Prevention through Design: Eliminating Confined Spaces and Minimizing Hazards

American Industrial Hygiene Association®

Developed by the AIHA® Confined Spaces Committee

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OSHA defines confined spaces in 1910.146 as those spaces that are large enough to enter and perform work, have a restricted means of entry and exit and are not designed for continuous human occupancy. The standard further defines a permit required confined space as being a confined space with a serious hazard such as a hazardous atmosphere or the potential for engulfment. The prevention through design concept for confined spaces utilizes these two definitions as starting points to figure out how to eliminate the hazards associated with confined spaces and thereby "design out" the aspects that define the space as a confined spaces or a permit required confined space. For example, if a restricted means of entry and exit is eliminated, or if a space is designed for continuous human occupancy, then the confined space hazard has been "designed out". Likewise if a serious hazard within a confined space is eliminated the permit required confined space has been designed out. The elimination of the confined space or permit required confined space will lead to decreased risk to workers for years to come.

Background

Fatalities in confined spaces remain a concern. The Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries indicated that confined space fatalities ranged from approximately 80-100 deaths per year from 1997-2011 with an average of 92 fatalities per year. The State of California had 7 fatalities in confined spaces in 2011 alone, prompting the state to launch a confined space entry emphasis program in 2012.

The Prevention through Design initiative at NIOSH began in 2007. NIOSH recognized one of the best ways to prevent and control occupational injuries and illnesses and fatalities is to design out or minimize hazards in the design phase. Confined spaces are an example of a hazard that can often be eliminated in the design or redesign phase. Intentionally or not, confined spaces are typically the result of the design process; they do not occur randomly. When confined spaces are built, unnecessary risks to workers can result.

By definition, confined spaces are not designed for human occupancy, but people often have to enter them for maintenance, inspection, cleaning, repair, and other reasons. With thoughtful planning, many of these confined spaces—and the need to enter them—could be eliminated entirely. If it is not possible to eliminate a confined space, good design can minimize the hazards within the spaces and allow for the safe, non-entry rescue of workers.

Engineering contracts should contain language requiring confined space hazards to be "designed out" whenever possible. A safety professional should review all plans before final approval and the start of construction to ensure that confined space hazards are eliminated or minimized.

Up-front safe design is generally recognized to be more cost effective than a retrofit. Prevention through Design concepts can provide a cost-effective means of preventing injuries.

The following examples are some of the top design principles to consider for confined spaces.

Prevent the Creation of Confined Spaces or Eliminate Existing Confined Spaces

Make the confined space too small to bodily enter. This principle has limited applicability, but some spaces can be partitioned or otherwise broken into multiple compartments that are too small for a person to get inside. For example, a large compressed air receiver could be filled with a honeycomb lattice to prevent entry without affecting function as an air reservoir. Inability to enter due to size keeps employees out of harm's way and eliminates coverage under OSHA's confined spaces standard.

Provide unrestricted access and egress. This will allow workers to enter without having to contort their bodies, crawl, or use their hands to climb in or out.

- Provide large access openings, such as standard doorways, through which workers can pass easily and quickly. Provide standard overhead clearances so that workers can stand in the space whenever possible.

- Install standard steps with handrails in lieu of ladders or spiral staircases. Steps allow safer, unrestricted entry and exit from the space.

- Provide sufficient aisle clearances within the space and provide clear access to openings and exits. Locate pipes, ducts and other equipment so that workers do not have to climb over, under or around them.

- Provide multiple access openings at regular intervals in long spaces, such as crawl spaces and tunnels, to ensure that employees' ability to exit the space is not restricted by distance.

- House equipment in buildings above ground with a standard doorway for access rather than placing equipment in a vault below grade.

Design the space for continuous human occupancy during normal use. Some confined spaces, such as utility vaults, only need minor modification to make them much safer and to eliminate classification as confined spaces.

- Install continuous-operation or door-switched mechanical ventilation to control air quality and temperature in confined spaces. If a confined space is dependent on ventilation for human occupancy, install an alarm to indicate when ventilation is not working and consider installing fixed-gas equipment with an alarm to verify air quality.

- Install adequate fixed lighting in the space. Place light switches at entrances.

- Seal the space to prevent water intrusion and/or ensure proper drainage to prevent accumulation of free-standing liquid.

- Ensure that all mechanical equipment is properly guarded and that all electrical equipment is sealed correctly.

- Guard open-sided edges, floor holes, wall holes, and any other hazards that may cause falls.

Eliminate the Need for Entry into Confined Spaces

Many confined space entries could be eliminated by modifying equipment and its installation.

- Install critical equipment (valves, gauges, etc.) that requires periodic operation, inspection, or maintenance outside the space so that entry will not be necessary.

- Extend valve handles so they can be operated from outside the confined space.

- Use flexible components and install retrieval systems for items that are located at the bottom of the confined space (e.g., sump pump) so they can be removed and serviced without entry.

- Install extension tubes and fittings to make lubrication possible from outside the confined space.

- Install catch baskets at the bottoms of tanks or other spaces that can be raised to retrieve fallen parts to prevent the need to enter the confined space.

- Use remote monitoring systems (cameras, gas detection, leak detection, wireless meter readers, etc.) to obtain information while outside the space.

- Select mechanical equipment for maximum service life and minimal maintenance requirements to reduce the number of entries required. Over the long term, the additional cost of such equipment may pale in comparison to the cost of routine confined space entry.

- Install viewing and cleaning ports in tanks and other equipment so that the interiors can be seen and cleaned without entering the space.

Make Entry Impossible If Entry Is Not Required

If entry into a particular confined space will never be required, modify the space to make entry impossible.

- Make access openings too small for a person to fit through.

- If existing access openings are large enough to pass through, seal the openings (use security locks, weld openings shut, and so on), or block them by installing grating across the openings.

If Entry is Necessary, Eliminate or Reduce the Health and Safety Hazards

Eliminate or minimize health hazards.

- Prevent entry and accumulation of organic debris that could decompose and lead to oxygen deficiency or the generation of toxic gases.

- Prevent moisture and water intrusion that could cause rusting and lead to oxygen deficiency. If this is not possible, use materials that do not rust or seal materials with a rust preventer.

- Eliminate the placement of piping or conduit containing hazardous materials, gases, chemicals, or sewage in the confined space. Where pipes do enter the space, provide means to drain, purge, and blank any piping. Use welded joints on any piping that will carry hazardous materials to prevent leakage.

- Provide ventilation ports at regular intervals if there is potential for a hazardous atmosphere, and provide multiple openings at opposing ends of the space to facilitate complete and effective ventilation.

- Seal or screen any openings to the space as needed to keep out insects and other animals.

- When possible, select and install equipment with low noise ratings.

- Remove or seal any asbestos-containing materials within the confined space.

Eliminate or minimize safety hazards.

- Install sumps and pumps to prevent accumulation of free-standing liquid, such as groundwater.

- Ensure all electrical equipment is properly enclosed, grounded, and approved for the particular environment (e.g., Class 1 equipment for flammable gas and vapor environments, Class II equipment for combustible dust environments).

- Install ground fault circuit interrupters (GFCIs) in wet areas or where highly conductive surfaces exist.

- Ensure that all energy sources in the space can be locked out, ideally from outside the space.

- Construct fixed ladders using rust-free materials strong enough to hold 350 pounds. Install climbing devices wherever possible.

- Protect all open-sided floor edges, floor holes, wall holes, and similar hazards with standard railings and toe boards.

- Use non-slip flooring materials where possible.

- Provide self-closing, swinging gates at the top access openings to fixed ladders.

- Ensure that the means of entry does not pose a hazard. Use mechanical devices to lift or open heavy in-ground doors or manhole lids. Use lighter composite lids if possible. Make sure doors will not swing shut in windy conditions.

Design to Ensure Ability to Rescue

If confined spaces cannot be eliminated, the space should be designed to facilitate non-entry rescue to the extent feasible.

- Provide access platforms of sufficient size to accommodate entry and potential rescue when access openings are elevated above floor level.

- Provide multiple access openings into the space, preferably at different locations for better access to all areas of the space.

- Ensure openings are at least 24 inches wide or measure 24 inches in diameter.

- Ensure adequate overhead clearance for use of a tripod or davit arm retrieval system during vertical entries. If there is not sufficient clearance, install a permanent anchor point (with at least 5,000 pounds static load capacity) above the opening to which a pulley or winch can be attached for rescue.

- Employ a pulley system or install regular access points for rescue from spaces where a horizontal entry is used,.

- Install multiple large release hatches at the bottoms of sloped hoppers and silos that could be opened to empty those structures quickly in case of engulfment.

Reference Materials

1. OSHA Permit Required Confined Space Standard 1910.146.
2. American National Standards Institute (ANSI)/ASSE Z590.3 Standard: “Prevention through Design: Guidelines for Addressing Occupational Risks in Design and Redesign Processes.”
3. American National Standards Institute (ANSI)/ASSE Z117.1 2009: “Safety Requirements for Confined Spaces.”
4. NIOSH Prevention through Design Link http://www.cdc.gov/niosh/topics/PTD/