



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

SOFT GOODS IN 34% O₂ 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...



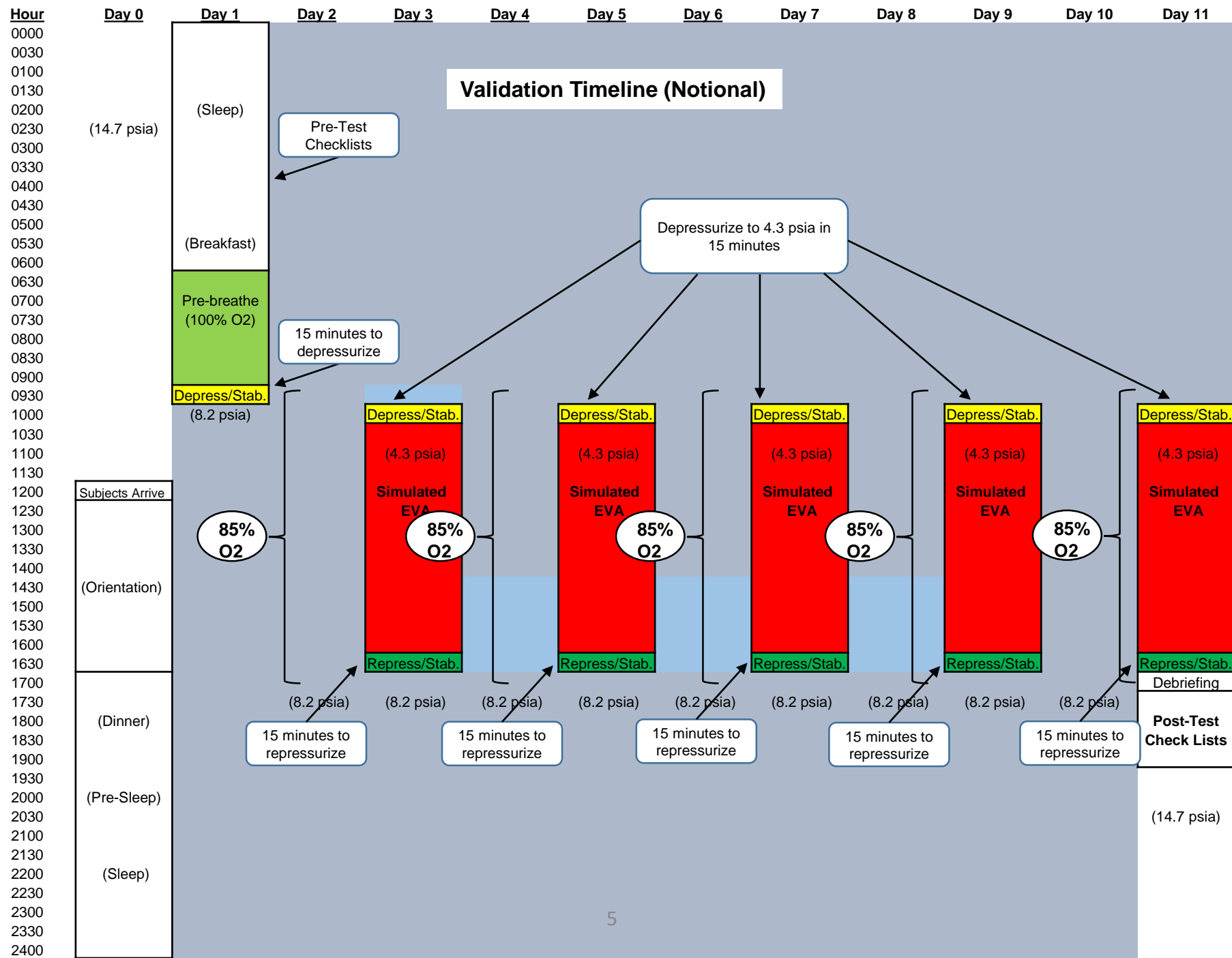
Approach for the 20-Foot Chamber Exploration Atmosphere Test

- 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% O₂. Subjects remain at this atmosphere for 48 hours.
 - Day 2: 8.2 psia / 34% O₂ operations
 - Day 3 (EVA Day): Subjects don masks (85% O₂ for test subjects / 100% O₂ 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% O₂.
 - Days 4, 6, 8, and 10: 8.2 psia 34% O₂ 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% O₂ at 5 psia
Textiles: Apparel, sleeping bags, pillows, curtains, towels

LOW FIDELITY



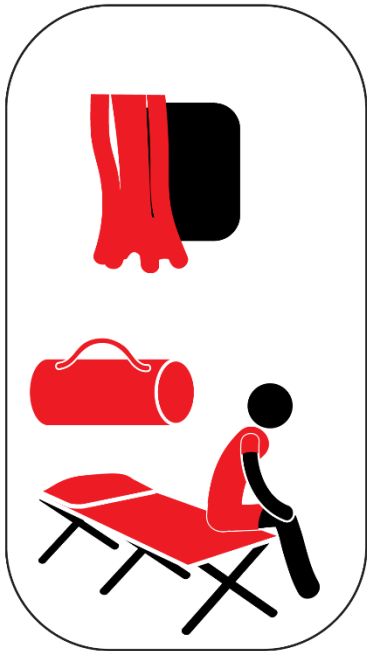
Lunar Mars Life Support Test (30/60/90 Days)
Tests Ambient Atmosphere
Textiles: Apparel, sleeping bags, pillows, sound barrier, carpet, towels, wipes



TEST RESEARCH LEVEL/COMPARISON

34% O₂

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% O₂
 - Outer layer clothes
 - Sleep station: Flame retardant curtains, sleeping bags, pillows, canvas cots.
- Flame Retardant in 21% O₂:
 - 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

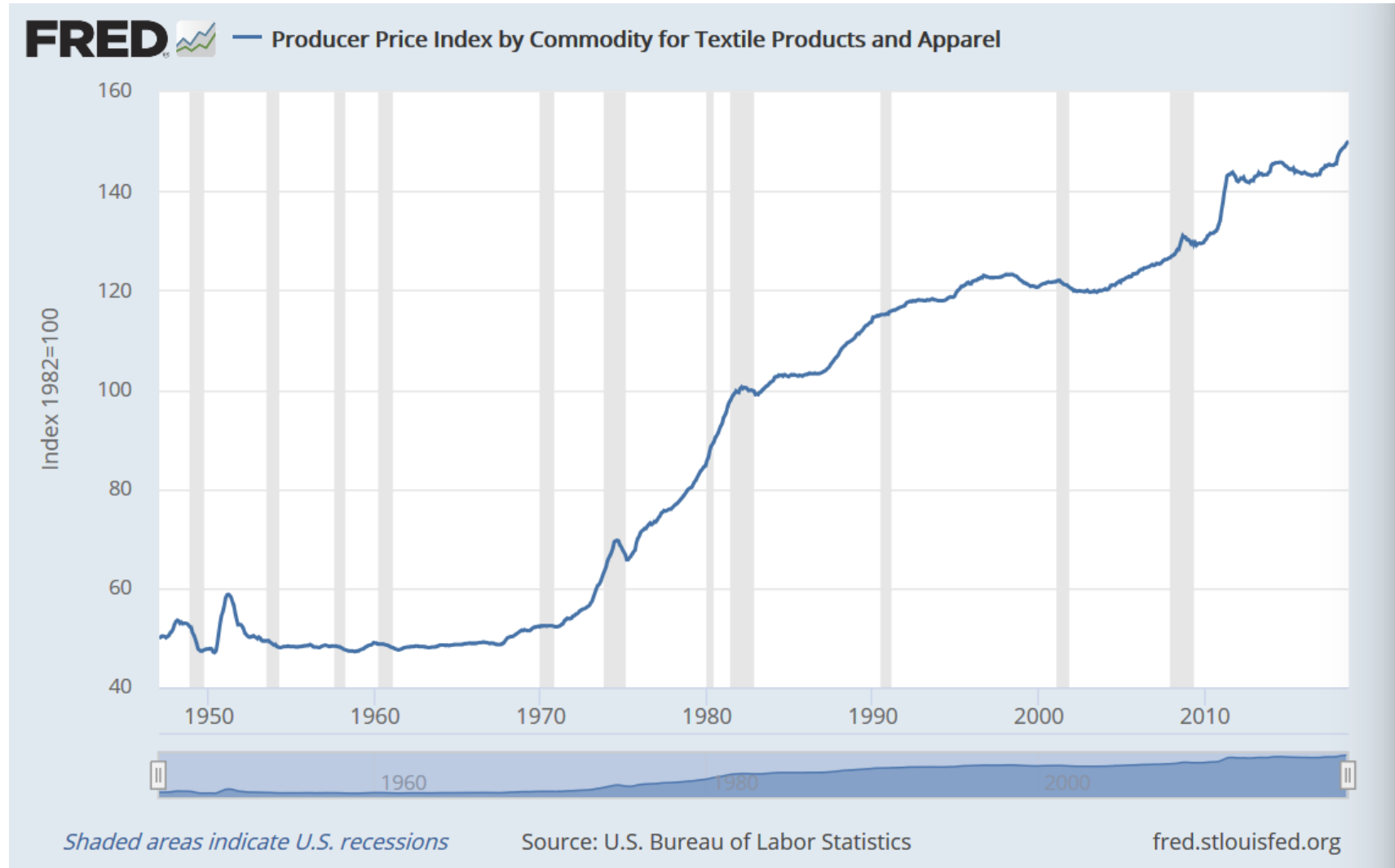
Cost

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>

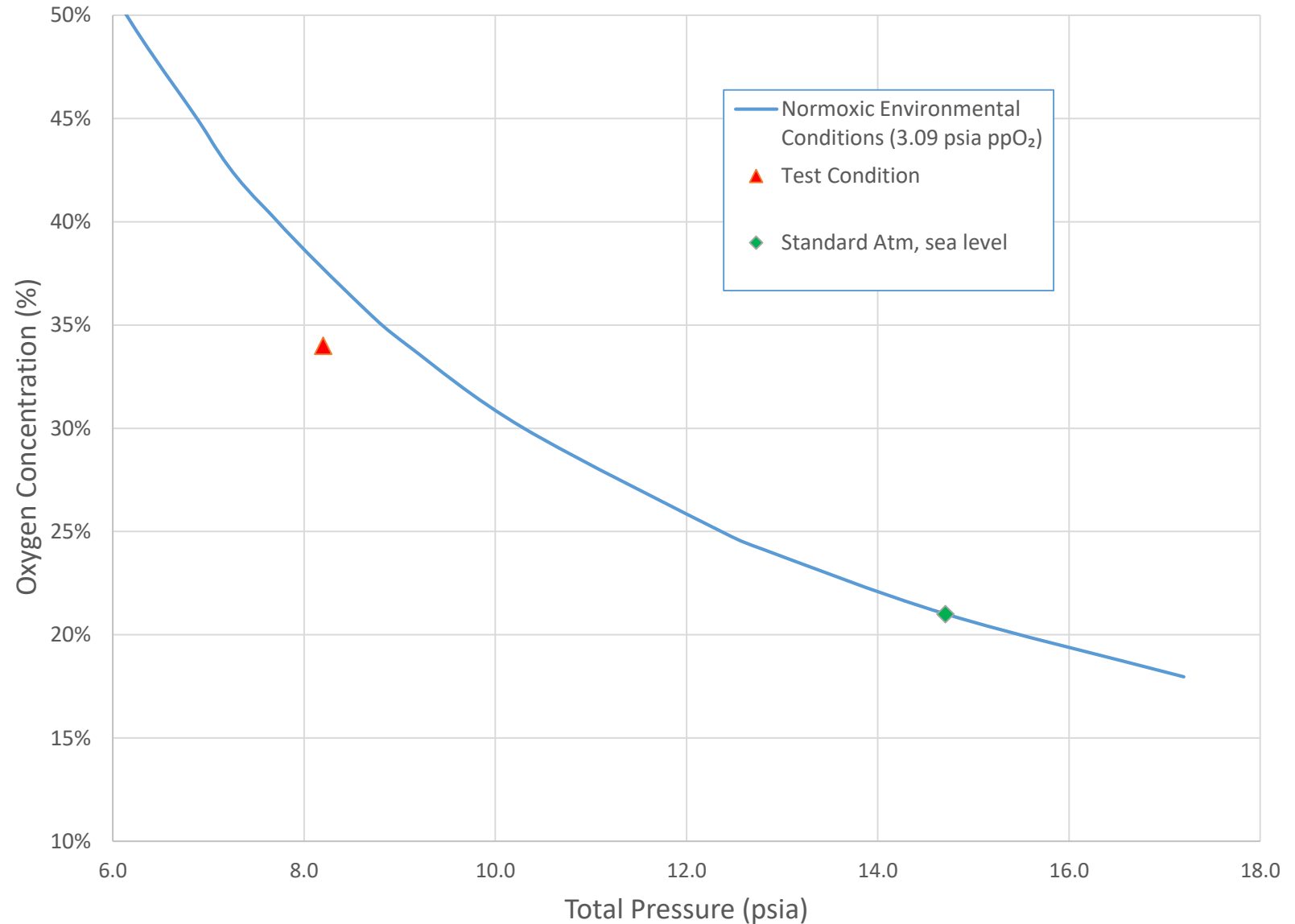




FLAMMABILITY RISK IN MIDDLE PRESSURE RANGE

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)

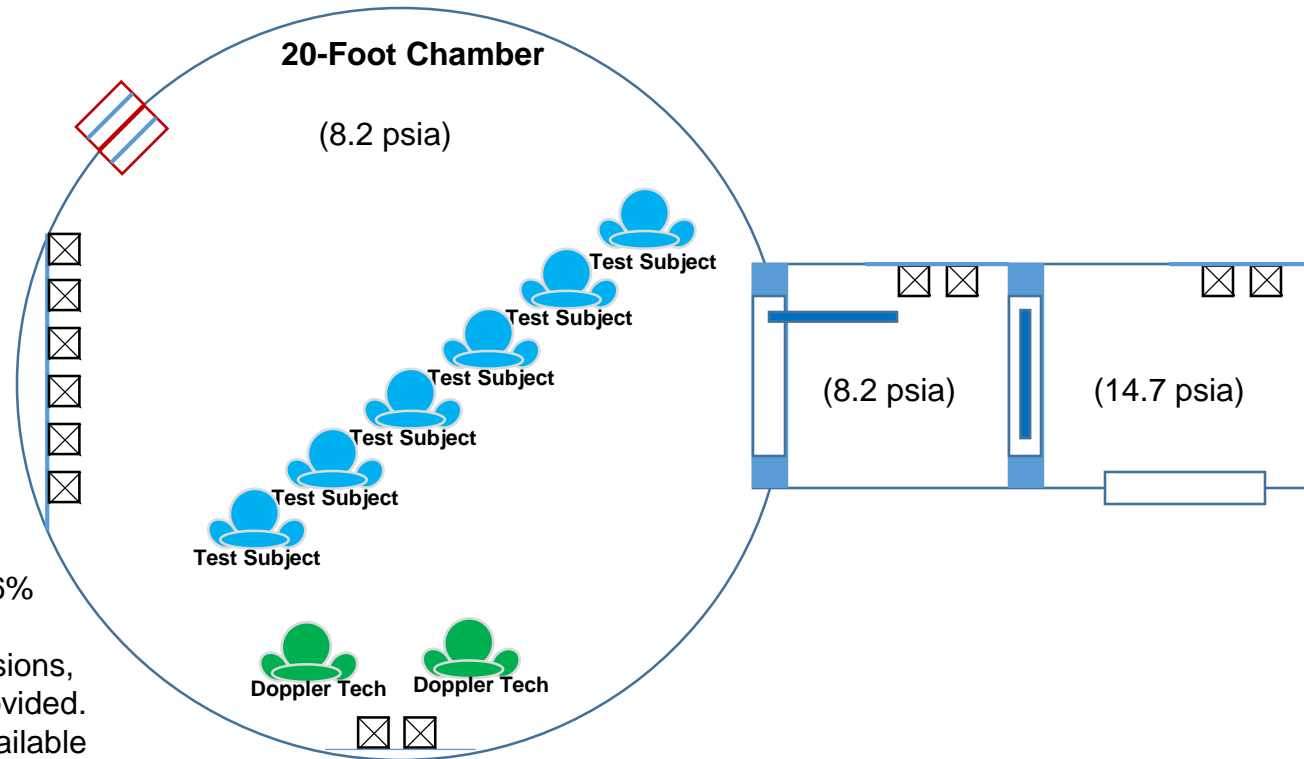
6. 48-Hour Period @ 8.2 psia & 34% O2

- 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% O₂)
 - Subjects: Masks On (85% O₂)
- 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 O₂ concentrations.

