



# EXPLORATION ATMOSPHERE & EVA PREBREATHE PROTOCOL VALIDATION IN THE 20-FOOT CHAMBER

SOFT GOODS IN 34% O<sub>2</sub> 8.2 PSIA ATMOSPHERE

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THE 2020 EXPLORATION ATMOSPHERE & EVA PREBREATHE  
PROTOCOL VALIDATION IS THE FIRST TEST IN >30% OXYGEN  
SINCE THE SKYLAB MEDICAL EXPERIMENTS ALTITUDE TEST.

*48 years later...*



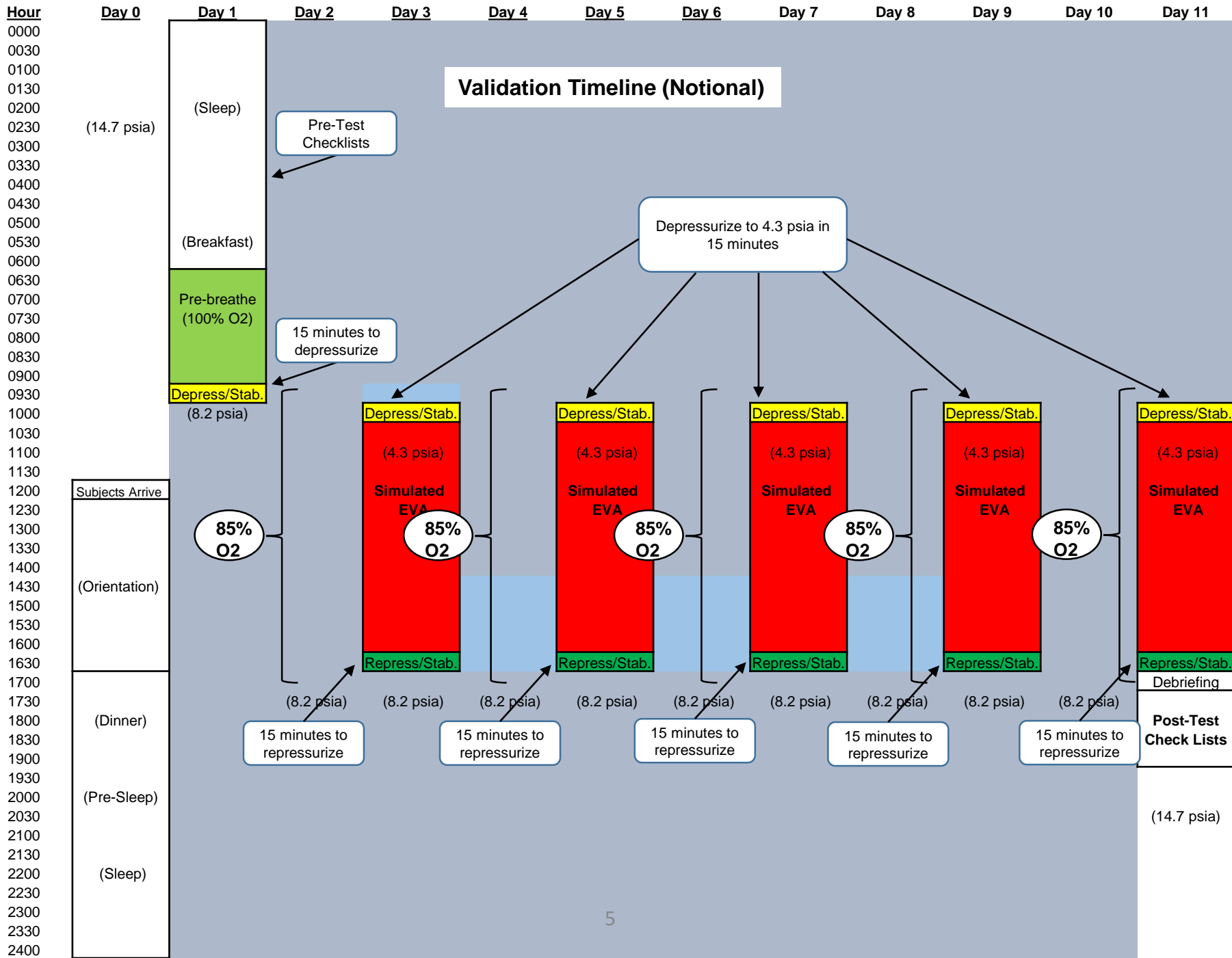
# Approach for the 20-Foot Chamber Exploration Atmosphere Test

- Test Overview
- Test fidelity
- Test atmosphere
- Textiles selection
- Resources
- Flammability risk in middle pressure range
- Verification
- Back-Up Material



# TEST OVERVIEW

- 12-day runs, each with 6 test subjects + 2 Doppler techs
- Timeline:
  - Day 0: Open-door familiarization
  - Day 1: Subjects complete 3-hour mask prebreathe (P/B), then chamber is taken to 8.2 psia and 34% O<sub>2</sub>. Subjects remain at this atmosphere for 48 hours.
  - Day 2: 8.2 psia / 34% O<sub>2</sub> operations
  - Day 3 (EVA Day): Subjects don masks (85% O<sub>2</sub> for test subjects / 100% O<sub>2</sub> for Doppler Techs). Chamber is taken to 4.3 psia for 6-hour EVA simulation. After EVA simulation, chamber is brought back to 8.2 psia / 34% O<sub>2</sub>.
  - Days 4, 6, 8, and 10: 8.2 psia 34% O<sub>2</sub> operations.
  - Days 5, 7, 9, and 11: EVA simulation. Chamber is returned to sea-level on Day 11.





# PREVIOUS HUMAN TESTS IN THE 20-FOOT CHAMBER

## HIGH FIDELITY



SKYLAB Medical Experiment Altitude Test (SMEAT) (56 Days)  
Atmosphere 70% O<sub>2</sub> at 5 psia  
Textiles: Apparel, sleeping bags, pillows, curtains, towels

## LOW FIDELITY

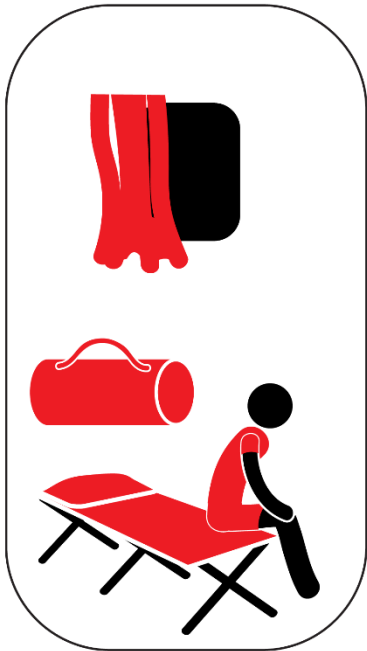


Lunar Mars Life Support Test (30/60/90 Days)  
Tests Ambient Atmosphere  
Textiles: Apparel, sleeping bags, pillows, sound barrier, carpet, towels, wipes

# TEST RESEARCH LEVEL/COMPARISON

## 34% O<sub>2</sub>

Exploration Atmosphere Test  
6 people + 2 medical personnel



Basic necessities, minimal fabrics

## AMBIENT

Orion Atmosphere Test



PPE & clothing

## ?

Hab Atmosphere Test



complex mixture of textiles & hygiene supplies



# APPROACH TO THE SELECTION OF TEXTILES

- Flame Retardant in 34% O<sub>2</sub>
  - Outer layer clothes
  - Sleep station: Flame retardant curtains, sleeping bags, pillows, canvas cots.
- Flame Retardant in 21% O<sub>2</sub>:
  - Hygiene and household products (e.g., towels, wipes, etc.) with short exposure to enriched oxygen atmosphere can be stowed away in flame retardant bags or passed through chamber ports.





# SELECTION OF TEXTILES

- Review past tests in 20-Foot chamber to extract useful information.
- Perform market survey of textile fibers and fabrics that do not ignite in 34% oxygen atmosphere.
- Select textiles for clothing, towels, bedding, and space partitioning.
- Test candidate fabrics: flammability test, abrasion, raveling, lint production, comfort.
- Evaluate cost and lead time to procure finished soft goods.



# FABRICS THEN AND NOW

## SMEAT Fabrics

- Durette 400 (Monsanto Research Corp.)
- Polybenzimidazole (Celanese Corp.)

## Exploration Atmosphere Fabric candidates:

- modacrylic co-polymers (i.e. PyroTex from PyroTex Industries, Protex M from Kaneka Corp.)
- PBI blended fabrics (PBI Performance Inc.)
- P84 polyimide (Evonik Industries)

### Challenges:

Availability of fabrics and finished goods

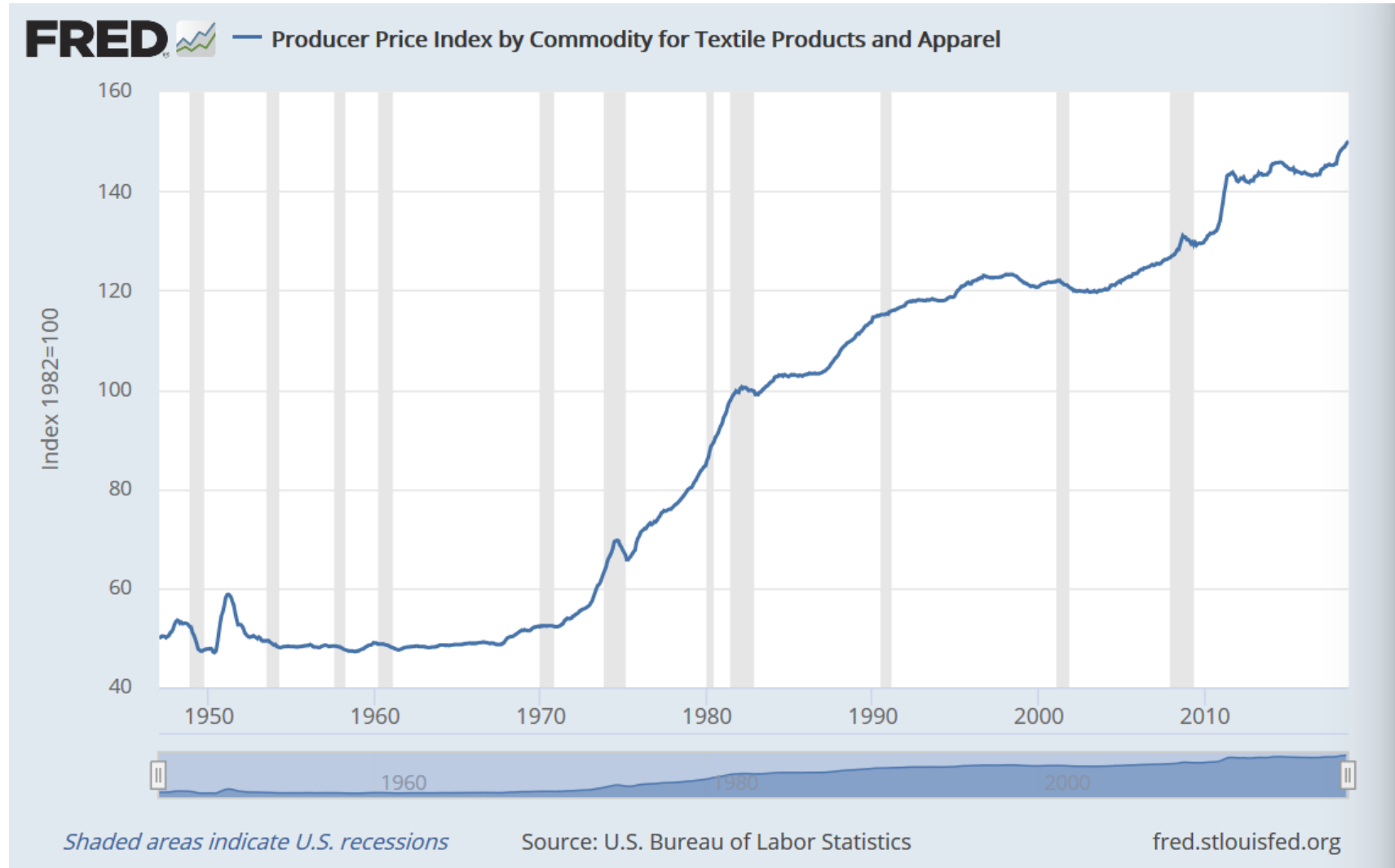
Cost

Verification



## FABRIC DEVELOPMENT COST IN 2018 COMPARED TO COST IN 1969 BASED ON PRODUCER PRICE INDEX

- NASA Contract NAS9-10397 cost \$130,000 in 1969; it would cost \$374,400 in 2018
- Producer Price Index (PPI) by Commodity for Textile Products and Apparel. The PPI in 1969 was ~52 and the PPI in 2018 is ~150.
- The ratio  $150/52 = 2.88$  is the factor by which to multiply the cost in the contract that you have.
- Source: <https://fred.stlouisfed.org/series/WPU03>

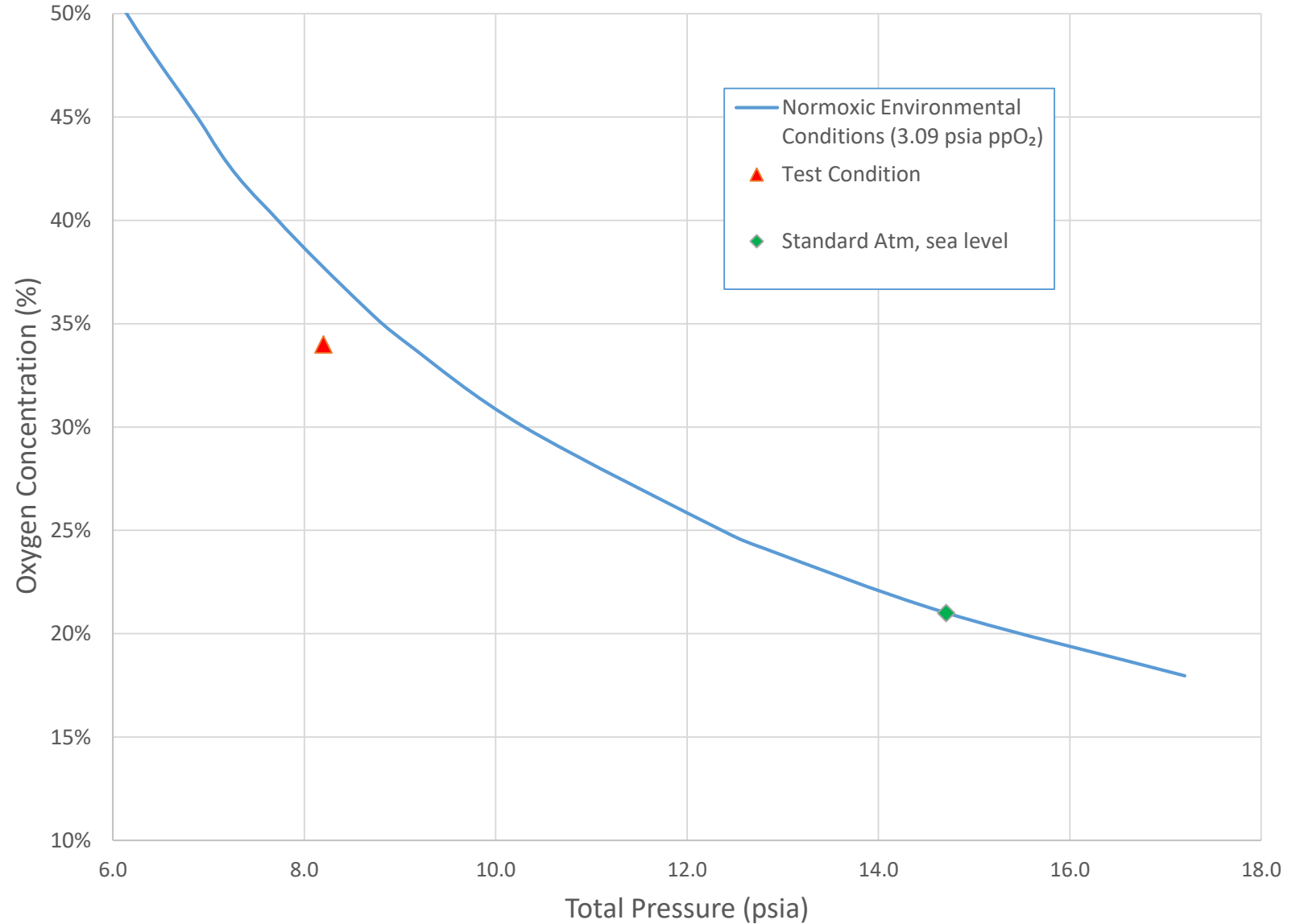




# FLAMMABILITY RISK IN MIDDLE PRESSURE RANGE

Physical Effect: weak convective thermal removal from ignitable domain to the ambient atmosphere

Chemical Effect: so-called “explosion peninsula” as a result of depleting radical consumption due to third-body recombination reaction





# FIRST GATE: LIMITING OXYGEN INDEX TEST

JSC has the in-house capability allowing for considerable cost savings vs. outsource testing to White Sands.

ASTM D2863; BS 2782:141 & ISO 4589-2

This is a widely used, but frequently misinterpreted test which provides a single figure related to ignitability.

Limiting Oxygen Index (LOI) is the per cent concentration of oxygen at which a small specimen will only just burn downwards in a candle like manner. The test is probably the most well-known of the standard fire tests.

The apparatus holds a small specimen of material which is clamped vertically in a tube in an atmosphere where the relative concentration of oxygen and nitrogen can be changed. The aim is to test the flammability of the sample with a small pilot flame to find the minimum oxygen concentration required to just sustain combustion of the sample.





# SECOND GATE: OUTGASSING AND TOXICITY?

While JSC also has the in-house capability to perform outgassing and some toxicity tests, some tests may be done at WSTF to satisfy the JSC Institutional Review Board

# BACK-UP MATERIAL:

## EXCERPTS FROM CONCEPT OF OPERATIONS

# Exploration Atm. & EVA P/B Protocol Validation (Test Conduct)

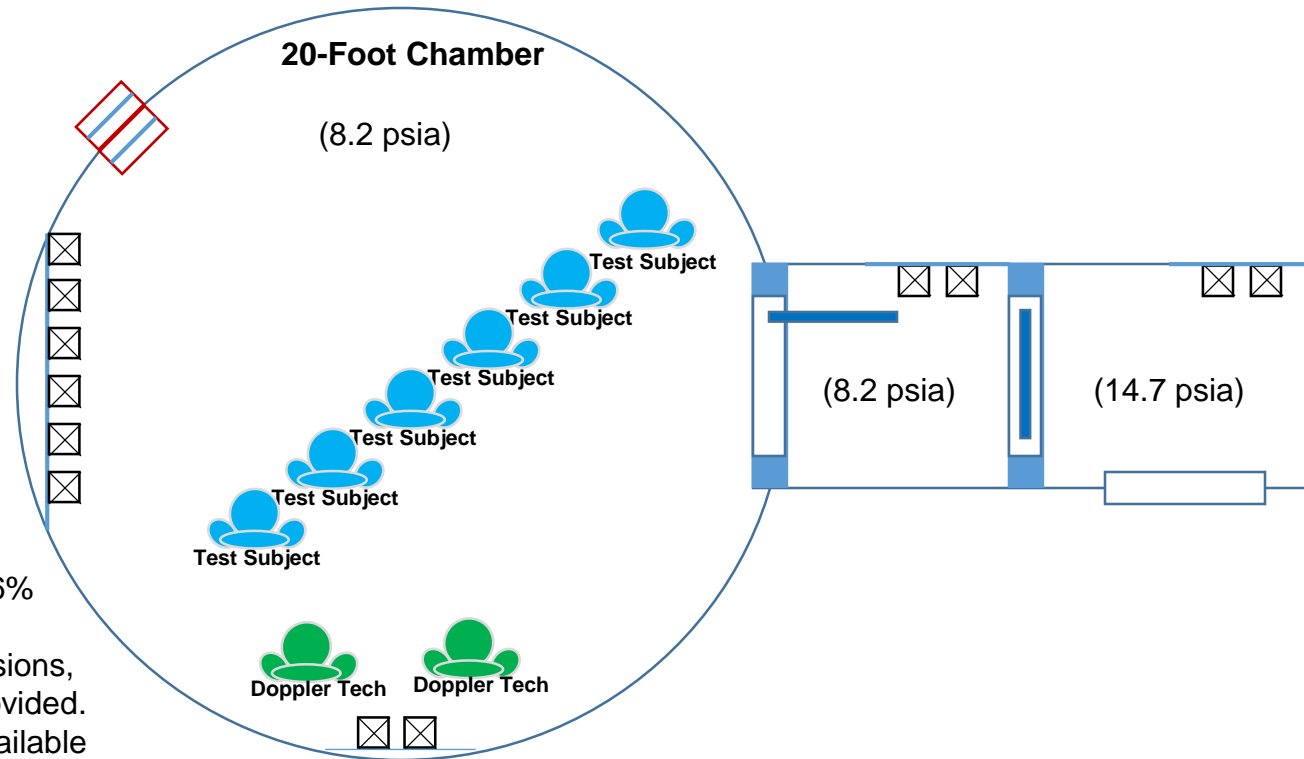
## 6. 48-Hour Period @ 8.2 psia & 34% O2

- Main Chamber
  - Hatch: Open
  - Techs: Masks Off
  - Subjects: Masks Off
- Man-lock
  - Hatch: Closed
  - Techs: N/A
  - Subjects: N/A
- Observer-lock
  - Techs: N/A

Time: Day 1 - Day 3  
1000 – 1000 hours

### Notes:

- Subjects and Doppler Techs remain in this environment for 48 hours between EVAs.
- All materials rated for exposure to 36% O2 and operation at 8.2 psia.
- Exercise, sleep and recreation provisions, including computer workstations, provided.
- Food, water, and other resources available via Man-Lock and / or Transfer Lock. Man-Lock available for crew extraction.
- Full Sink / Shower / Toilet services available.
- 8.2 psia operations include several 'piggy-back' research activities.
- Blood / urine specimens collected during course of evaluation.





# Exploration Atm. & EVA P/B Protocol Validation (Test Conduct)

## 8c. Conduct EVA: EVA Operations

- Main Chamber
  - Hatch: Open
  - Techs: Mask On (100% O<sub>2</sub>)
  - Subjects: Masks On (85% O<sub>2</sub>)
- Man-lock
  - Hatch: Closed
  - Techs: N/A
  - Subjects: N/A
- Observer-lock
  - Techs: N/A

Time: Day 3  
1015 - 1615 hours  
(Time EV: 00:00 –  
06:00 hours)

### Notes:

- 6-hour simulated EVA (max)
- Surface EVA simulation
- Subjects are in 2 groups (A & B).
- Each group runs through a series of tasks (e.g., exercise) at pre-defined intervals.
- Doppler Techs help to coordinate the test activities.
- All materials rated for operation at 4.3 psia (or powered OFF / removed from chamber).
- Facility uses 'purge' operations to manage O<sub>2</sub> concentrations.

