsports Federation
Question

• Concerning Oxygen USE?

• What are the current altitude LIMITS for glider flying?
**EAS ISSUE:** General Aviation (GA) Request to easa

a) ICAO rules “copied“ into EASA regulations
   1. -Carry and breathe Oxygen starting at 10,000 ft
   2. -Passengers for 30 min w/o Oxygen up to 13,000 ft
   3. -GA PIC assesses the use of Oxygen at any altitude

d) EASA deleted # 3 during the “copy“ process!

c) GA - EAS requests to revert to ICAO rule
   -EASA GA Safety Strategy admits this kind of move
   -EAS application, arguments, suggestions under review
   -includes risk assessment and other considerations
Figure II-1-3. Barometric pressure and altitude
Atmospheric Air

- non linear pressure reduction -

LUFT
Druckzunahme (oder Abnahme) nicht linear
(in geringen Höhen starke Druckabnahme, in größeren Höhen zunehmend geringere Druckabnahme)
Large Surfaces in the human body improve Oxygen uptake.

The shape of the Red Cells increases surface.

The surface of the Red Blood Cells Size of a Socker Field
Respiration and Circulation

Altitude (feet) vs. pO$_2$ (mm Hg)

- Sea-level: normal O$_2$ - Partial Pressure
- Altitude 10,000: reduced O$_2$ - Partial Pressure
- 34,000: nullified O$_2$ - Partial Pressure

O$_2$ - Deficiency

AIR, Airways, Lungs, Blood, Cell
Effects of hypoxia at different altitudes

2 450 m (8 000 ft): blood oxygen saturation 93 %, reduced night vision

3 050 m (10 000 ft): OX Sat 89 %, („Zugspitze“- FL 100, IFR)
Complex cerebral functions, begin to suffer.

3 650 m (12 000 ft): OX Sat 87 %,
Arithmetical computation difficulties, short-term memory impaired

4 250 m (14 000 ft): OX Sat 83 % impaired
Mental functional intellectual and emotional changes.

4 550 m (15 000 ft): OX Sat 80 %
Serious impairment („Mont Blanc“)

5 500 m volume of gas at sea level doubles at 18 000 ft, 1/2

6 100 m (20 000 ft): OX Sat 65 %
TUC 10 minutes, (TUC, time of useful consciousness, until inability

7 600 m (25 000 ft): blood oxygen saturation below 60 %, TUC 2.5 minutes. DCS
(„Mount Everest“)

9 150 m (30 000 ft): TUC is approximately 30 sec

10 350 m (34 000 ft): TUC 22 sec. (100 % oxygen = 95% OX Sat )

11 300 m (37 000 ft): TUC is 18 sec, Gas Volume 1/5
(„Airliner“)

13 700 m (45 000 ft): TUC is 15 sec, Positive-Oxygen Pressure Breathing
Table II-1-3. Signs and symptoms of hypoxia

<table>
<thead>
<tr>
<th>Subjective symptoms</th>
<th>Objective signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breathlessness; dyspnoea</td>
<td>Hyperpnoea or hyperventilation</td>
</tr>
<tr>
<td>Headache</td>
<td>Yawning</td>
</tr>
<tr>
<td>Dizziness (giddiness)</td>
<td>Tremor</td>
</tr>
<tr>
<td>Nausea</td>
<td>Sweating</td>
</tr>
<tr>
<td>Feeling of warmth about face</td>
<td>Pallor</td>
</tr>
<tr>
<td>Dimness of vision</td>
<td>Cyanosis</td>
</tr>
<tr>
<td>Blurring of vision</td>
<td>Drawn, anxious facies</td>
</tr>
<tr>
<td>Double vision (diplopia)</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Confusion; exhilaration</td>
<td>Bradycardia (dangerous)</td>
</tr>
<tr>
<td>Sleepiness</td>
<td>Poor judgement</td>
</tr>
<tr>
<td>Faintness</td>
<td>Slurred speech</td>
</tr>
<tr>
<td>Weakness</td>
<td>Incoordination</td>
</tr>
<tr>
<td>Stupor</td>
<td>Unconsciousness; convulsions</td>
</tr>
</tbody>
</table>

- dangerous: “**Euphoria** / Increased sense of **well being**
- cave **Hyperventilation**: Exhaling CO², Alcalization of the Blood, **Hypoxic Symptoms**
Oxygen-Saturation Curve

Human blood

Oxygen requirements

100% O₂
Supplemental O₂

Critical Zone
Insufficient Compensation Zone
Full Compensation Zone

(TUC 5 min) (TUC 30 min) (TUC Hours)

Night Vision restricted-
(Safe Without Oxygen)

% O₂

PO2 alveolar kPa mmHg

0 10 20 30 40 50 60 70 80 90 95 100

1.33 (40) 2.67 (20) 4.0 (30) 5.33 (40) 6.67 (50) 8.0 (60) 9.33 (70) 10.67 (80) 12.0 (90) 13.33 (100)

27.000 22.000 18.000 12.000 10.000 0 ft
Bell Distribution Curve of Hypoxic Symptoms

Hypoxic Symptoms, Obvious Start

max permissible threshold

15.000 ft  17.000 ft  19.000 ft
Table of Hypoxia-Effects at different Altitude Levels

- **Critical Threshold**
  - Death
  - Night Vision reduced

- **Potential Failure Threshold**
  - Lethal Zone
  - Unconsciousness
  - Disturbances

- **Reaction Level**
  - 70-65%

- **Full Compensation**
  - 96-98%

- **Lack of Compensation**
  - 65
  - 105

- **Oxygen Saturation**
  - 70-65%
  - 86-90%
  - < 60%
  - 92-95%
  - 96-98%

- **Altitude Levels**
  - 38000 ft
  - 22000 ft
  - 12000 ft
  - 7000 ft

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Hypoxia

Reduced Partial Pressure of Oxygen combined with

- Hypoxic Hypoxia: *Reduced Oxygen*  
  *Altitude*

- Anaemic Hypoxia: *Decreased Hemoglobin*  
  *Smoker*

- Ischaemic Hypoxia: *Reduced Bloodflow*  
  *Heart*

- Histiotoxic Hypoxia: *Tissue Poisoning*  
  *Hydrogen Cyanide*

*(Beispiele:)*
Time of useful consciousness following change from breathing oxygen to breathing air at various simulated altitudes (mean values for 50 subjects), the magnitude of the standard deviation is shown by the length of the vertical bar through each mean. (After Mackenzie, Riesen, Bailey Tahmisian and Crocker, 1945)

Distribution of Hypoxia symptoms at different altitudes
Provence – France, 12,000 ft

aeromednews@t-online.de
Mountaineering: Adaptation possible

FLying: basically no Adaptation!
Pulsoximetry:
- Nonin WristOx
- LCD Display
- 24 hours store
Electronic Oxygen Delivery System(s) (EDS)
Mountain High, USA
EDS - Principle

• \( \text{O}_2 \) on demand: = “BOLUS”
• “Bolus” (on demand)
  • altitude
  • Triggered by inhalation
  • supplied first 0.2 sec
• \( \text{O}_2 \) amount
• Nasal Canula
New Developments

• Small
• On board “SYSTEMs“
• Technically tested

• Puls-Oximeter
• Airlines
• Light Bottles
### Table of Hypoxia-Effects at different Altitude Levels

<table>
<thead>
<tr>
<th>Altitude (ft)</th>
<th>Critical Threshold</th>
<th>Reaction Level</th>
<th>Potential Failure Threshold</th>
<th>Lethal Zone</th>
<th>Critical Zone</th>
<th>Unconsciousness</th>
<th>Zone of Incomplete Compensation</th>
<th>Full Compensation</th>
<th>Performance Decrease</th>
<th>Night Vision reduced</th>
<th>Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>7000</td>
<td>&lt; 60 %</td>
<td>92-95%</td>
<td>86-90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>105</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Zone of Incomplete Compensation</td>
<td>Full Compensation</td>
<td></td>
<td>VOLLE LEISTUNG</td>
<td></td>
</tr>
</tbody>
</table>

**Oxygen Saturation**

- pO₂ (mmHg) Atmosphäre
  - 0: 96-98%
  - 38000: 86-90%
  - 7000: 92-95%
  - 12000: 86-90%
  - 22000: 70-65%
  - 38000: < 60 %

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Ohlmann
Roadmap for EASA GA -APPLICATION

-are there any known problems? -cave overregulation!

-individual adaptation at elevated airfields -FAI-WCC

-less stringent EASA GA are rules possible! -GA Strategy

-statistical risk assessment, third party risks?

-aeroclub guidance, education, self control

-economical, technical, logistic burden -grandfather rights

-NAC advise on safe operation up to 15.000 ft

-development-plan of additional GA concept

-“mandatory brief, education, specialist advise“

-awareness training, pulse oximeter use -developments
Roadmap for EASA GA - APPLICATION

- **less stringent** EASA GA are rules possible!

- **are there problems?**
  - cave overregulation! statistical risk assessment, third party risks?

- economical, technical, **logistic burden?** grandfather rights

- aeroclub guidance, education, self control
- safe operation up to 15,000 ft
- plan additional GA concept “mandatory briefs, education, spec.t advise“
- pulse oximeter use - developments
way forward

• FAI IGC be aware of this problem
  (valid starting 2016, political level)

• Europe Airsports (EAS) ist working on it

• Application to EASA
  – (EASA General Aviation Flight Safety Strategy!)
  – Under way to revert to ICAO recs
    • dubious outcome!
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