Demonstration Testing for Ground Servicing of the Commercial Crew Vehicle Emergency Breathing Air Assembly

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Overview

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- Flight Requirements
- Constraints
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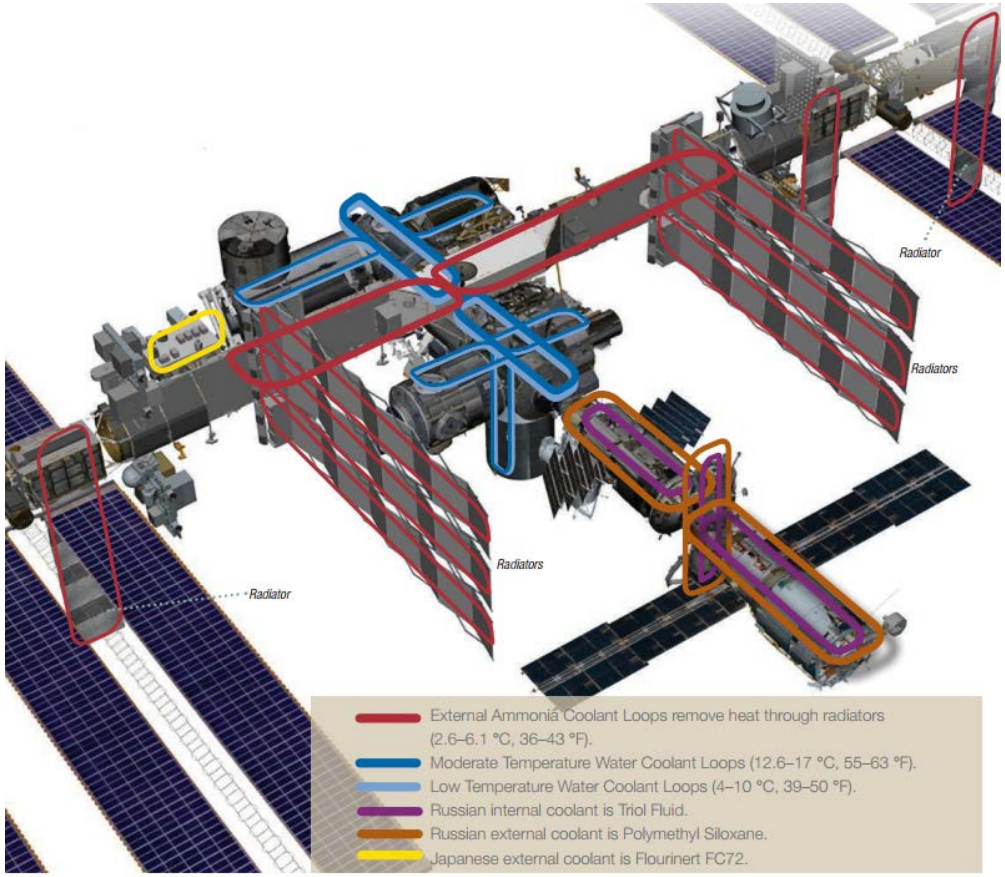
- Test Method
- Test Results
- Conclusion
- Backup

Background

What is CEBAA and why is it needed?

- ISS Temperature regulation uses NH3
- New Capability to support Commercial Crew
- Emergency breathing air for crew evacuation

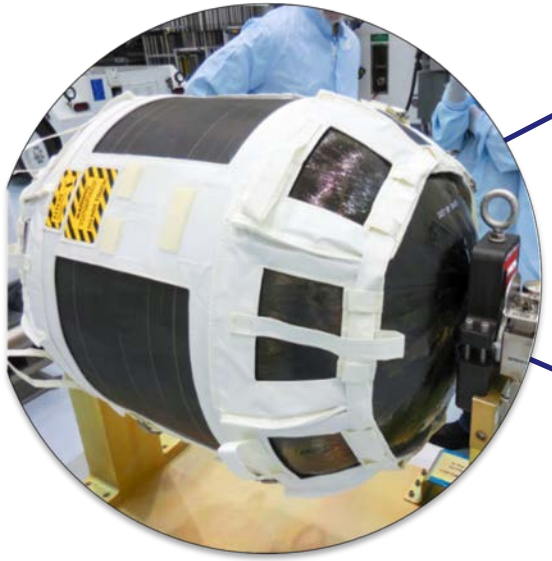


Background

Flight Requirements

- Service a COPV with a specific mixture of breathing air

- Specifications based on:
  - Support five crew
  - Up to one hour breathing time
  - Flammability limits of materials within cabin



Specific Air Composition (GN2/GO2)

Specific Air Quantity (lbm)

Constraints

Budget & Schedule

Utilize existing GO2/GN2 servicing capabilities

First flight servicing potentially within 1 year of requirements development

Use existing GSE

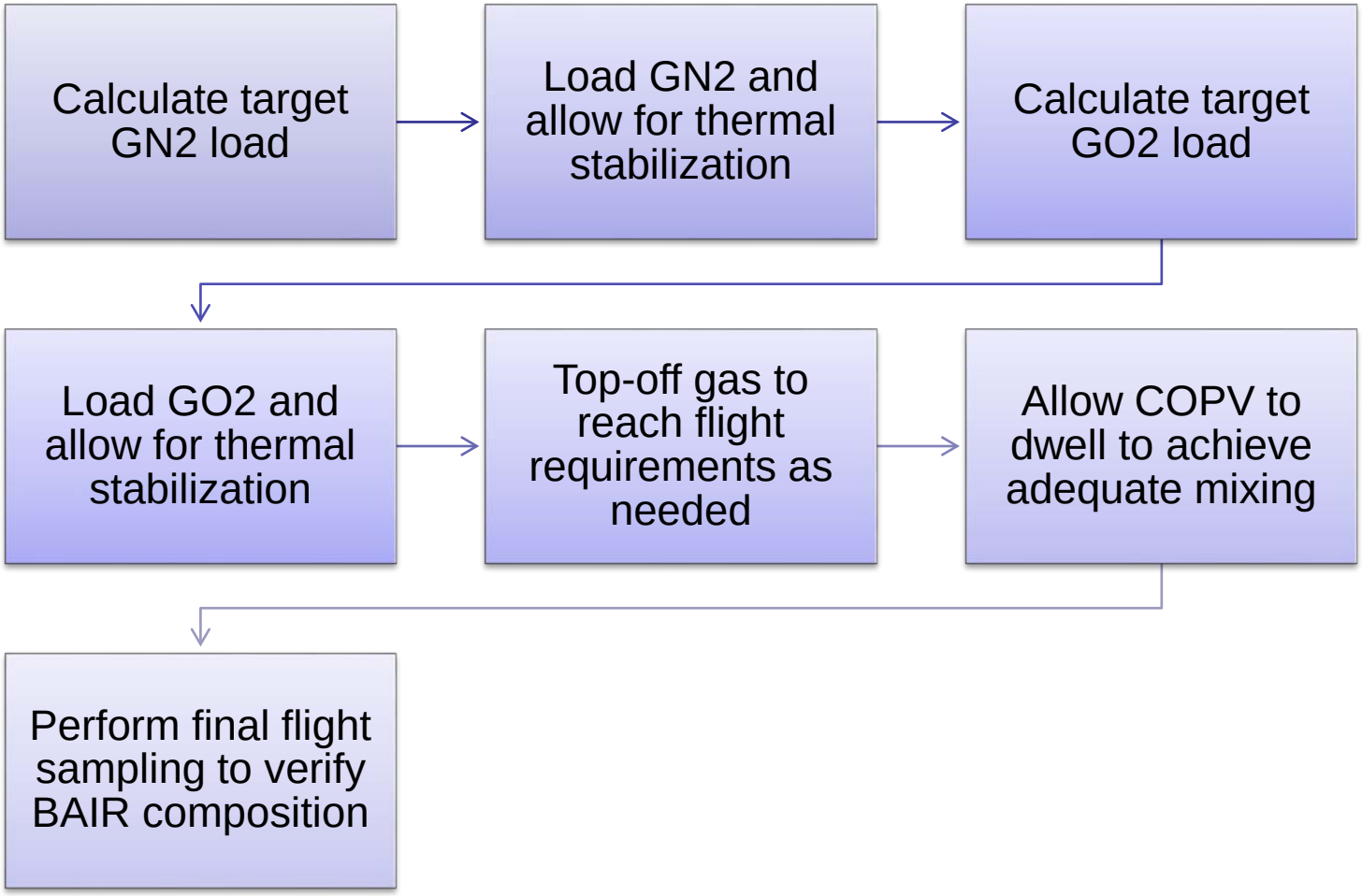
CEBAA can use same GSE as NORS to deliver GO2 and GN2 to ISS

Minimal, if any, GSE modifications

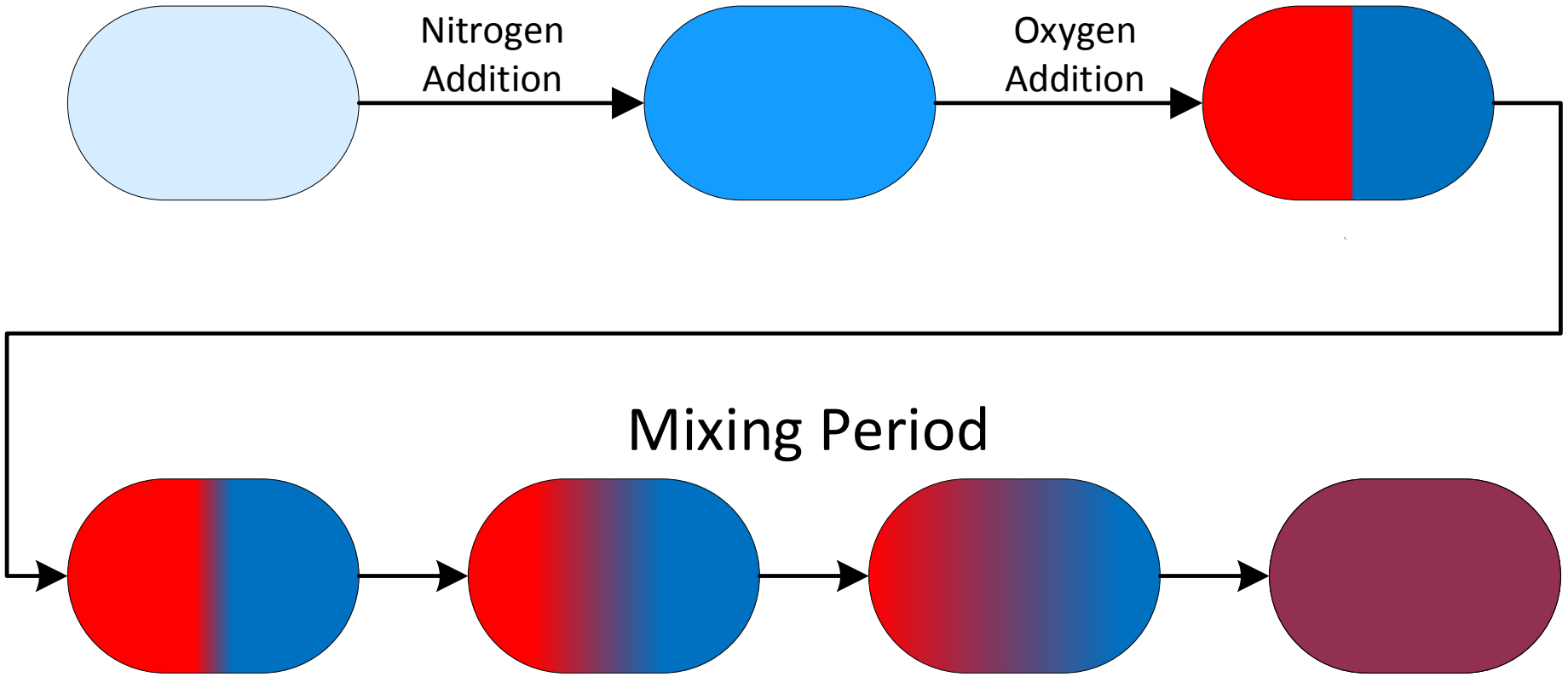
Service gas serially

NORS GSE only allows serial addition of gases to COPV

Proposed Process

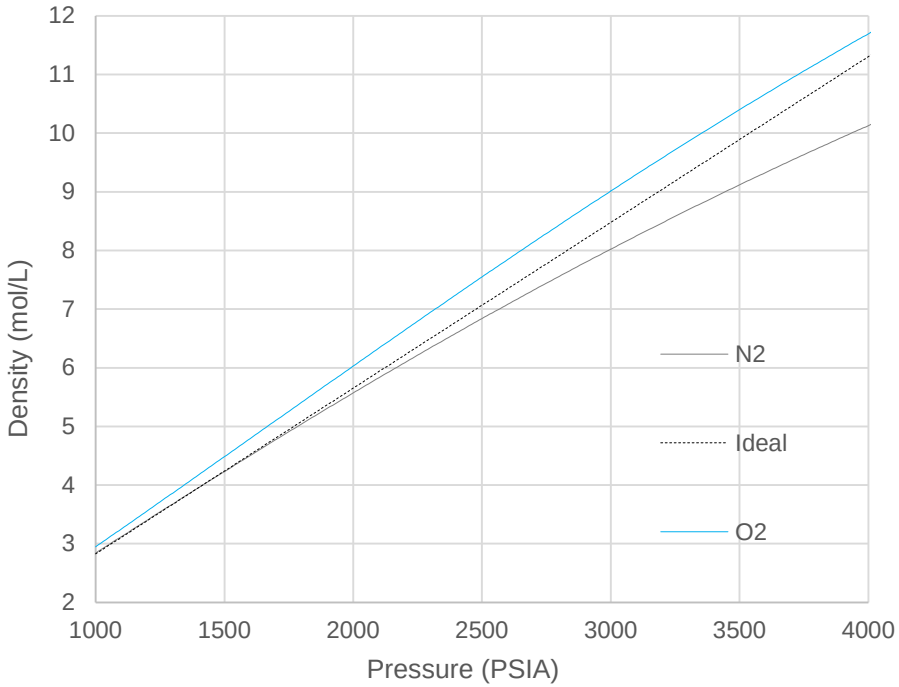


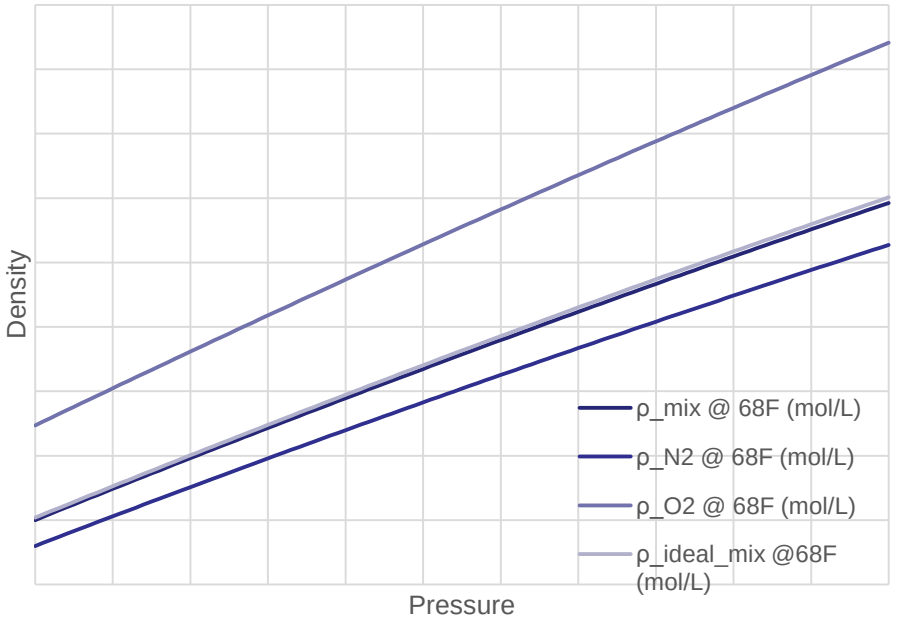
Proposed Process



Assumptions

- Non-Ideal Fluid
- Ideal Mixture
- Temperature-Pressure-Density relationship available from REFPROP





Concerns and Test Objectives

Concern	Test Objective
Reduced diffusivity at high pressure slows mixing	Achieve adequate mixing at high pressure in a reasonable time
Error may prevent ability to meet concentration requirement	Demonstrate that NORS GSE can accurately deliver GN2 and GO2 to meet requirements
Stratification may cause samples to misrepresent tank contents	Show that stratification of gases within the COPV does not persist after fill

Test Method

- Testing broken into two parts: Stratification and Accuracy
  - Same process used in both tests to fill COPV with GN2 and GO2
- Stratification Testing
  - Test for adequate mixing by filling a COPV and collecting a series of purity samples at various pressures
  - COPV weight measurements pre- and post- GN2 and GO2 fill used to corroborate sample results
  - First iteration of testing dwelled over 2 days and increased as necessary based on test results
- Accuracy Testing
  - Three attempts made using proposed process with oxygen concentration analyzed to determine process accuracy
  - One attempt intentionally missed target GO2 to test correction method

Test Results

- Stratification

Trial	Sample 1 O_2 Concentration Deviation from Target (mol%)	Sample 2 O_2 Concentration Deviation from Target (mol%)	Sample 3 O_2 Concentration Deviation from Target (mol%)	Dwell Time (Days)
1	0.78	-0.12	-0.12	2
2	0.03	0.07	0.03	7
3	0.06	0.06	0.16	7
4	0.08	0.08	-0.02	7

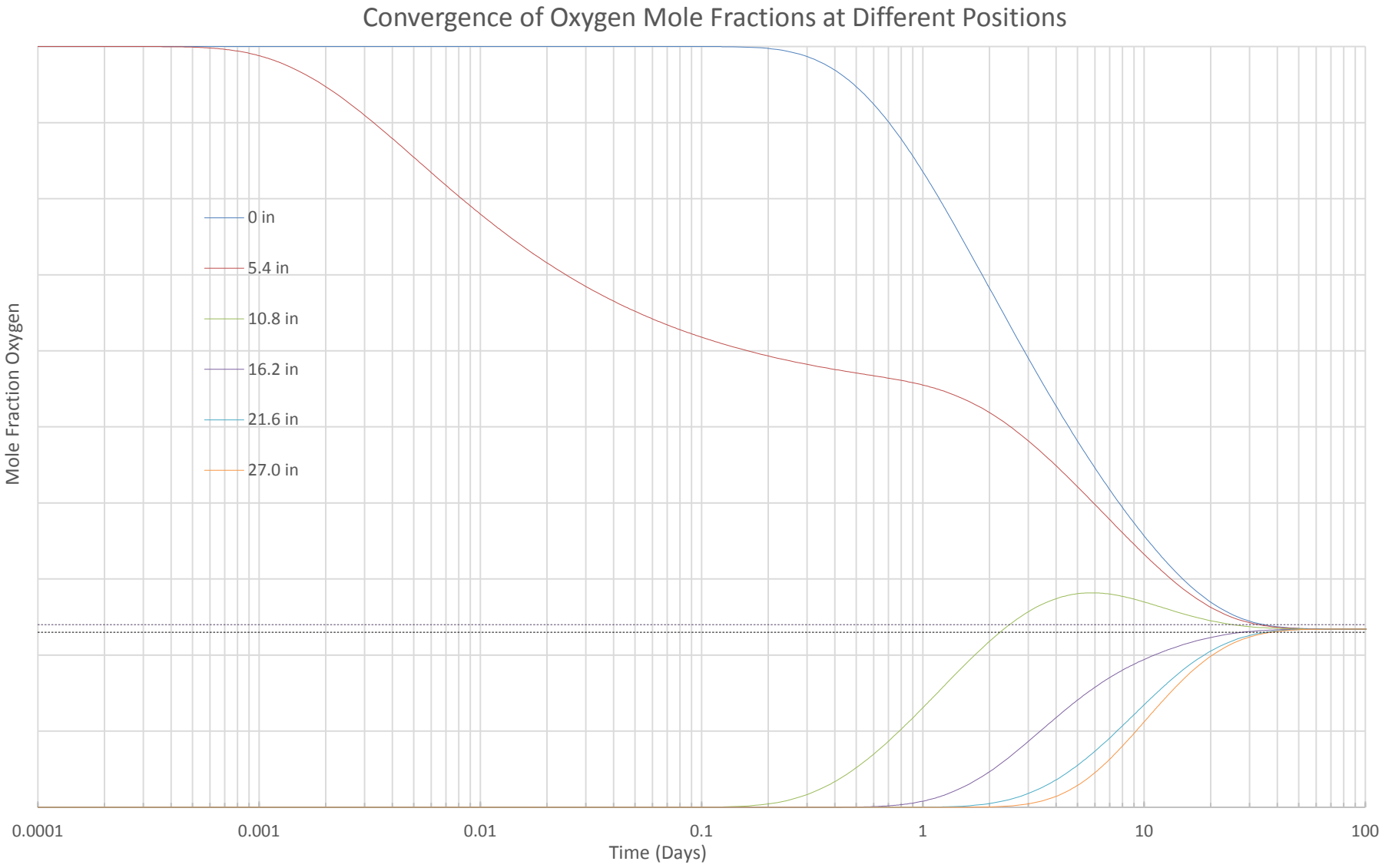
- Accuracy
  - Stratification tests were more successful than predicted, so results were used to validate accuracy objectives

Conclusion

- Testing shows that some stratification does occur as a result of the serial addition of GN2 and GO2
- Testing indicated that GN2 and GO2 mixing in a COPV reaches acceptable mixing levels within 7 days
- Process error is small enough to make the process viable
- NORS GSE is validated for CEBAA processing

Backup

Diffusion Model



Acronyms

BAIR – Breathing Air

CEBAA – Commercial Crew Vehicle Emergency Breathing Air Assembly

COPV – Composite Overwrapped Pressure Vessel

GN2 – Gaseous Nitrogen

GO2 – Gaseous Oxygen

GSE – Ground Support Equipment

ISS – International Space Station

Lbm – Pound (mass)

Mol% - Mole Percent

NH3 – Anhydrous Ammonia

NORS – Nitrogen/Oxygen Recharge System

REFPROP – Reference fluid Properties