



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

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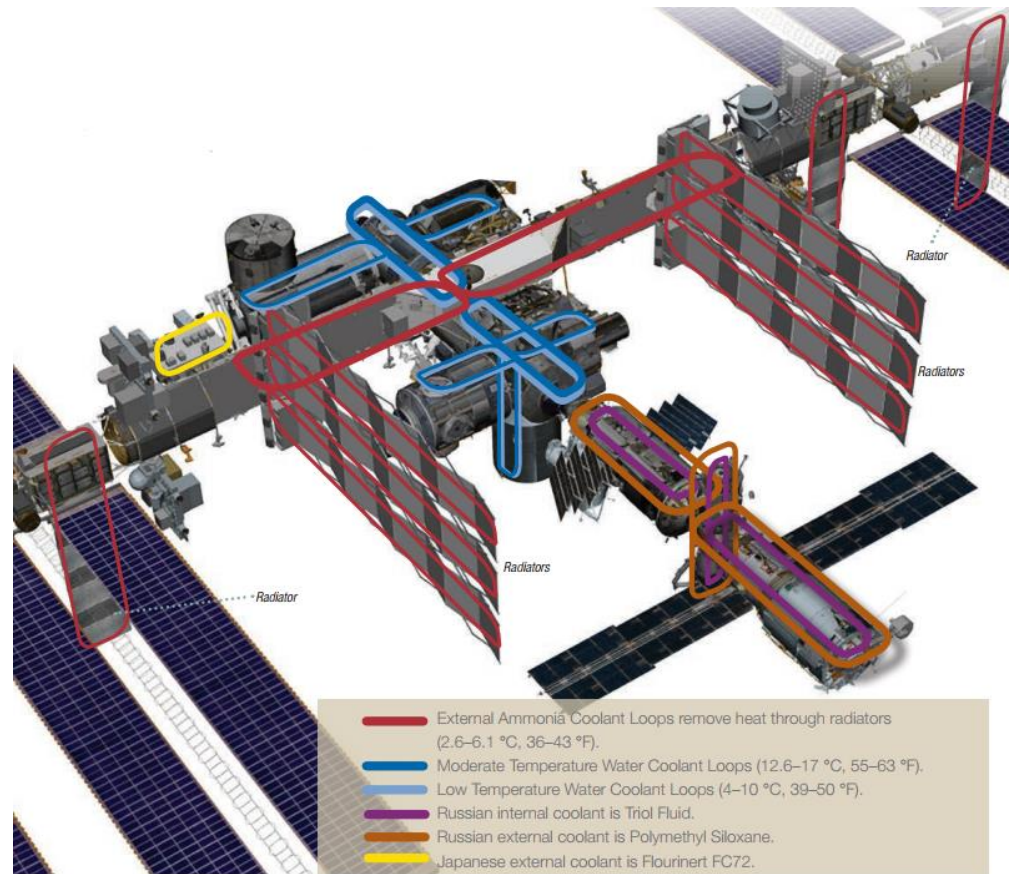
# Overview



- Background
- Flight Requirements
- Constraints
- Proposed Process
- Assumptions
- Concerns and Test Objectives
- Test Method
- Test Results
- Conclusion
- Backup

## What is CEBAE and why is it needed?

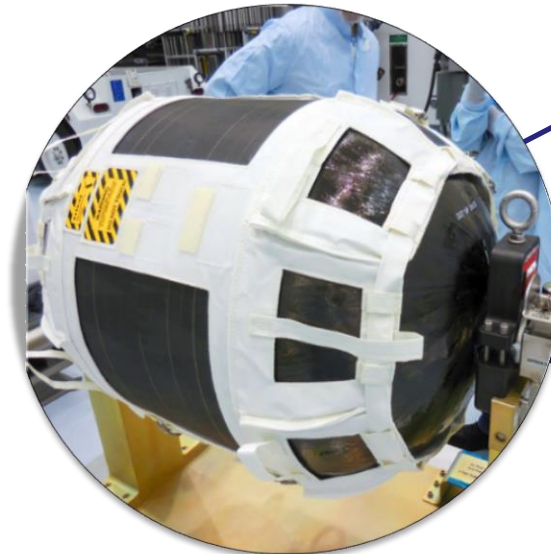
- ISS Temperature regulation uses  $\text{NH}_3$
- New Capability to support Commercial Crew
- Emergency breathing air for crew evacuation



# Background



- 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  
(GN<sub>2</sub>/GO<sub>2</sub>)

Specific Air  
Quantity  
(lbm)

## Budget & Schedule

Utilize existing  
GO<sub>2</sub>/GN<sub>2</sub> servicing  
capabilities

First flight servicing  
potentially within 1  
year of requirements  
development

## Use existing GSE

CEBAA can use same  
GSE as NORS to  
deliver GO<sub>2</sub> and GN<sub>2</sub>  
to ISS

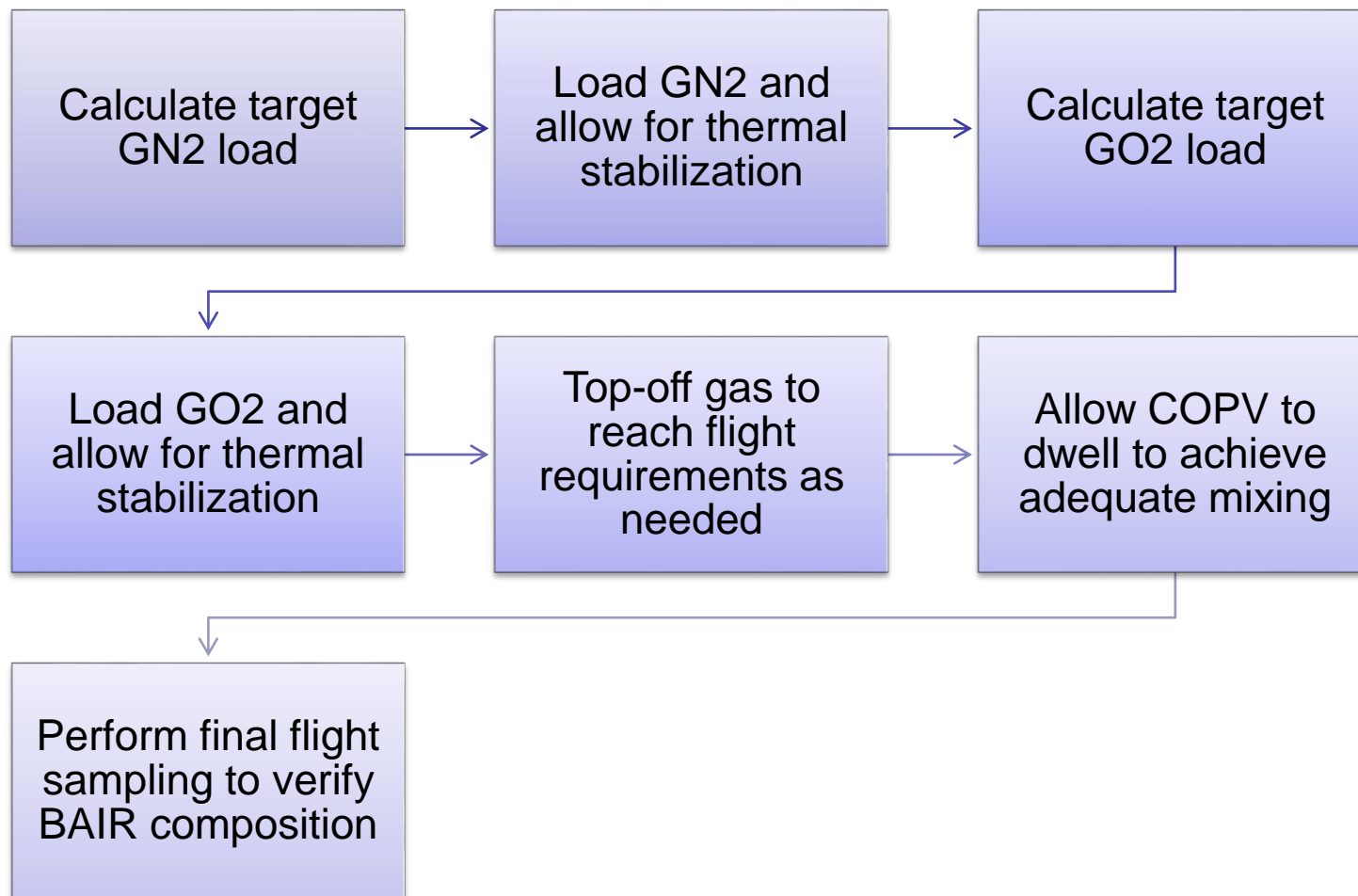
Minimal, if any, GSE  
modifications

## Service gas serially

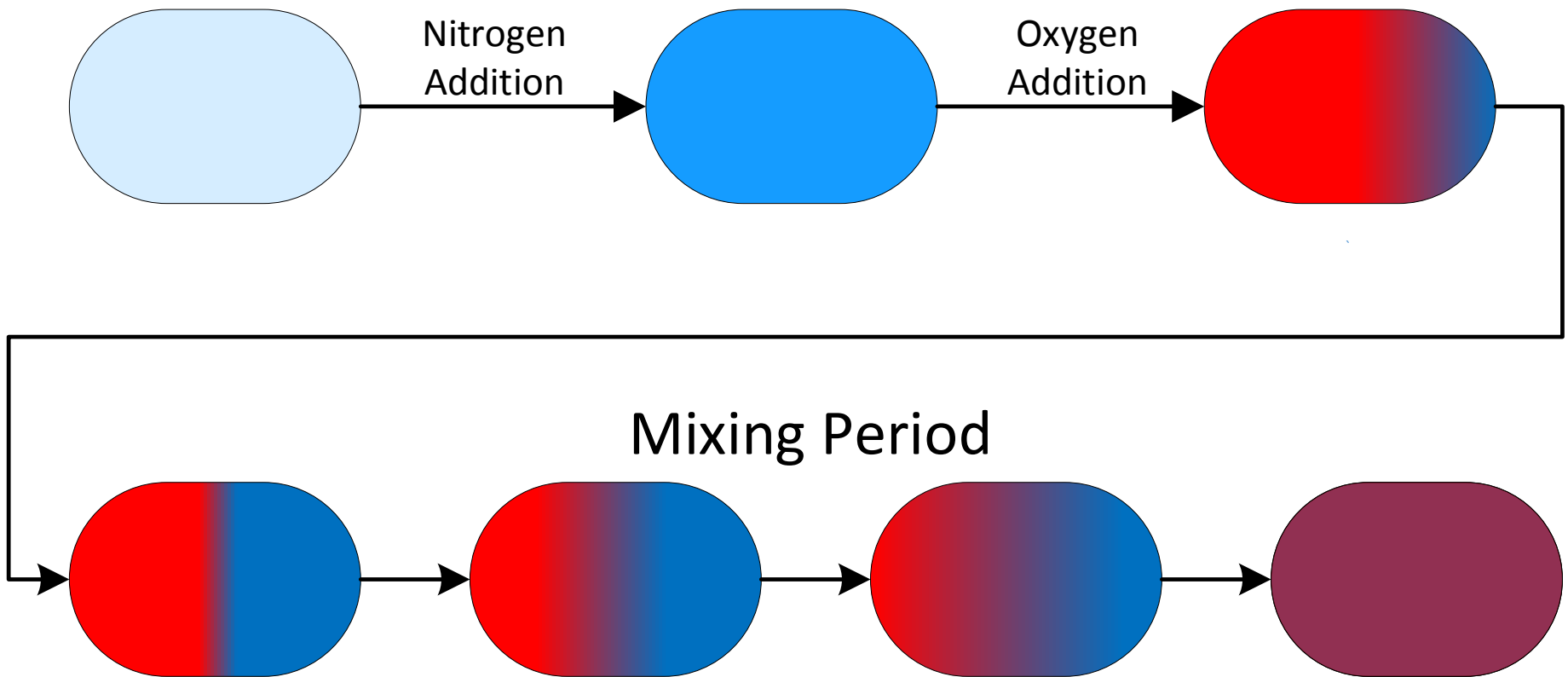
NORS GSE only  
allows serial addition  
of gases to COPV



# Proposed Process

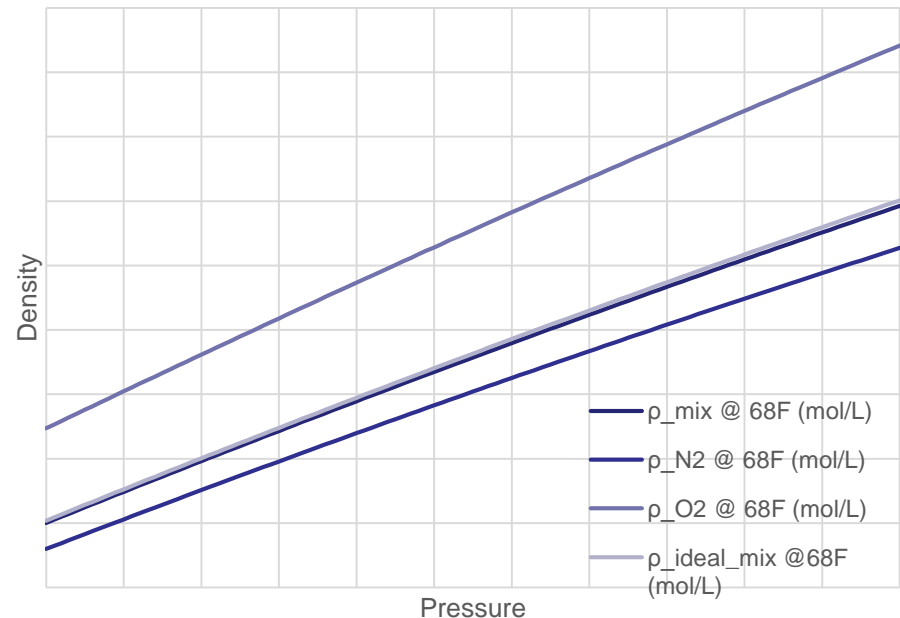
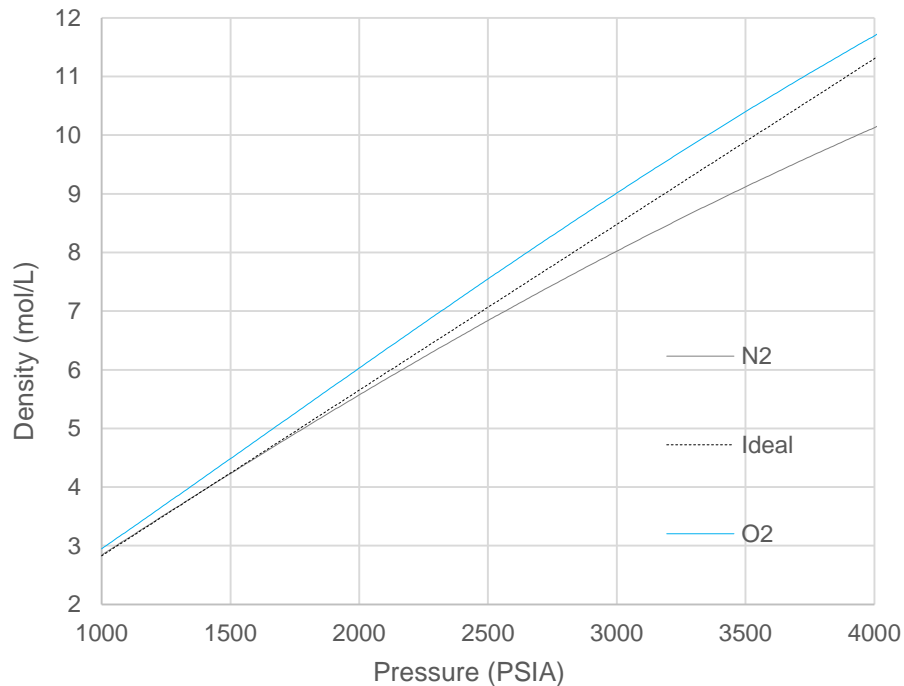


# Proposed Process





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



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

- Stratification

Trial	Sample 1 O <sub>2</sub> Concentration Deviation from Target (mol%)	Sample 2 O <sub>2</sub> Concentration Deviation from Target (mol%)	Sample 3 O <sub>2</sub> 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

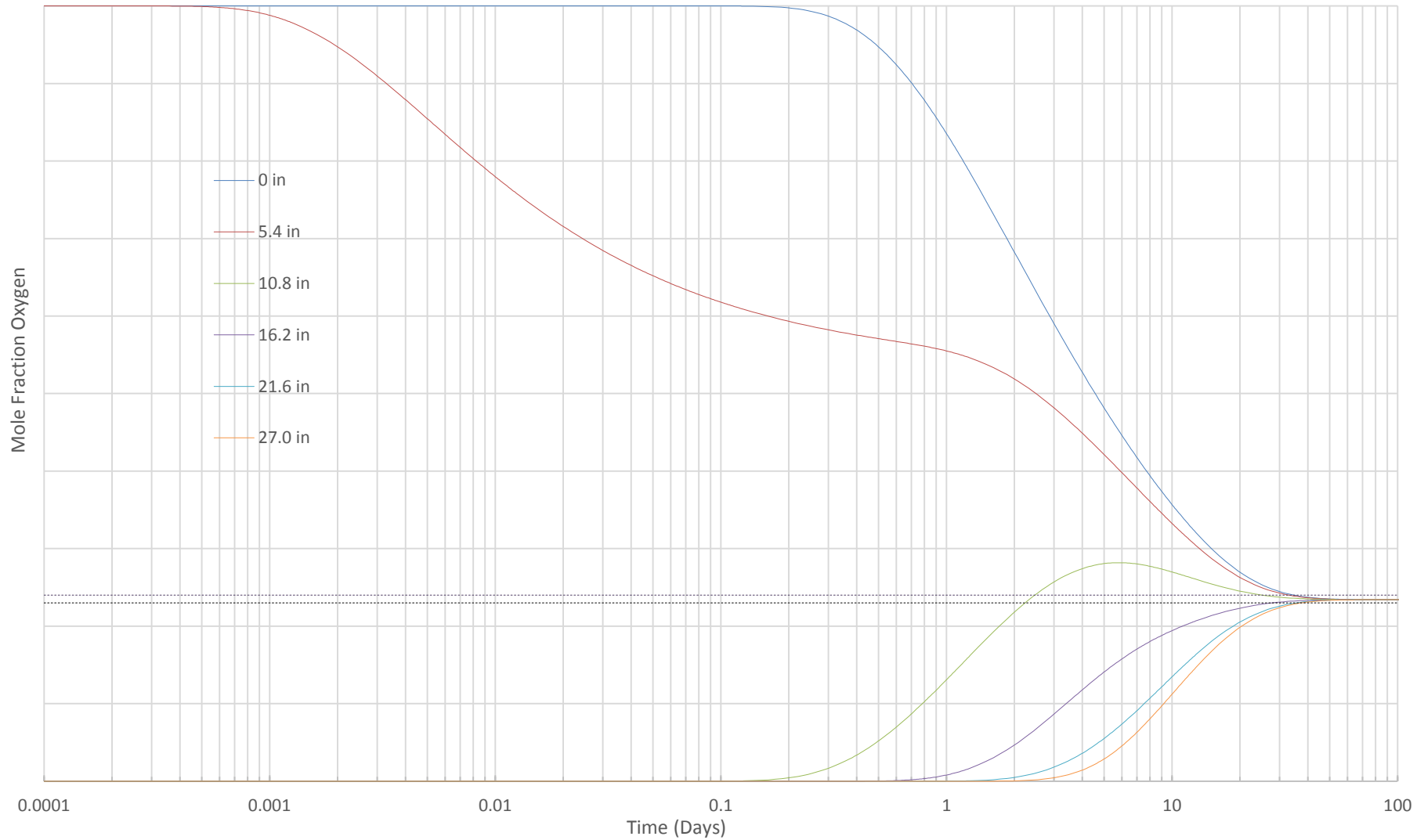
- Stratification tests were more successful than predicted, so results were used to validate accuracy objectives

- 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 CEBAAs processing



# Backup

Convergence of Oxygen Mole Fractions at Different Positions







# 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