



Sampling and Ventilating Confined Space in Breweries

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Properly sampling and ventilating brewery confined spaces is critical for worker safety.

This seminar demonstrates:

use of gas detectors, discusses effective ventilation techniques and explains correct documenting sampling results in your confined space permit.





Let's look at:

- Ventilation guidance found in an OSHA letter of interpretation.
- We will simulate behavior of light and heavy vapors in a space.
- Review effective ventilation techniques in our simulated space.
- Correct use of gas detectors and probes.
- What will and won't provide safe breathing air.
- How to know air is safe.
- Discuss why O₂ results can mislead about CO₂.
- Practice documenting sampling results correctly on a confined space form.

Begin with a “Confined Space”

- Examples: Fermenters, tuns, kettles, basements, walk in coolers.
- Restricted area with no air exchange: **simulated by Cornie keg.**
- Test for substances potentially present in the space: CO₂, low O₂, ?
- Breathe in the space: decrease O₂; increase CO₂.
- *1910.146(d)(5)(ii) states:*

...Test the permit space as necessary to determine if acceptable entry conditions are being maintained during the course of entry operations...





Question 1: What constitutes "continuous forced air ventilation" in 29 CFR 1910.146(c)(5)(ii)(E)?

OSHA's Reply:

"Continuous forced air ventilation" means a delivery system that provides positive pressure for the confined space where the employees are working.

When continuous forced air ventilation is used during the entries that follow the Alternative Entry Procedures and authorized under 29 CFR 1910.146(c)(5)(i)(A) through (F), the following conditions must be met:



Question 1: What constitutes "continuous forced air ventilation" in 29 CFR 1910.146(c)(5)(ii)(E)?

OSHA's Reply:

1. No employee may enter the permit space until the forced air ventilation has eliminated any hazardous atmosphere found within the space.
2. Ventilation must be directed to ventilate the immediate areas where an employee is or will be present within the space and must continue until all employees have left the space.
3. Air supply for the ventilation must be from a clean source and not increase hazards in the space.

These provisions ensure (air) in the space remains safe during the entire entry operation.”



Question 2: Does the use of a portable blower fan to clear the air, satisfy the OSHA requirement?

OSHA's Reply:

- A portable blower fan could be used as the continuous forced air ventilation, provided that it does remove any hazardous atmosphere.
- This depends on several factors, not limited to:
 - Size and configuration of the space,
 - Openings, access doors, vents,
 - Quantity, and position of those openings,
 - Blower capacity, cubic feet/ minute (CFM) of the fan itself, limitations of that blower.

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=25169

Why ventilate?

- "Ventilating confined space stabilizes the atmosphere.
- It sets a reference for the most important piece of confined space equipment: atmosphere monitor.
- Stabilizing atmosphere moderates how quickly that atmosphere could change.
- It maximizes the time a worker has to evaluate any change, and recognize a need to exit the space."



Should I ventilate?

- Ventilating a space does not exclude the use of respiratory protection.
- Ventilation makes the atmosphere stable for work, but may not make it breathable.
- Work in the space may change atmosphere, and require respiratory protection.
- Are sanitizers in the steam more dangerous?



Natural Ventilation

- 1) Opened manway, CO2 inside >5% maximum of meter.
- 2) Outside, directly below and around tank, CO2 peaked >5% for about 2 minutes.

Gradually drop to 0.3% (3000). Inside remains >5%.

- 3) After several minutes, opened the bottom outlet. Caused brief spike right under the tank; area readings ~5000 ppm.
- 4) After 5 min; all readings outside tank dropped ~5000 ppm.
- 5) Inside tank, the area above the manway was still ~1%, but in the cone was still >5% by volume.



Natural Ventilation

Lesson Learned:

- CO₂ doesn't clear from tanks quickly or easily.
 - Entry after a gas purge requires force ventilation.
 - Confirm safe air with a CO₂ detector.
- You can't use O₂ level to determine what your CO₂ level is.
 - You must specifically measure each gas separately.
- During the test, O₂ levels were always higher than 19.5%.
- The math:
 - 5% CO₂ will displace 5% of the air; (20.9% oxygen).
 - Displacing 5% of O₂ lowers it to ~19.8%.
- CO₂ levels do not displace the O₂ in even, consistent pattern.



Planning Ventilation: Stratified Light Vapors



- What is in the contaminant.
- Is it heavier or lighter than air?
- How fast does it generate?
- Can it be cleared?
- Does it re-generate after removal?
- Size of the space, restrictions that limit air flow, etc.;
- Breeze needed for worker comfort: is it still hot?
- CFM required out duct to control hazards.
- The CFM your blower can provide.
- Is there room to set down the blower and duct?

Planning Ventilation: Stratified Heavy Vapors

- Breeze: provide ACGIH "air velocity ranges" from 75 - 200 fpm to provide cooling.
- Friction has greatest affect reducing air flow from fan to end of the duct.
- Friction loss can be over 50% in a 15 ft duct.
- Use manufacturer instructions to achieve their stated airflows.
- Heavy gas like CO₂ are very hard to move.



Negative Pressure, Exhaust Ventilation, Suction



Exhaust ventilation, Negative pressure, Suction.

- This is an example of negative pressure.
- Suction barely changes air flow in this space.
- Smoke rises with little change in direction.
- Heavy gases are very hard to move.
- OSHA said “forced air ventilation with positive pressure air”, because negative pressure is less affective.
- Fire fighters use Negative pressure effectively; they use windows and doors to let air in.
- How many windows, doors are in your fermenter?

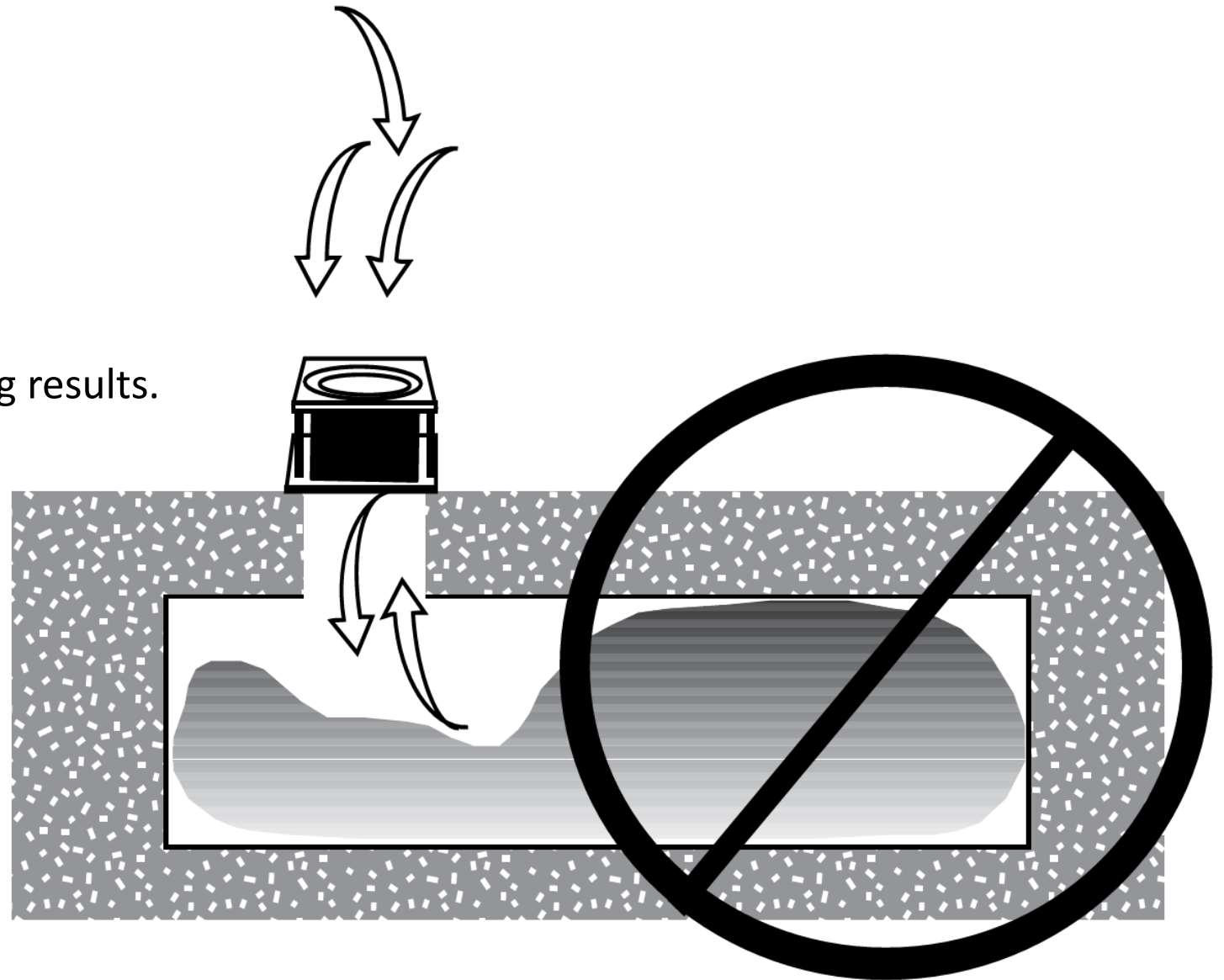
Supply ventilation, Positive pressure, Blow air

- Just enough opening into this test space to blow air in; similar to a manway.
- Positive ventilation blows air in.
- Blowing and mixing; but Gas is still present.
- Without vents, pressure in the box increases.
- Pressure increases in the space and slows fan.
- Vapors mix; but remain somewhat contained.
- Fan doesn't easily move the heavy CO₂.



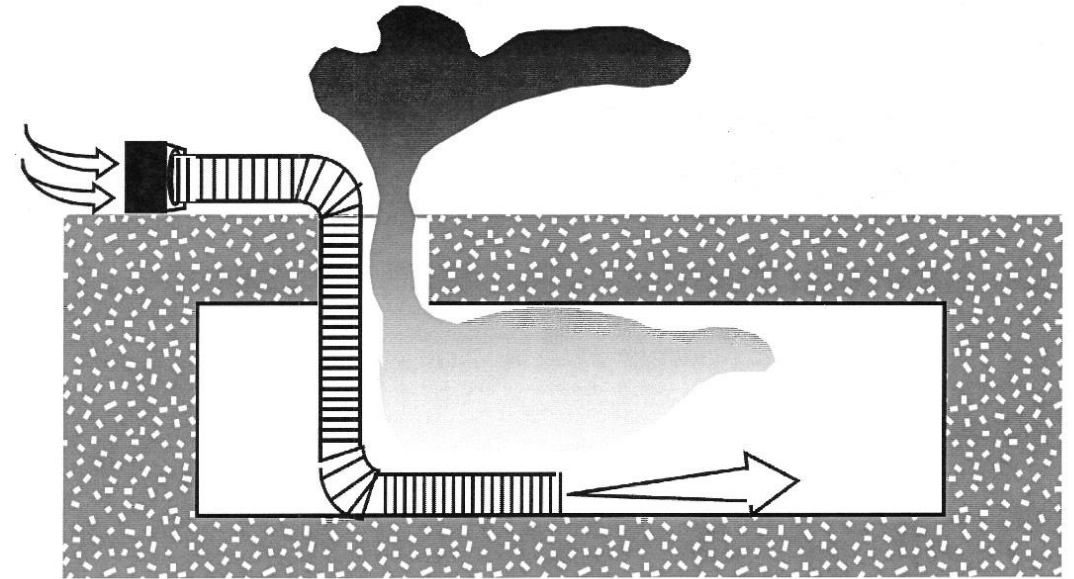
“Short Circuit” Flow

- Fan only stirs up air near opening.
- Testing this stirred up air gives misleading results.
- SuperVac air flow examples.



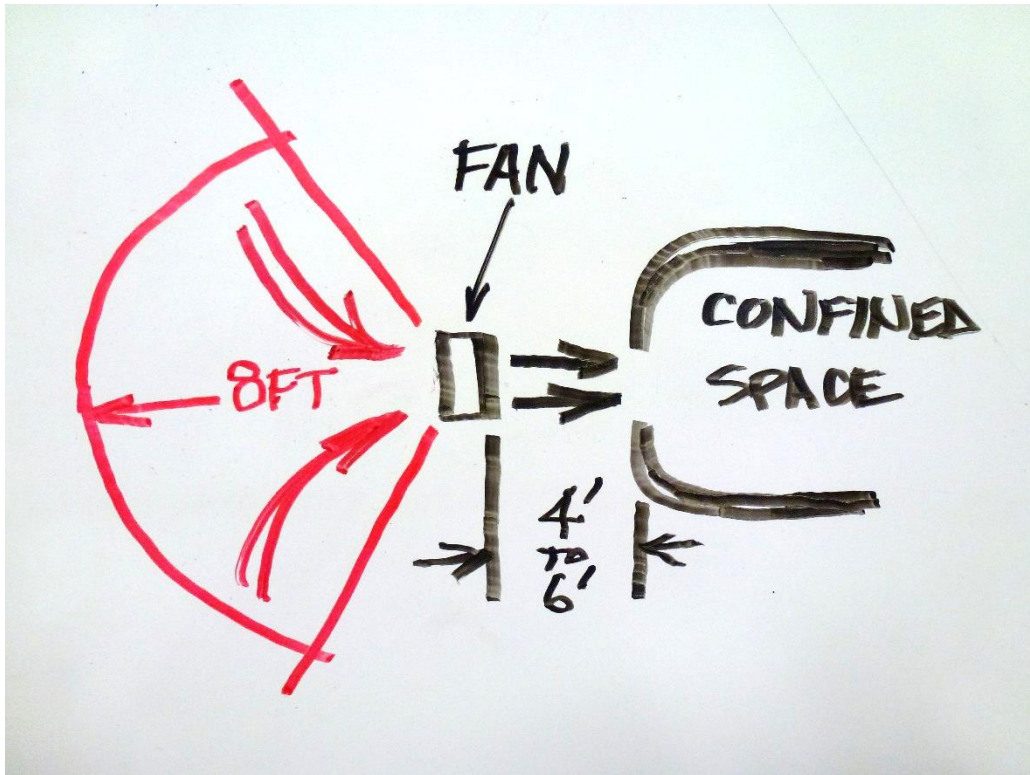
Use of Ducts.

- Ducts put fresh air deep in the space.
- Helps to flush out the space.
- In this example, air continues to mix.
- Contaminants are reduced by combined mixing and displacement.
- Eventually becomes clean air.
- ***Clearing doesn't happen quickly.***
- Ducts direct clean air to the face of the worker, as OSHA expects.

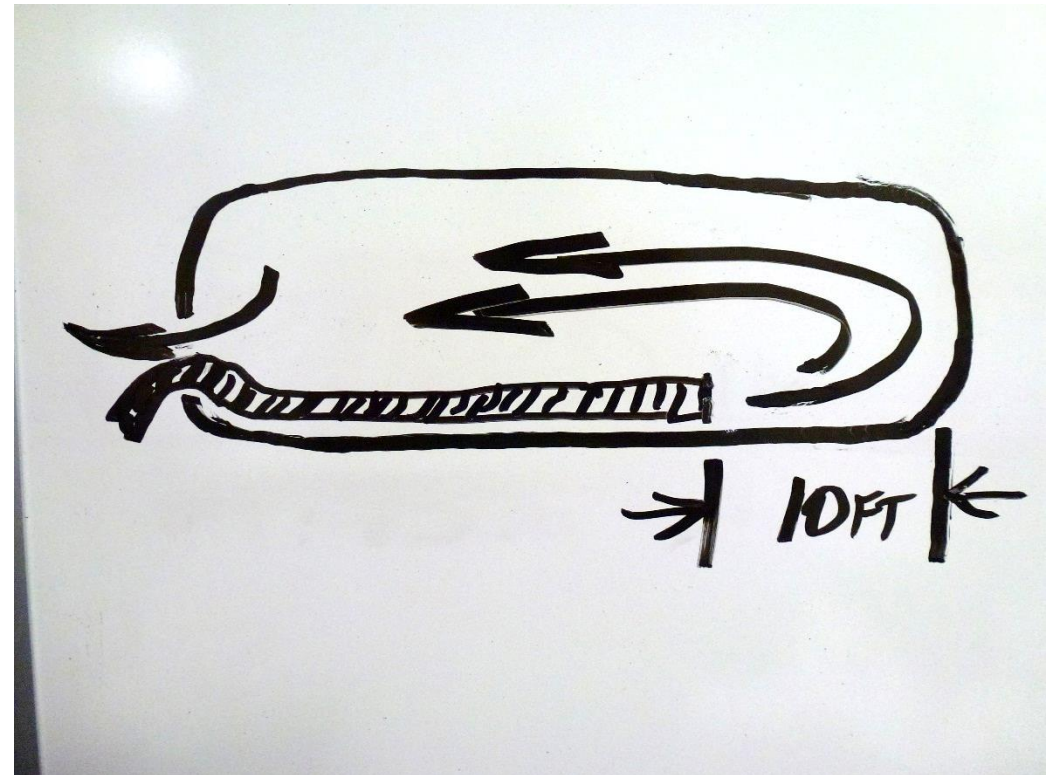


Effective Supply Ventilation

Place fan 4 to 6 feet from manway;
Provide clean air, with no contaminant or debris
within 8 feet of intake.



Place duct in horizontal spaces within 10 feet of
the far wall.



Bends and Length Reduces air flow.

- From TA Pelsue Certification data:



1/3 HP Electric, Certified Air Flow:

- Free Air: **1075 cfm**
- w/ one 90° bend: **668 cfm** / 588 cfm
- w/ two 90° bends: **585 cfm** / 553 cfm

Static Pressure: 2.09" W.C. (0.07543 PSI)



- Flow certified by CEESI for 8 inch diameter
15ft & 25ft collapsible duct.

Limitations quoted from Shop Vac[®] Web Site

- Peak horsepower is outside normal operating range, and may not indicate actual air power.
- Maximum suction pressure is at zero air flow.
- Suction decreases as air flow increases.
- CFM is air moved at a particular system load.
- Your load is your hose, dirty filter; your CFM.
- Air power is suction and air flow based on dirty filters, leaks.
- This spec is for an uninstalled fan on a bench.



Effective Ventilation: Research

- Many variables affect confined space ventilation.
- **BELL TELEPHONE**: remove smoke from telephone vault.
- Clearing vault requires a fan and duct positioned to get 7 air exchanges per hour.
- Changing, reconfiguring space or contaminants alters results.

- **U of MICHIGAN** study: Confined Space ventilation.
- Studied gases, shapes of spaces, other variables.
- They prescribe 20 air exchanges per hour.
- No matter your ventilation procedure, a gas monitor must verify ventilation is effective.

7 ACH

20 ACH

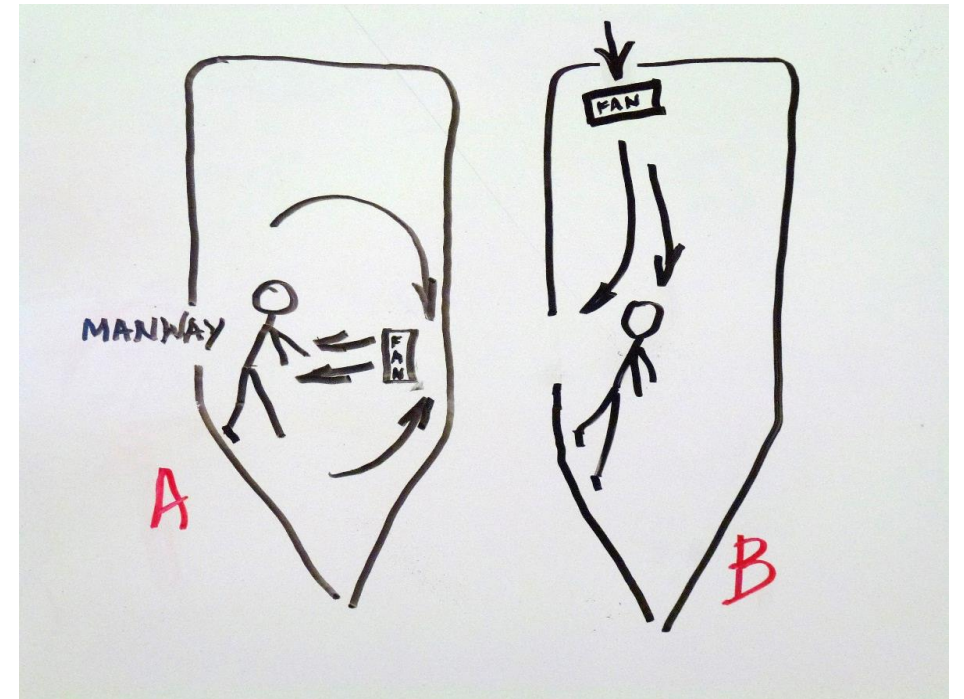


Calculating “AIR CHANGES Per HOUR”

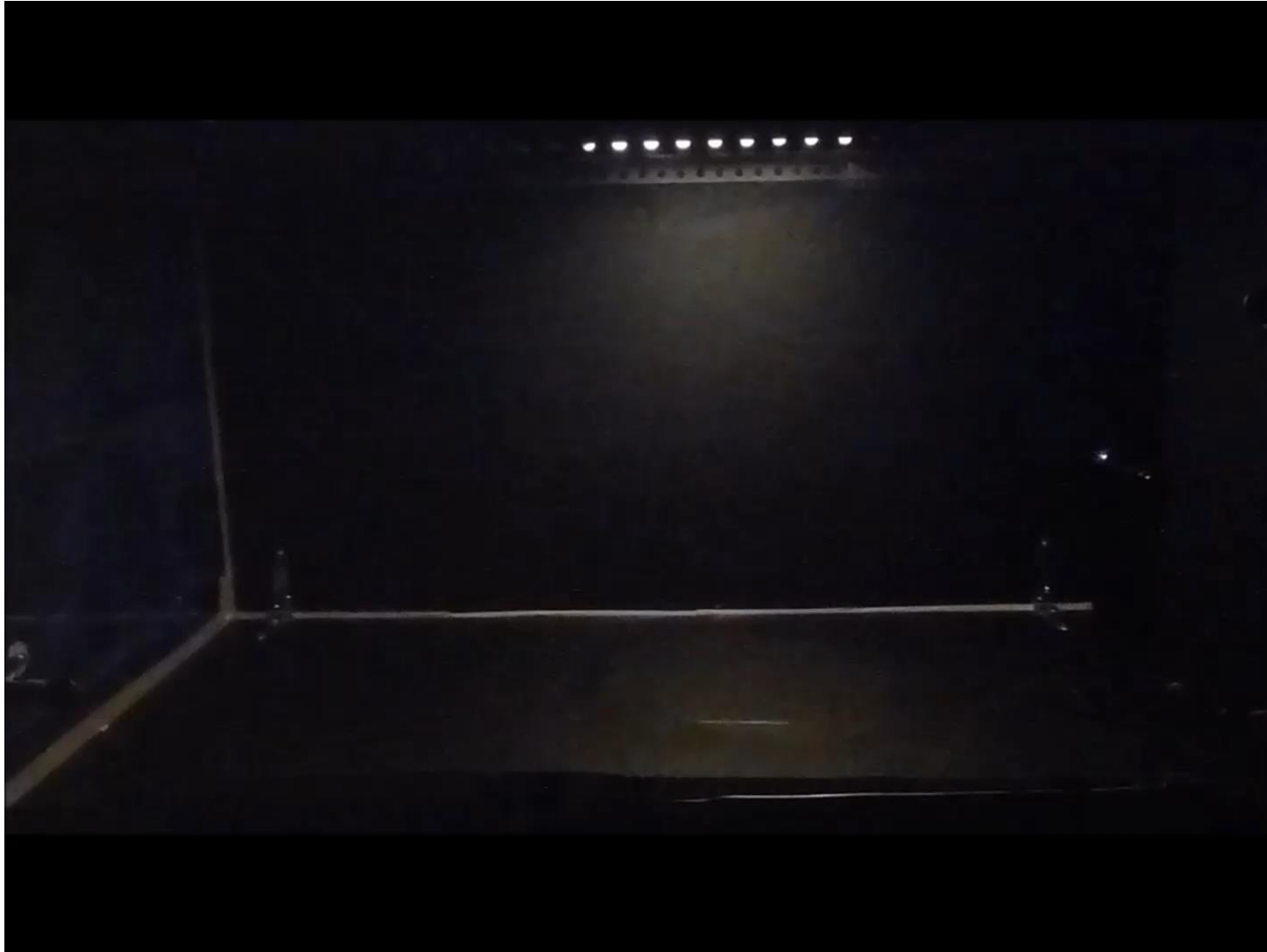
- Air Changes per hour, or Air Exchanges per hour.
- Adequate purge time is essential before entry.
- To calculate purge time: feet³ of the space, divided by CFM of blower.
- Answer equals time for 1 single air exchange.
- Danger: only enter space after documented test by qualified person using gas test equipment confirms safe atmosphere.
- It's like taking a breath.
- Area in Feet³ / CFM^{Blower} = purge time
- 10 barrel tank: 45Ft³ or 1175 L
- 6L x 14 = 84L or 3.0 to 4.25 Ft³
- Exercise rate 50 to 100 Liters/min; 150L/min
- 45 cfm should be 1/ min to clear
- Bathroom fans 50 cfm to 120 cfm:
How long to clear the smell?

Allow time for Effective Air Changes

- Blower with duct for 2 complete air changes.
- Then turn blower off before testing air inside space.
- Test air throughout entire space.
- Prevent "short circuiting" air.
- If there's only a manway, place blower on opposite side from the manway. (A)
- If space has a second opening, place blower at smaller opening to improve air flow through space. (B)



Proper use of probe to sample a space.



- Sweep the probe side to side.
- Test low where heavy gas settles.
- Air settles in the middle.
- Test where light gases rise to top.
- and either from top to bottom or bottom to top.
- Make a repeating pattern that makes sure to catch any pockets of those layered gases we saw in the earlier video.



CO2 versus Oxygen

- Datalog records gas concentration.
- Datalog of air testing during barrel filling and keg filling.
- CO2 concentration does not correlate to reduction in the Oxygen level.
- Write these results on your form.
- Record the level every 30 minutes, etc.

1/22/2016 5:25:50 PM	20.8	0.2
1/22/2016 5:26:00 PM	20.8	0.19
1/22/2016 5:26:10 PM	20.8	0.18
1/22/2016 5:26:20 PM	20.8	0.16
1/22/2016 5:26:30 PM	20.9	0.14
1/22/2016 5:26:40 PM	20.9	0.1
1/22/2016 5:26:50 PM	20.9	0.22
1/22/2016 5:27:00 PM	20.8	0.34
1/22/2016 5:27:10 PM	20.8	0.43
1/22/2016 5:27:20 PM	Low 20.7	0.6
1/22/2016 5:27:30 PM	Low 20.7	0.88
1/22/2016 5:27:40 PM	HI 20.3	1.73
1/22/2016 5:27:50 PM	HI 20.2	2.65
1/22/2016 5:28:00 PM	HI 20.5	2.67
1/22/2016 5:28:10 PM	Low 20.9	0.99
1/22/2016 5:28:20 PM	Low 20.8	0.51
1/22/2016 5:28:30 PM	20.8	0.41
1/22/2016 5:28:40 PM	20.8	0.38
1/22/2016 5:28:50 PM	20.9	0.34
1/22/2016 5:29:00 PM	20.8	0.3
1/22/2016 5:29:10 PM	20.8	0.3
1/22/2016 5:29:20 PM	20.8	0.33
1/22/2016 5:29:30 PM	20.8	0.35
1/22/2016 5:29:40 PM	20.8	0.3
1/22/2016 5:29:50 PM	20.8	0.28
1/22/2016 5:30:00 PM	20.8	0.27
1/22/2016 5:30:10 PM	20.8	0.28
1/22/2016 5:30:20 PM	20.8	0.3



Documenting the sampling results

- Write Atmosphere test results on Confined Space Permit.
- *Sample the air in the cornie keg.*
- Use the results to fill out the form.

- How long do you normally ventilate before entering your tanks?

... test the atmosphere before entry and record the readings below?

13. Is it true that the air monitoring equipment did not go into alarm during initial testing?

14. Will the confined space atmosphere be monitored continuously during your entry?

15. Is the opening guarded to prevent persons or objects from falling into the space?

Atmospheric Testing Record:

Sampled for:	Permissible Entry Levels	Initial reading	30 min	1 hr	1.5 hr	2 hr	2.5 hr	3 hr	3.5 hr	4 hr
OXYGEN	20.9%									
LEL	0%									
CARBON DIOXIDE	400 ppm (AMBIENT)									
CARBON MONOXIDE	0 PPM									
HYDROGEN SULFIDE	0 PPM									

If you have completed the above checklist and answered "yes" to all questions, you may authorize properly trained individuals to enter the confined space using Alternate Entry Procedures.

Entrants: _____

Document Atmosphere Test results

- We document:
- To prove we tested the space.
- Show that air is safe when we enter.
- To Prove that air stays safe during the entry.
- If something goes wrong, what happened?
- Do we provide first aid for bad atmosphere, or something else?
- Responders can help the victim faster.



The basics

- Who should ventilate? Everyone.
- What should be ventilated? Every confined space.
- When should you ventilate? Always, before test.
- Where do we ventilate? From clean air supply.
- Why ventilate? To provide air safe to breathe.
- How do I ventilate? Consult safety, industrial hygiene, or authorized personnel.
- Protect yourself and others.



We learned:

- OSHA Ventilation guidance.
- Behavior of light and heavy vapor.
- Effective ventilation techniques.
- Correct use of gas detector and probe.
- What provides safe air.
- Oxygen level doesn't correlate to CO2 hazard.
- Correctly documented Confined Space air test.



Thank you!

- The Team at Dry Dock Brewing
- Industrial Scientific Gas Detection
- The team at Bell's Brewery
- Iron Hill Brewery
- Super Vac
- T A Pelsue
- Brewer's Association Safety Subcommittee
- OSHA letter of interpretation 11/ 17/ 2005 1910.146 c 5 I



Please fill out your course evaluation!