
CONTROLS

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1st Jan, 2025

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Keywords Spiritual Safety, Process Safety, Chemical Engineering, Risk Assessment

Learning Outcomes

- Identify and distinguish between various control techniques, including inherent safety, engineering controls, administrative controls, and PPE.
- Understand the implementation of engineering controls like ventilation systems and specialized hoods to reduce toxic concentrations.
- Evaluate the trade-offs, such as energy costs and effectiveness, between positive and negative pressure systems.

Reading

- Foundations of Spiritual and Physical Safety: with Chemical Processes; Chapter 7, Sec. 4 through the end of the chapter.

Inerting (Vacuum/Pressure purging); Piping/Bonding/Grounding; Work Permits; Hot Work.

1 Inerting Approaches

Inerting is the process of replacing the atmosphere in a vessel with an inert gas (nitrogen, carbon dioxide, etc). This is done to prevent the formation of flammable/explosive mixtures. There are multiple approaches to purging and inerting:

- vacuum purge (removing the atmosphere from the vessel and replacing it with an inert gas in stages; stages used to prevent the container from collapsing)
- pressure purge (replacing the atmosphere in the vessel with an inert gas by pressurizing the vessel, also completed in stages)
- sweep purging (replacing the atmosphere in the vessel with an inert gas by flowing the inert gas through the vessel)
- siphon purging (replacing the atmosphere in the vessel with a liquid then filling with an inert gas)

- combination of the above

2 Control Techniques

There are multiple control techniques that can be used to reduce the exposure to workers from a toxic gas or vapor. These include:

Inherent Safety: Designing the process to eliminate or reduce the use of toxic gases or vapors.

- **Substitution:** Replace the toxic gas or vapor with a less toxic or non-toxic alternative.
- **Minimization:** Reduce the amount of toxic gas or vapor that is used in the workplace.
- **Isolation:** Use of barriers or other methods to separate the toxic gas or vapor from workers.

Engineering Controls: Use of ventilation, enclosures, or other engineering controls to reduce the concentration of the toxic gas or vapor in the workplace.

Administrative Controls: Use of work practices, policies, and procedures to reduce the exposure of workers to toxic gases or vapors.

Personal Protective Equipment (PPE): Use of PPE such as respirators (full or half face) or supplied air respirators to reduce the exposure of workers to toxic gases or vapors.

2.1 Engineering Controls

Ventilation: Ventilation occurs with HVAC systems where air is circulated and filtered. However, most of the air is recirculated and only a small fraction is replaced with fresh air. The recirculation of air can lead to a build up of toxic gases and or distribute them to other areas of the workplace.

Ventilation where outside air is brought in can help reduce the concentration of toxic gases or vapors but it has significant energy costs.

Typical ventilation occurs with negative rather than positive pressure systems. Know the difference between positive and negative pressure systems and why one might be used over the other.

Local Ventilation: Hoods

Hoods are effective at containing and expelling toxic gases or vapors. However, they can be expensive to install and maintain. They also require a significant amount of energy to operate.

Action Items

1. Define the hierarchy of control techniques: Inherent Safety, Engineering Controls, Administrative Controls, and PPE.
2. Explain the three methods of purging (vacuum, pressure, and sweep) and describe a scenario where vacuum purging would be dangerous for a specific vessel.
3. Determine the value of the fuel concentration at Point B in Figure VII.9([Guymon, 2025](#)). This point represents a safe point where when air is then used to sweep the tank out completely, at no time is the concentration in the flammable range.
4. Personal Reflection: Visit your kitchen or garage and identify one engineering control and one administrative control you use to stay safe
5. What spiritual safeguards do you have in place? Write a descriptive paragraph.

References

C. Guymon. *Foundations of Spiritual and Physical Safety: with Chemical Processes*. 2025.