# Exploration Life Support

ELS Functions &
Materials Interfaces

# Advanced Life Support Analysis

- Centered around Unit Operations like:
  - Evaporation, Pervaporation, Adsorption, Desorbtion, of both liquids and gases
- Develop White Papers which allow us to take information from the literature and emphasize their applicability to ELS
- Tools include Aspen Custom Modeler which we have used to built a library of Tools and Unit Ops Models

Table 3 - Chemical composition of key materials (Ref 12, 29, 30, 32).

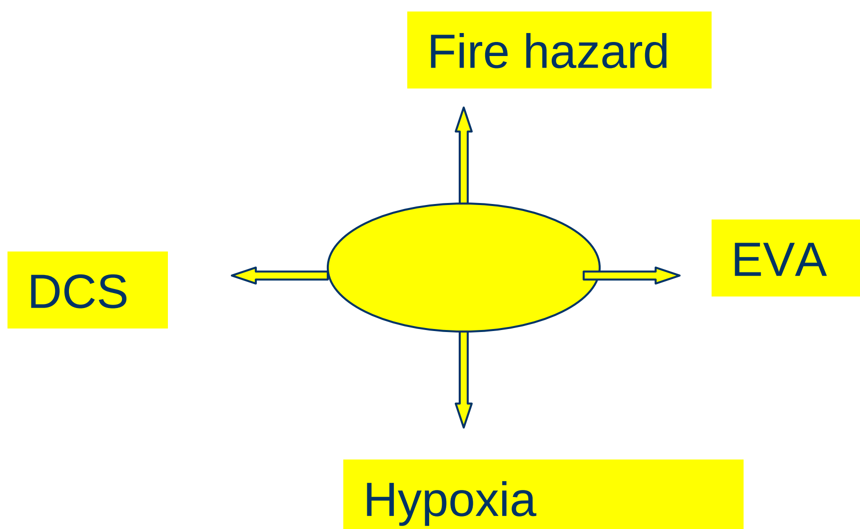
| Material | ID | Atom | Z | A | Atoms/gram | Density g/cm$^3$ |
|---|---|---|---|---|---|---|
| | | | | | | |
| Aluminum 2219 | ALM | Al | 13 | 27 | 2.08E+22 | 2.83 |
| | | Ti | 22 | 48 | 7.53E+18 | |
| | | V | 23 | 51 | 2.18E+19 | |
| | | Mn | 25 | 55 | 3.31E+19 | |
| | | Cu | 29 | 64 | 5.90E+20 | |
| | | Zr | 40 | 91 | 1.19E+19 | |
| | | | | | | |
| Poly-etherimide | PEI | H | 1 | 1 | 2.44E+22 | 1.27 |
| | | C | 6 | 12 | 3.76E+22 | |
| | | N | 7 | 14 | 2.03E+21 | |
| | | O | 8 | 16 | 6.10E+21 | |
| | | | | | | |
| Polysulfone | PSF | H | 1 | 1 | 3.00E+22 | 1.24 |
| | | C | 6 | 12 | 3.68E+22 | |
| | | O | 8 | 16 | 5.45E+21 | |
| | | S | 16 | 32 | 1.36E+21 | |
| | | | | | | |
| Poly-ethylene | PET | H | 1 | 1 | 8.60E+22 | 0.92 |
| | | C | 6 | 12 | 4.30E+22 | |
| | | | | | | |
| Water | | H | 1 | 1 | 6.69E+22 | 1.00 |
| | | O | 8 | 16 | 3.34E+22 | |
| | | | | | | |
| Food (Molasses) | | C | 6 | 12 | 2.01E+22 | 1.48 |
| $C_6H_{12}O_6$ | | H | 1 | 1 | 4.01E+22 | |
| | | O | 8 | 16 | 2.01E+22 | |
| | | | | | | |
| Carbohydrate | CHO | C | 6 | 12 | 2.01E+22 | 0.81(granulated sugar) |
| $C_6H_{12}O_6$ | | H | 1 | 1 | 4.01E+22 | |
| | | O | 8 | 16 | 2.01E+22 | |
| | | | | | | |
| Fat | | C | 6 | 12 | 3.76E+22 | 0.93(Crisco) |
| $C_{16}H_{32}O_2$ | | H | 1 | 1 | 7.53E+22 | |
| | | O | 8 | 16 | 4.70E+21 | |
| | | | | | | |
| Protein | | C | 6 | 12 | 2.90E+22 | 0.93(gelatin) |
| $C_4H_5ON$ | | H | 1 | 1 | 3.63E+22 | |
| | | O | 8 | 16 | 7.26E+21 | |
| | | N | 7 | 14 | 7.26E+21 | |
| | | | | | | |
| Fiber | | C | 6 | 12 | 2.23E+22 | |
| $C_6H_{10}O_5$ | | H | 1 | 1 | 3.72E+22 | |
| | | O | 8 | 16 | 1.86E+22 | |
| | | | | | | |
| Lithium Hydride | LIH | H | 1 | 1 | 7.53E+22 | 0.82 |
| | | Li | 3 | 7 | 7.53E+22 | |
| | | | | | | |
| Liquid methane | LME | H | 1 | 1 | 1.51E+23 | 0.47 |
| | | C | 6 | 12 | 3.76E+22 | |
| | | | | | | |
| Graphite nanofibers | GNF | H | 1 | 1 | 4.04E+23 | 2.25 |
| | | C | 6 | 12 | 1.63E+22 | |
| | | | | | | |
| Liquid hydrogen | LH2 | H | 1 | 1 | 6.02E+23 | 0.07 |

# Summary of Recommendations for Constellation Mission Systems

| Vehicle | Nominal Total Pressure | Nominal Oxygen Partial Pressure (mmHg) [4] | Nominal Oxygen Concentration ( % | Range of Total Pressure Capability | Tissue Ratio ( R ) After 60 Minutes Prebreath |
|---|---|---|---|---|---|
| CEV to ISS | 14.7<br>10.2[5] | 160 ( 0 ft )<br>140 (3500 ft) | 21<br>26.5 | 0-14.9 | |
| CEV In-Space Suit | 4.3 | 222 | 100 | 4.0-4.6 | 1.55 from 10.2 psia CEV to 4.3 psia suit |
| Lunar and Mars CEV | 14.7<br>10.2 | 160 ( 0 ft )<br>140 (3500 ft) | 21<br>26.5 | 0-14.9 | |
| Lunar and Mars Landers | 10.2<br>8.0 | 140 (3500 ft)<br>132 (5000 ft) | 26.5<br>32 | 0-14.9 | |
| Lunar and Mars Surface Suits | 4.3<br>6.0 | 222<br>310 | 100<br>100 | 3.5-8.0 [2] | 1.13 from 8.0 psia Landers to 4.3 psia suit;<br>1.07 from 7.6 psia Surface Habitats to 4.3 psia suit |
| Lunar and Mars Surface Habitats | 8.0<br>7.6 | 132 (5000 ft)<br>126 (6500 ft) | 32<br>32 | 0-14.9 | |
| Mars Transit | 14.7<br>10.2 | 160 ( 0 ft )<br>140 (3500 ft) | 21<br>26.5 | 0-14.9 | |

**Note 1: Range of total pressure capability covers Earth launch, Earth entry, and contingencies.**
**Note 2: Surface suit 3.5 psia capability for suit emergency operations, 8.0 psia for DCS treatment.**
**Note 3: 60 minute in-suit prebreathe is defined as the time in the suit after purge and leak check until absolute pressure on the body reaches 4.3 psia after a nominal depressurization. Nitrogen is assumed diluent gas.**
**Note 4: All nominal values are centers of control boxes assumed +/-0.2 psia total pressure, +/-2% oxygen.**

# Exploration Atmospheres



# Events Leading Up to the EAWG

- Data on DCS came mostly from Dr. Johnny Conkin who in turn obtained a good deal of data from Brooks Air Force Base in San Antonio.  Dr Conkin's work is involved with DCS Physiology.
- Our involvement started trying to define the atmosphere necessary for a successful Mars mission which was felt by many to have many EVA's to make it a success.
- Formed a working group led by Dr Don Henninger at JSC where experts in all the associated fields were invited to participate

# Bounding the Spacecraft Atmosphere Design Space for Future Exploration Missions

June 2005

NASA/CR—2005–213689

**Bounding the Spacecraft Atmosphere Design**
**Space for Future Exploration Missions**

*Kevin E. Lange, Alan T. Perka, Bruce E. Duffield and Frank F. Jeng*
*Jacobs Sverdrup ESC Group*
*Houston, Texas*

# Flammable Materials at oxygen enriched atmospheres

- In order for ignition to occur there must be present: oxidizer, fuel, and ignition energy
- A flammable substance in the presence of $O_2$ requires only the necessary energy and combustion can occur
- Materials used in the EVA suit loop for CEV must be evaluated for use in 100% oxygen environments

$P := 7, 7.1 .. 16$

$f(P) := .3 \cdot P$

$y := 3$ $f2(P) := (.3 \cdot P) + .116$

$x := 10.2$ $f3(P) := .3 \cdot P - .116$

$g(P) := 2.7$ $g3(P) := 2.6 + .116$

$g1(P) := 2.5$ $g4(P) := 3.1 - .116$

$g2(P) := 3.44$ $g5(P) := 2.6$

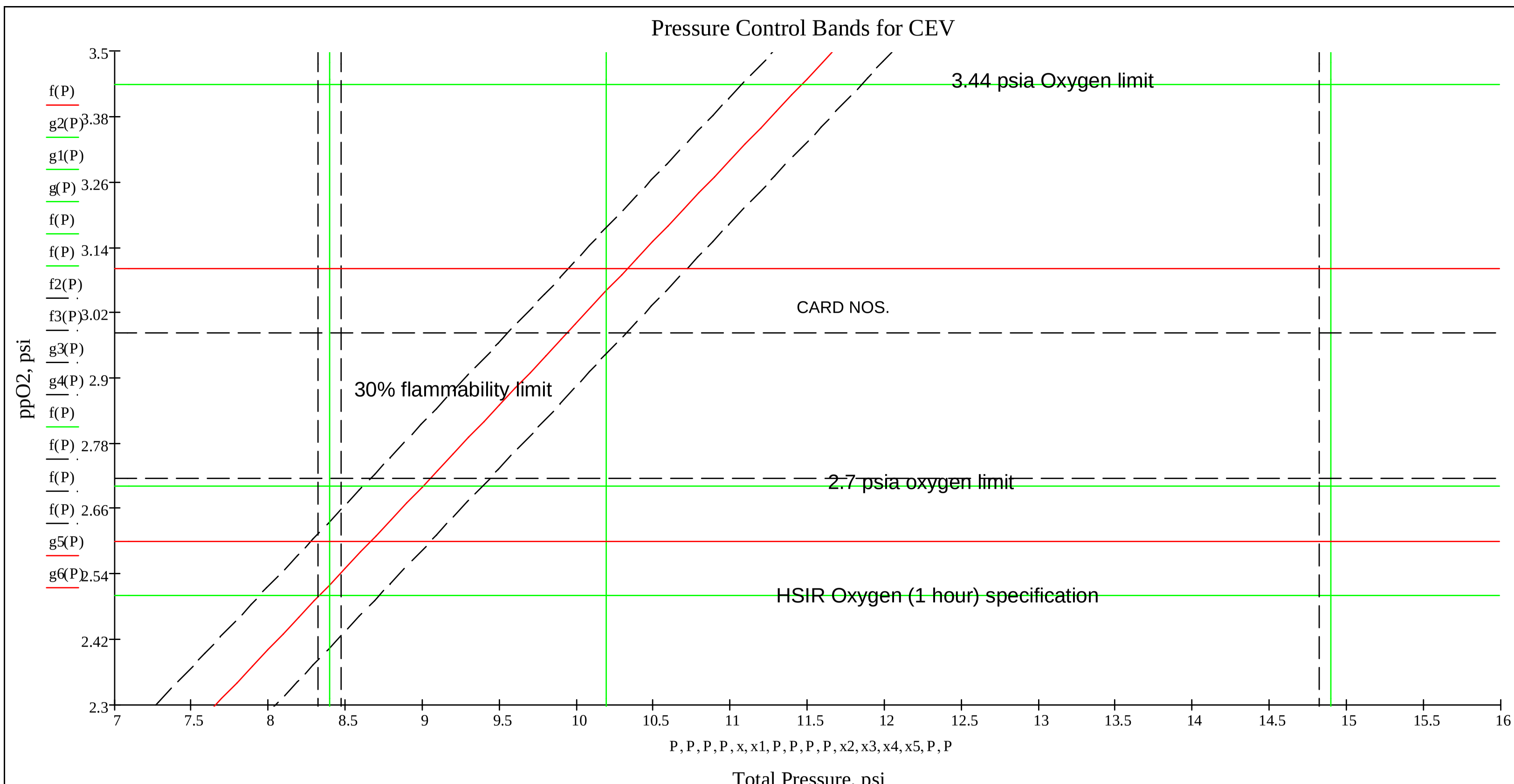
$g6(P) := 3.1$

$x1 := 14.9$

$x2 := 8.4$ $x4 := x2 - .075$

$x3 := x2 + .075$ $x5 := x1 - .075$

All error bands are set at +/- 2% of full scale (5.8 psi) for ppO2 (=0.116 psi) and at =/- 0.5% of FS (30 mV) for total pressure sensor (assumes 15 psi is 30 mV at full scale) per D684-10508, Volume 2, Book 02, Rev C of the ISS ECLS Architecture Description Document. pages 3.2-64 and 3.2-72. According to Kevin Lange the error bands are taken into consideration by the materials experts when the materials are evaluated.



# Design Space Initiated by Lange, et.al. and used by the EAWG