V-22 Osprey: High Altitude Flights

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V-22 Osprey: High Altitude Flights

- **Operational Concerns: To assess following operational concerns associated with physiological and medical status of crew members and passengers when flying in a V-22 Osprey at high altitude for a prolonged time period.**
- **1. Ferry flights up to 2,100 nmi for 8 hours at the altitude of 18,000 to 25,000 ft mean sea level (MSL).**
- **2. Hypothermia at high altitude: A heater in the aircraft maintains a delta temperature of 10 degrees warmer inside than the outside air temperature**
- **3. Due to an unpressurized cabin, requiring oxygen masks during the high altitude flight.**
- **4. High altitude sickness.**

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- **Military Requirements:**
- **Aircraft Cabin without Pressurization (AR 95-1, 8.7, 1 SEP 1997):**

- **1. For military aircraft when the "cabin pressure" is decreased while the altitude is at 14,000 ft, military requirements are to use oxygen supplement.**
- **2. For military free fall such as high altitude parachuting and cargo drops, additional oxygen is provided (liquid or pressurized oxygen cylinders).**
- **3. Flights above 14,000 ft without pressurized cabins significantly increase the risk for decompression sickness (DCS) among personnel.**

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Military Requirements:

- **4. For aircraft crew, on flights above 10,000 feet pressure altitude for more than 1 hour and on flights above 12,000 feet pressure altitude for more than 30 minutes, oxygen will be used (AR 95-1, 8.7, 1 SEP 1997).**
- **5. For aircraft crews and all other occupants, on flights above 14,000 feet pressure altitude for any period of time, oxygen must be used (AR 95-1, 8.7, 1 SEP 1997).**
- **6. For flights above 18,000 feet pressure altitude, oxygen pre-breathing using 100% for not less than 30 minutes at ground level and will continue while on route to altitude (AR 95-1, 8.7, 1 SEP 1997).**

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- Aircraft with Pressurization (AR 95-1, 8.7, 1 SEP 1997):
- 1. In flight, cabin pressure altitude will be maintained at or below 10,000 feet.
- Note: Most commercial aircraft will pressurize to an altitude of 7,000 to 8,000 feet.
- 2. As a minimum, a 10-minute emergency supply of oxygen will be available to all occupants when the aircraft is above 14,000 feet pressure altitude.
- 3. Above 25,000 feet pressure altitude, oxygen masks will be connected and readily available.
- 4. If pressurization is lost in flight above 14,000 feet pressure altitude, descent will be made immediately to a cabin pressure altitude of 10,000 feet or below.

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- **Heating, Ventilation, and Air Conditioning (MIL-STD-1472F):**

- **1. MIL-STD-1472F, 5.8.1.1 and MIL-HDBK-759C, 5.8.1.4.2.2 b: "Heating shall be provided within mobile personnel enclosures used in detailed work or occupied during extended periods of time to maintain interior dry bulb temperature above 10°C (50°F)."**

  " Heating system shall be designed such that hot air discharge is not directed on personnel."

- **2. MIL-STD-1472F, 5.12.6.1: "The crew compartment shall be provided a heating system capable of maintaining temperature above 20°C (68°F) during occupancy when personnel are not wearing Arctic clothing and exposure exceeds 3 hours."**

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- **Heating, Ventilation, and AC Continue:**

- **3. MIL-HDBK-759C, 5.8.1.4.2.2 d: Optimal temperature when wearing Arctic clothing is 1.5 to 7.0°C.**
- **4. For adequate ventilation, see MIL-STD-1472F, 5.8.1.2.**
- **5. For temperature uniformity, see MIL-STD-1472F, 5.8.1.5.**

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- **Definitions of High Altitude (as defined by the ISMM):**
- · **High Altitude: 1,500 – 3,500 m (5,000 – 11,500 ft)**
- · **Very High Altitude: 3,500 – 5,500 m (11,500 – 18,000 ft)**
- · **Extreme Altitude: above 5,500 m**

- **1. Altitude sickness rarely occurred below 2,500 m (8,000 ft).**
- **2. The flight altitude is expressed as Flight Levels (FL). For example, 35,000 ft is flight level 350 or FL 350.**

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- **3. <u>Space-equivalent zone</u>:**

  Begins at FL500 and 100% oxygen supplied under pressure will not protect from hypoxia; sealed cabin or pressure suits required. When reached at FL635, boiling of body when the total barometric pressure is less than the vapor pressure of water at 37°C (47 torr).

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- **Physiological divisions of the atmosphere:**

1. <u>Physiological zone</u>: From sea level to 10,000 ft; no oxygen or special protective equipment required; and ear or sinus difficulties begin during rapid ascents or descents.

2. <u>Physiologically deficient zone</u>: From 10,000 ft to above 50,000 ft (FL500); reduced pressure and oxygen deficiency becomes an increasing problem; supplemental oxygen is required when flying above FL100; trapped gas in the gut tract and evolved gas problems; and thermal protection is required.

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Medical Issues concerning high altitude without pressurization and hypothermia:

1. **Time of Useful Consciousness (TUC): "The period of time from the interruption of the oxygen supply or exposure to an oxygen-poor environment, to the time when useful function is lost." (Ref: USAF Flight Surgeon's Guide, Chapter 2, p 33) At high altitudes, the TUC becomes very short.**

Altitude	TUC
FL180	20 – 30 min
FL 250	3 – 5 min

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Medical Issues:

2. Hypoxia (Oxygen deficiency): Usually acute syndrome, resulting from inadequate oxygenation of tissues secondary to a decreased partial pressure of oxygen in the inspired air. Hypoxia may aggravate into anoxia (an absence of oxygen supply to an organ's tissues although there is adequate blood flow to the tissue).

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Medical Issues:

Hypoxic hypoxia. Specific causes are:

- **A reduced alveolar partial pressure due to reduced atmospheric pressure.**
- **Decreased pulmonary ventilation from any cause.**
- **Pneumonia.**
- **Obstruction of air passages by tumors or strangulation.**
- **Admixture of fully oxygenated blood with venous blood.**

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Medical Issues:

Factors influencing acute hypoxic hypoxia:

- **High altitude**
- **Rate of ascent**
- **Ambient temperature**
- **Physical activity**
- **Individual factors such as inherent tolerance, physical fitness, emotional state, and acclimatization.**
- **Hypercapnic hypoxia (carbon monoxide uptake among tobacco smokers)**
- **Histotoxic hypoxia (the effects of alcohol)**
- **Stagnant hypoxia (reduced blood flow)**

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Medical Issues:

Clinical signs and symptoms of hypoxia: Hyperventilation (increased rate of respiration) and depth or both; hypocapnia (decreased carbon dioxide), which leads to respiratory alkalosis (blood is alkaline). The signs and symptoms of hypoxia and anoxia are (NINDS, 2001):

- **Cyanosis**
- **Mental confusion, hallucination, seizures, memory loss (amnesia)**
- **Poor or impaired judgment and performance (for one to two hours after severe hypoxia)**
- **Loss of muscle coordination (“stiffening”, myoclonic jerks, and generalized muscular tetany when partial pressure of carbon dioxide is reduced to 24-30 torr).**

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- Unconsciousness, stupor or comatose
- Cerebral tissue euphoria (an exceptional feeling of well being) or belligerence
- Air hunger or oxygen wants
- A felling of apprehension
- Headache
- Dizziness
- Fatigue
- Nausea
- Hot and cold flushes
- Blurred vision
- Tunnel vision
- Tingling
- Numbness

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- Anoxia (without or no oxygen)
- Prevention and treatment of hypoxia (FM 3-04.301, 2-94):
  - Aircraft pressurization
  - Oxygen supplementation
  - Limiting the time at altitude

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Aircraft Pressurization and Decompression:

- · Isobaric Control (The cabin altitude is maintained constant, for example, 8,000 feet while the aircraft ascends to a hypobaric pressure).
- · Without isobaric control of cabin pressure, a rapid ascent from sea level to relatively high altitude causes the risk of increased decompression sickness (DCS) as well as hypoxia as indicated above.
- · Dysbarism (gas expansion induced by hypobaric pressure). This conditions lead to trapped-gas disorders and evolved-gas disorders (DCS or bends or gas embolism).

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Aircraft Pressurization & Decompression:

- DCS is an illness caused by hypobaric (reduced atmospheric) pressure on the body that results in production of nitrogen bubbles within body tissues, similar to bends. These bubbles result in symptoms of DCS, which can cause mild joint pain to right ventricular failure and circulatory collapse, to permanent neurological deficits (paraplegia), and to death.

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- **The following factors and conditions increase a greater incidence of DCS:**

  i. DCS is possible as low as 12,000 feet at an extended period of time of flight.

  ii. Above 21,000 feet pressure altitude, potentially lethal DCS is a virtual certainty unless oxygen discipline is strictly followed and all oxygen equipment functions adequately.

  iii. Increased time at high altitude greatly contributes to an incidence of DCS due to growth of nitrogen bubbles formation.

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DCS:

- **(Venous Gas Emboli, VGE) resulting from tissue nitrogen supersaturation during decompression. In addition to DCS, hypoxia is considered as the primary threat, increasing in severity of symptoms and rapidity of onsets above 18,000 feet.**

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- **DCS:**

  iv. A faster rate of ascent to higher altitude.

  v. Exercise and any additional movement of the limb during altitude exposure.

  vi. Post-flight combat (delayed DCS). For these reasons, personnel exposed to high altitude should be discouraged from strenuous exercise immediately after exposure such as combat operations for 12 hours post-flight.

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- **The most common "bends altitude" is 25,000 feet.**
- **Prevention and Treatment of DCS:**
  - **i. Denitrogenation (reduce nitrogen in tissues and blood) with 100% oxygen for 60 minutes prior to flight. An excess oxygen for a prolong time will develop pulmonary oxygen toxicity (Lorrain-Smith Effect) (Ref: USAF Flight Surgeon's Guide, Chapter 2, p 46). FM 3-04.301, 2-152 requires 100% oxygen for 30 minutes before flights above 18,000 feet in order to denitrogenate 30%.**

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- **Prevention And Treatment of DCS:**

ii. Cabin pressurization should be maintained at a pressure equivalent to an altitude of 10,000 feet or below (FM 3-04.301, 2-153).

iii. Limitations of time at high altitude.

iv. AR 40-8 restricts crews from flying for 24 hours after scuba diving, because DCS onset may occur at 5,000 feet altitude or less.

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4. Hypothermia (The uncontrolled lowing of the core body temperature to below 35°C or 95°F):

- **Atmospheric Temperature at high altitude (USAF flight Surgeon's Guide):**

  i. Temperature decreases linearly with increase in altitude until the isothermal layer begins (35,332 ft under standard condition). The temperature of the isothermal layer is constant at –55°C (-67°F).

  ii. A heat loss rate of 2 degrees C (3.6°F) with each 1,000 feet of altitude.

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Hypothermia:

- **iii. The temperature for some physical properties of the United States Standard Atmosphere. At sea level, the standard pressure and temperature are 760 torr (29.92 in.) and 15°C (59°F).**

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Hypothermia:

iv. Therefore, based upon the STP at the sea level: 760 torr and 15°C and a heat loss rate of 2°C with each 1,000 feet of altitude, temperatures, windchill value, and pressures at 18,000 and 25,000 ft will be:

Altitude (Ft)	Pressure (Torr)	Temperature	Windchill (kcal/m²hr)
Sea level	760	15°C (59°F)	
18,000	379.8	-20.6°C(-5.10°F)	550
25,000	282.40	-34.5°C (-30.0°F)	660

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Hypothermia:

- **As stated in the operational concerns for V-22 Osprey flights at high altitude of FL180 and FL250 for 8-hour flights, a heater, barely maintaining a delta temperature of 10 degree between the inside aircraft and outside, could, at best, maintain the cabin temperature of –10°C at 18,000 feet and –24°C at 25,000 feet. At these temperatures, exposed fresh many freeze within one minute (FM 3-04.301, 6-32). During the 8-hour flights, hypothermia and death would be the major health issue.**

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Hypothermia:

- **Less than 5°C causes a series of health hazards during an extended exposure time:**
  - **Immediate drowning (initial gasp and ensuring uncontrollable hyperventilation)**
  - **Cardiac arrhythmia due to peripheral cold shock**
  - **Loss of function in chilled hands**
  - **Coma due to CNS temperature depression**
  - **Death by drowning or hypothermia cardiac arrest.**

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Hypothermia:

- **At very low temperature, the severity of hypoxia and DCS greatly increase. At about 10°F (-12.2°C), the increase of DCS is about twice as high as it is at 70°F (21°C). At the same time, the severity of symptoms is much more serious in both hypoxia and DCS.**

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Hypothermia:

- **Signs and symptoms:**
  - **Alert and shivering at the core temperature between 90 and 95°F.**
  - **Muscular activity decreases when the core temperature falls below 90°F**
  - **Lethargic at the core temperature around 85°F**
  - **Decreased vital signs at the core temperature around 80°F**
  - **Apparent death at the core temperature below 80°F**

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