CO_2 Workgroup

Report-out

3Q2022 API ERG

Team ERG Assignment

1. Identify CO_2 applicable:
   - ✓ Regulations
   - ✓ Resources & Best Practices
2. Perform a Gap Analysis
3. Provide recommendations in 3Q2022 API ERG meeting

Methodology

CO_2 – API ERG Team

- ✓ ExxonMobil Pipeline
- ✓ Oxy
- ✓ Chevron
- ✓ Denbury
- ✓ Phillips 66
- ✓ Kinder Morgan
- ✓ AOPL/API ERG advisors

- Team 1

  CO_2 Resources & BP
  - ✓ Oxy
  - ✓ Denbury
  - ✓ Kinder Morgan
  - ✓ API ERG advisor
- Team 2

  CO_2 Regulations
  - ✓ ExxonMobil Pipeline
  - ✓ Phillips 66
  - ✓ Kinder Morgan
  - ✓ AOPL advisor

Research

Gap Analysis

Recommendations

Regulations

Conclusions

1. Current emergency response regulations cover any type of hazardous liquids. CO_2 can be addressed within our actual emergency response plans. Tactics may need to be updated.

2. Emergency response plans (including OCC*), procedures and training may need to address CO_2 specific hazards.

3. Stakeholders, including industry, may demand more explicit requirements or guidance on the specific needs of CO_2 pipelines.

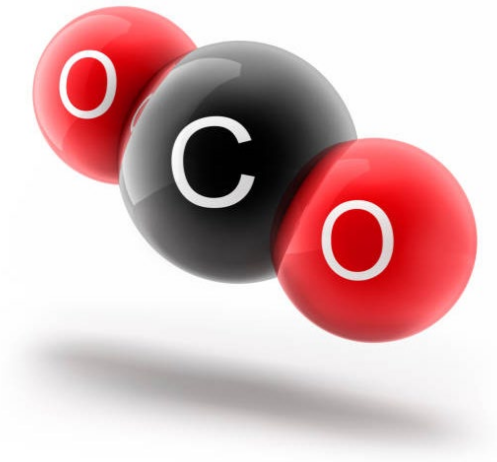
***OCC**: Operations Control Center

Resources & Best Practices

Conclusions

1. Controlling/isolating the source and public safety are the most important actions during the initial phase of a response

2. A guidance document is needed for local emergency responders to make decisions regarding initial evacuations or shelter in place.



Current On-Going Work

CO_2 ER Tactical Guidance Document

1. A committee was formed to prepare the tactical guidance document in late 2022

2. Members from Oxy, Chevron, P66, Kinder Morgan, Exxon, and Denbury participated on the committee

3. The first draft tactical guidance document has been completed and will be reviewed by the committee prior to the API/LEPA ER Work Group meeting on Feb 28-Mar 1

CO_2 ER Tactical Guidance Document Contents

Contents

Indoor Carbon Dioxide Loading Following a Simulated Carbon Dioxide Pipeline Release: Results & Conclusions

CTEH, LLC
February 15, 2023

DRAFT

CTEH®

Study Design – CO_2 Source

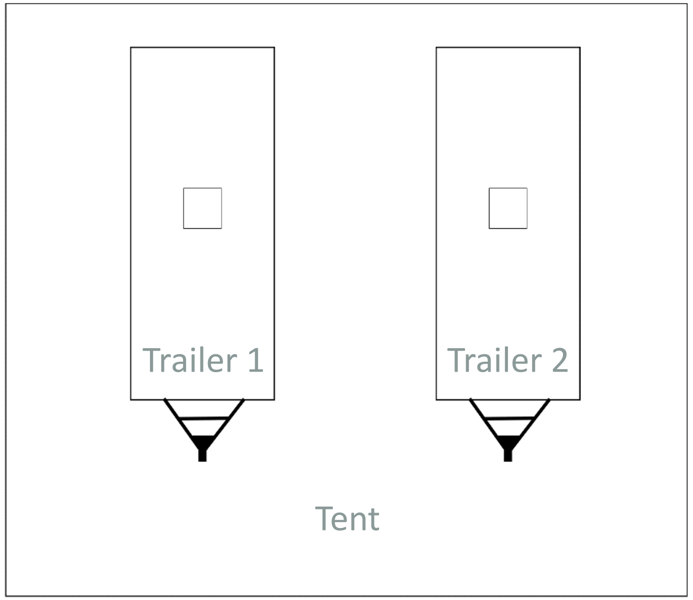
- CO_2 was supplied from a main distribution pipeline.
- Flow was controlled using a combination of chokes and valve.

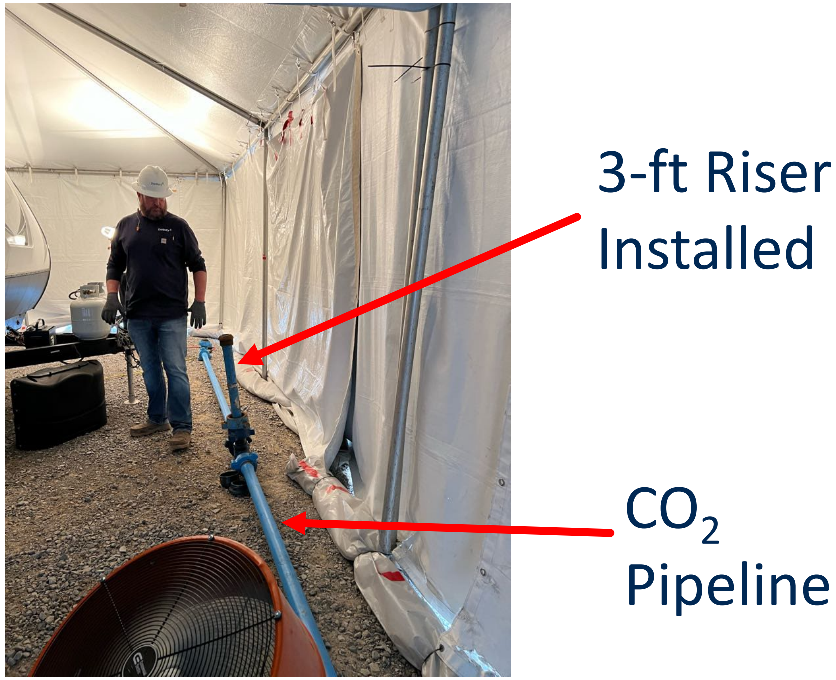
CO_2 Source Components

Carbon Dioxide (CO_2)	≥ 99.3%	≥ 993,000 ppm
Hydrogen Sulfide (H_2S)	< 0.001 %	< 10 ppm
Methane (CH_4)	0.30%	3,000 ppm
Nitrogen (N_2)	0.30%	3,000 ppm

Study Design –
Exposure Chamber Setup

- Two approximately 28’ travel trailers were placed in a 40’ x 40’ tent.
- CO_2 delivery pipelines positioned at ground level in front of and behind the trailers.
- Weights and visqueen used to attempt a sealed environment.
- CO_2 was released at height of approximately 3’ and 6’.
- Fans were positioned in the corners and center of the tent ends to facilitate mixing.





Study Design - Instrumentation

- CO_2, O_2 measured using telemetering AreaRAEs.
- AreaRAE CO_2 measuring range: 50,000 ppm.
- AreaRAEs were placed:
  - Center of the tent near ground level and breathing zone height.
  - Within the tent on the top of the roof of each trailer.
  - Near the center of each trailer interior near floor level and breathing zone height.
- An RKI Eagle2 was used to measure concentrations of CO_2 greater than 50,000 ppm.

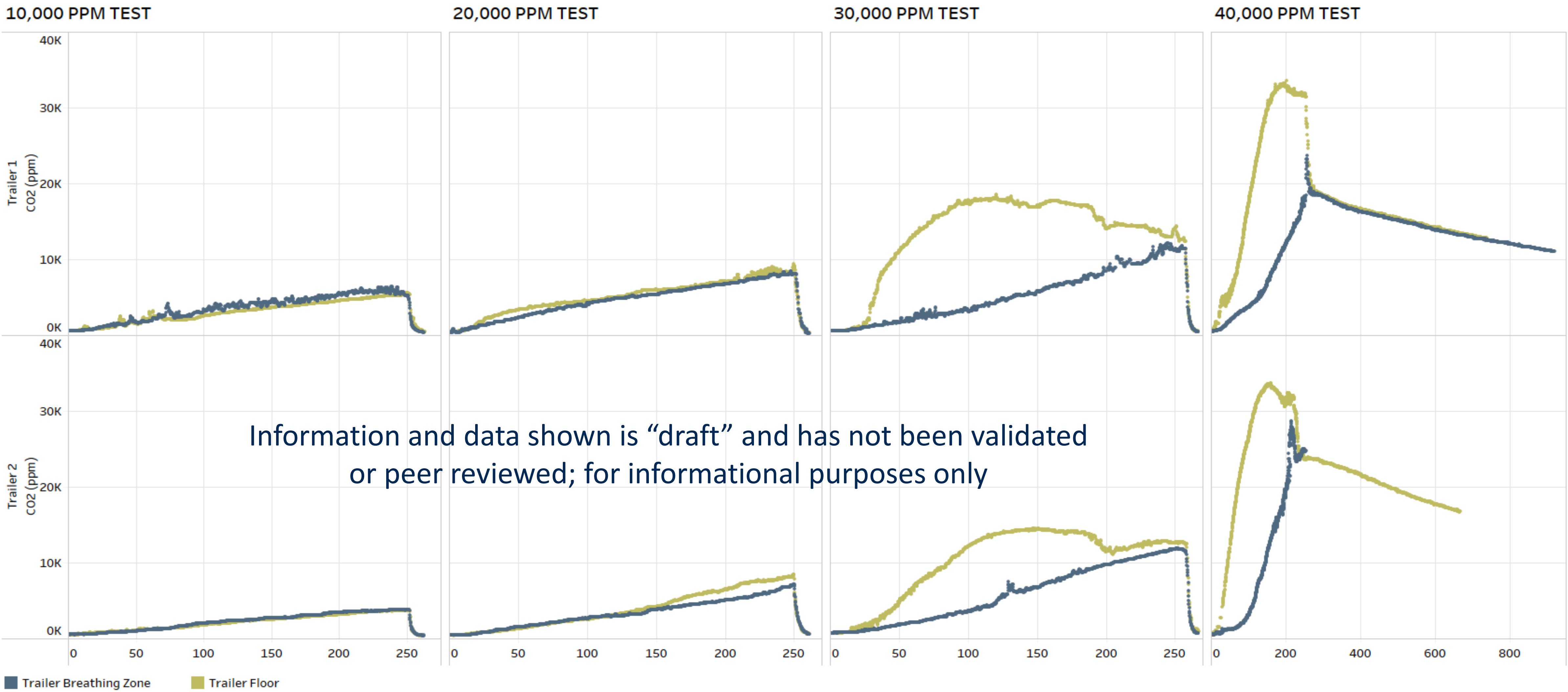
Study Design – Participating Personnel

- Michael Lumpkin, PhD, DABT – Study Director
- Angie Perez, PhD, CIH
- Jason Callahan, MS, CIH, CSP
- Cole Ledbetter, CIH, CSP
- Ernie Shirley
- Taylor Simoneau

*Taylor's photo not available

Trailer Floor and Breathing Zone CO_2 Time Profiles

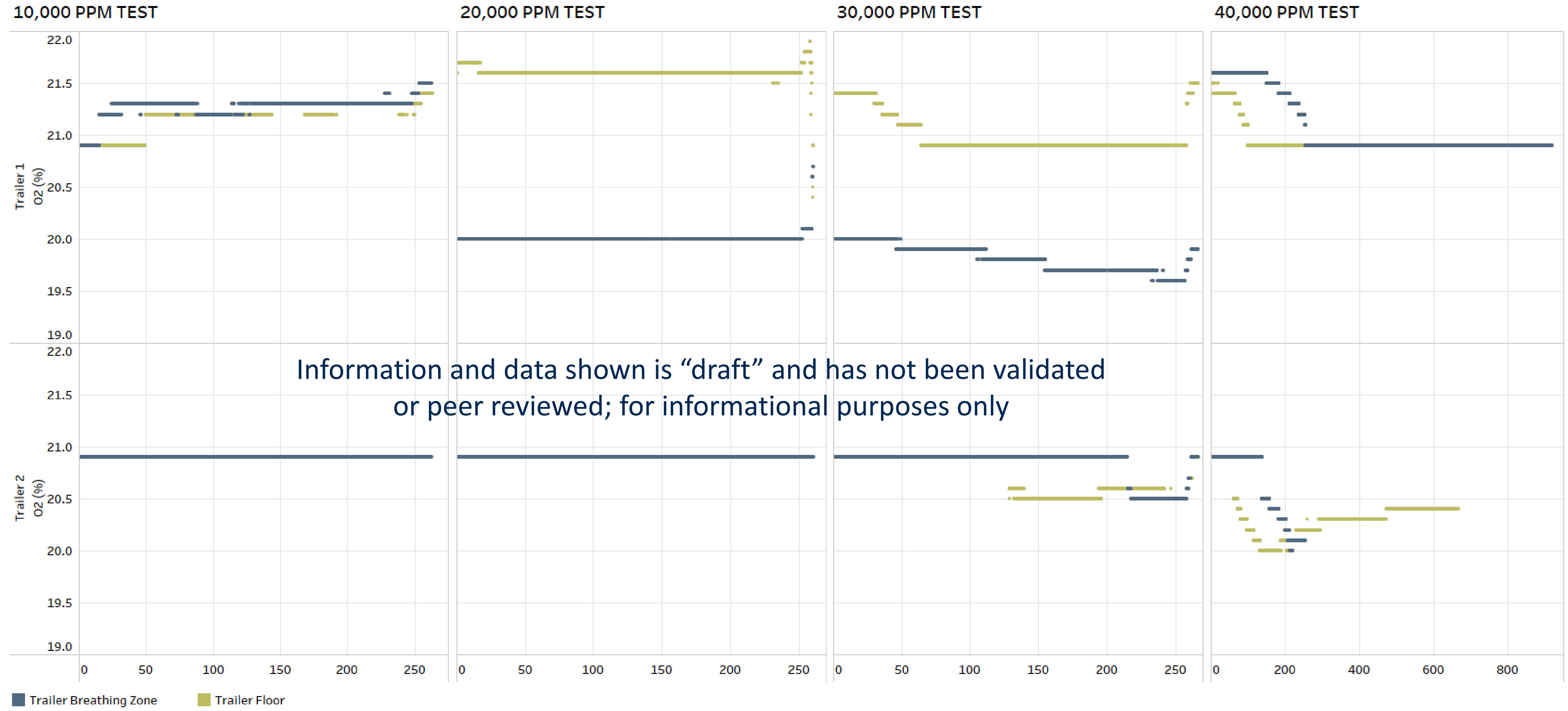
- CO_2 floor and BZ concentrations increase linearly at 10K and 20K ppm.
- 30k ppm exhibited a supralinear* increase in BZ as floor CO_2 becomes saturated.



*Supralinear = more than linear, less than exponential

Trailer Floor and Breathing Zone O_2 Time Profiles

- Oxygen decrease appears to be mostly associated with CO_2 concentrations >30,000 ppm.
- Oxygen never fell below 19.5%.

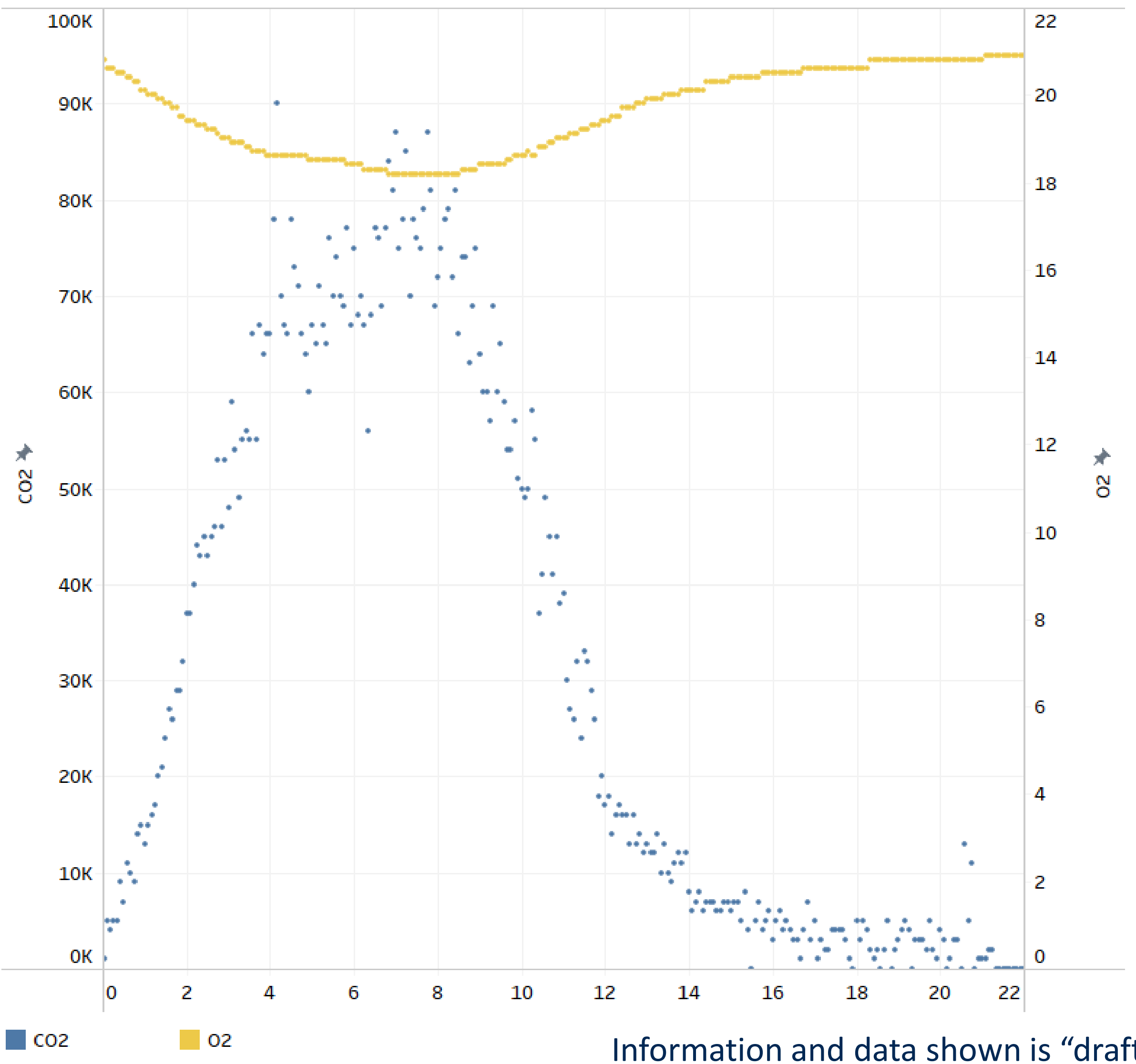


CO_2 Maximum Loading Test: CO_2 and O_2 Time Profile

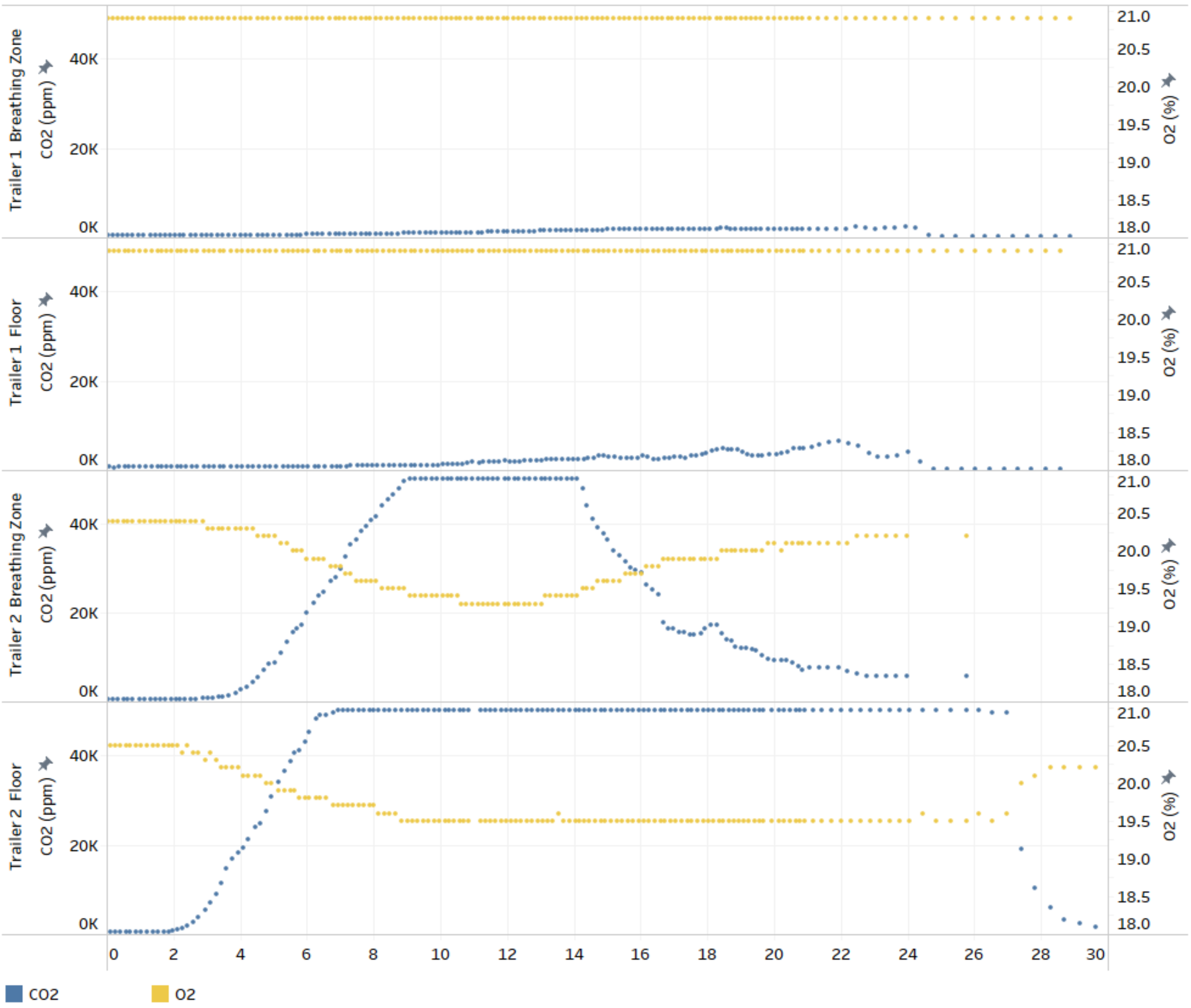
- Goal to understand catastrophic displacement of O_2 with CO_2.
- Study aborted at approximately 20 min. due to an enclosure leak.
- Measured CO_2 concentrations were 90,000 ppm at the stop time.
- O_2 decreased to 18.2% within the tent.
- Minimum oxygen inside trailer with opened windows was 19.5%.
- O_2 not affected in trailer with closed windows.

CO_2 Maximum Loading Test: CO_2 and O_2 Time Profile

Tent CO_2 and O_2 Concentrations



Trailer CO_2 and O_2 Concentrations



Information and data shown is “draft” and has not been validated or peer reviewed; for informational purposes only

Analysis: Potential for O_2 Deprivation

- Decreases in trailer O_2 content were observed at concentrations of approximately 30,000 ppm or greater.
- However, O_2 within the trailers remained greater than 19.5% at all CO_2 concentrations up to and including 40,000 ppm.
- During the maximum CO_2 test, O_2 decreased to 18.2% within the breathing zone of the tent when CO_2 concentrations reached 87,000 ppm.
- The closed window trailer did not show an O_2 decrease during the maximum CO_2 test.

Analysis: Shelter-in-Place Implications

- Equilibrium levels of CO_2 up to and including IDLH were slow to infiltrate test trailers when windows and doors were closed.
- O_2 in closed trailers did not fall below 19.5% regardless of whether outdoor concentrations were at equilibrium for a duration of time or were quickly elevated to a peak for 20 minutes (maximum test)
- Shelter-in-place is a viable, health protective option up to four hours following a CO_2 release (and possibly longer).
- The effectiveness of shelter-in-place is less certain for residences that are significantly leakier than the trailers used in this experiment.

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