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Occupational Safety and Health Program Requirements Handbook

Appendix 40-1

Part 445-2-H, Chapter 40

Confined Space Program for Stilling Wells"

Reviewed by: Anthony Zepeda

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I. BACKGROUND

Many stilling wells used at surface-water gaging stations meet the definition of confined space under Title 29 of the Code of Federal Regulations (CFR) sections 1910.146. The Occupational Safety and Health Administration (OSHA) require employees to be protected from hazards associated with confined space entry. The confined space hazard in stilling wells is real. The probability of a serious accident in a stilling well is low; however, the results can be fatal.

1. Hazardous Atmosphere Not Present

The first confined space procedures for stilling wells were based on the confined space standard, which was proposed by the National Institute for Occupational Safety and Health (NIOSH) before the OSHA standard was promulgated. This new stilling well confined space program requires that stilling wells be tested for hazardous atmosphere before and during entry. If atmospheric conditions are within acceptable limits and other hazards have been eliminated or controlled, the confined space will be reclassified to “non permit space” only for that day or entry. Enter information and data on Certification for Confined Space Entry of Stilling Well. (See Example Form 1.)

2. Hazardous Atmosphere Controlled with Ventilation (Alternate Procedures)

If atmospheric conditions are not within acceptable limits, then forced ventilation with an electric powered ventilator is required. If atmospheric conditions can be maintained within acceptable limits, entry is allowed with specific requirements. This type of entry is based on the “Alternate Procedures” allowed in the OSHA regulation at 29 CFR 1910.146(c)(5). Enter information and data on Certification for Confined Space Entry of Stilling Well. (See Example Form 2.)

Although not required for every entry, it is recommended that entrants use FORCED VENTILATION EVERY TIME an entry is performed in a stilling well that has a confined space. Stilling wells have the potential to have a hazardous atmosphere, such as when organic sediment at the bottom of the well is disturbed. Forced ventilation will help control the actual or potential atmospheric hazards.

3. Hazardous Atmosphere Present (Permit-required)

If atmospheric conditions cannot be maintained within acceptable limits using forced ventilation, entry is not allowed except through the permit system. Contact the Regional Safety Officer and/or the Bureau Industrial Hygienist for help in developing a permit.

II. IMPLEMENT MEASURES NECESSARY TO PREVENT UNAUTHORIZED ENTRY

Each stilling well that has a confined space will be labeled as or with similar wording. Confined Space Hazard Authorized Personnel Only



follows

III. IDENTIFY AND EVALUATE HAZARDS OF CONFINED SPACES BEFORE EMPLOYEES ENTER

Safety evaluations should be conducted just prior to entry of a stilling well. Personnel who conduct the safety evaluation for both physical and electrical safety hazards must have the necessary experience and skills needed to complete the evaluation. See example certification below.

1. Document the number of years the stilling well has been safely entered. Review historic safety evaluations/incidents to help identify potential safety concerns.

2. Evaluate and eliminate all identified physical hazards.

- Are ladders safe? Is fall protection needed? It is recommended, but not required, that a fall arrest harness be entering a stilling well. If an entrant is hurt and must be helped stilling well, a harness will make the extraction much easier and

- Fixed ladders should comply with design requirements of 1910.27. If they are more than 20 feet high, they should have landing platforms or ladder safety devices.

- Objects such as tools, shovels, sounding weights, tanks, etc. into the stilling well should be secured or removed. Personal gear (hard hat, rubber gloves, eye protection, etc.) must be used as appropriate.

- Wear a personal flotation device unless exempted by a Job Hazard Analysis.

3. Evaluate and eliminate all identified electrical hazards.

- All AC electrical circuits in gaging stations and stilling wells must be protected by a Ground Fault Circuit Interrupter (GFCI) device.

- Electric power tools used in stilling wells must be double-insulated or connected to a GFCI circuit.

4. Evaluate and eliminate all identified biological hazards such as sanitary concerns, snakes, wasps, mice (Hantavirus), bats (histoplasmosis), etc.

5. Test for, eliminate, and monitor for potential atmospheric hazards such as:

- Oxygen deficiency: Oxygen is used up by breathing, combustion, rusting, and decaying organics. An oxygen deficiency is defined as less than 19.5% oxygen.

- Propane: Propane may leak, displacing oxygen and could create an explosive hazard. Propane may burn inefficiently creating carbon monoxide. It is recommended that the use of propane to heat stilling wells be discontinued.

- Flammable gases or vapors: Flammable gases, such as methane, can be created by the decay of organic matter;



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29 CFR cages,

that could fall protective available and

- Carbon Monoxide is a product of incomplete combustion. The permissible exposure limit is 50 parts per million for an eight-hour time weighted average.
- Carbon Dioxide: If there is considerable organic debris in the bottom of the stilling well, carbon dioxide may be displacing oxygen.
- Hydrogen sulfide: Anaerobic digestion of organic matter such as when it is covered with water can release hydrogen sulfide. Hydrogen sulfide will cause olfactory fatigue. The nose will lose its ability to smell the gas, even though it is present in the space.
- Welding, painting, spills, and other activities may introduce other toxics such as lead, cadmium, arsenic, xylene, toluene, and benzene. **If these hazards are present, do not use this procedure without first consulting your safety professional.** You may need to use a permit system under these conditions.



IV. PROCEDURES FOR SAFE ENTRY

1. Eliminate any conditions making it unsafe to open an access door.
2. Place a guard or temporary barrier over the opening (if feasible) to prevent an accidental fall through the opening and to protect employees working in the space from foreign objects entering the space.
3. Control or eliminate physical hazards (*i.e.* falls, electrical) and biological hazards (*i.e.* snakes, wasps, mice, bats) as described above. Follow the Centers for Disease Control and Prevention recommendations to prevent Hantavirus. <http://www.cdc.gov>. Specific procedures are located in the section, “Precautions for Cleanup of Rodent-Contaminated Areas and Dead Rodents” at <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5109a1.htm>.
4. Lockout any identified hazardous energy sources.
5. Test the stilling well atmosphere before entry and after all other hazards are eliminated or controlled. However, if employees will disturb the bottom of the well, which could release hydrogen sulfide or methane or if they will use or produce hazardous chemicals by activities such as painting or welding, continuous atmospheric monitoring must be used while the employees are working in the stilling well.

6. Consider using forced ventilation, such as a portable electric blower, to supply fresh outside air into the stilling well before and during entry. Gasoline powered ventilators must not be used. The blower should be able to supply enough clean, fresh air to replace the total volume of air within the stilling well one (1) time each minute. (See Table 1 for Volume Calculations of Stilling Wells.) Direct the forced air to ventilate the immediate areas where an employee is or will be present within the space and continue ventilating until all employees have left the space. Exhaust from gasoline or propane powered sources (such as an electrical generator) must be vented downwind and down gradient from the stilling well and the mechanical blower to prevent accidental contamination of air in the stilling well.

7. Only trained and certified employees may enter stilling well confined spaces. (See section VIII for training requirements.)

8. Two or more persons are required for entry into a stilling well when maintenance is performed. For entry into a stilling well other than maintenance, a single individual may enter the stilling well without an attendant present provided that all potential hazards have been identified in a site-specific Job Hazard Analysis (JHA). The JHA must contain an exemption to a two or more person entry and it must be signed by the supervisor. The site-specific JHA should fully describe emergency procedures, emergency response agencies and the Center's "call-in" entry policy. Continuous air sampling is required.

9. Verify that conditions in the confined space are acceptable for entry throughout the duration of an authorized entry. If the forced ventilation stops working, the gas meter alarms, or if conditions in the area change, exit the confined space and re-evaluate.

10. Document the entry and conditions. See example certification below. Note any unusual circumstances that should be added to the confined space program. Forward those hazards or suggestions to the Bureau Industrial Hygienist (703-648-7556).

11. Get out of the stilling immediately if a hazardous condition is detected during entry. The space shall be evaluated to determine how the hazardous condition developed. Measures will be implemented to protect employees from the hazardous condition before any subsequent entry takes place. Examples of hazardous conditions are:

- Ventilation equipment fails;
- Fire in the immediate area;
- Outsiders attempt to enter the confined space;
- A hazardous or unknown material is released nearby;
- An entrant appears to be confused or overly tired; and
- Meter alarm sounds.

12. An employee who is trained and certified to operate the air monitoring equipment can certify that the atmosphere is safe and can reclassify a confined space. This can be the same employee who is going to enter the stilling well.

V. SUPPLIES AND EQUIPMENT PROVIDED AT NO COST TO EMPLOYEES

Examples of equipment that may be needed include:

- Ventilation equipment and generators if necessary
- Barricade
- Ladder
- Lights
- Hard hats
- Gloves
- Disposable coveralls
- Pump sprayer and bleach solution to disinfect rodent droppings
- Particulate respirator (voluntary use)
- Full body harness and life line
- Insect repellent containing N, N diethyl-*m*-toluamide (DEET) to repel ticks, fleas and mosquitoes
- Testing and monitoring equipment
- Communication equipment
- Potable water
- Hand washing supplies
- First aid kit
- Fire extinguisher

VI. DUTIES AND RESPONSIBILITIES

1. The **Bureau Industrial Hygienist** is responsible for implementing the confined space program and:

- Ensuring that a list of confined spaces is maintained;
- Advising supervisors of type of required training for personnel;
- Advising supervisors of type of equipment to use to be in compliance with standards;
- Advising supervisors of how and when to coordinate with outside responders;
- Reviewing entry data for lessons learned to update the program;
- Periodically reviewing procedures and training; and
- Ensuring the written program is reviewed and updated annually.

2. **Project Supervisors** are in charge of any confined space work and are responsible for:

- Ensuring training of personnel is conducted;
- Ensuring equipment is in compliance with standards;
- Determining the entry requirements;
- Requiring a certification review and signature from the authorized entry supervisor;
- Determining the number of employees required to perform the work; and
- Ensuring the employees know how to communicate with each other and how to obtain assistance.

3. Entry Supervisor. This person is on site and may play all roles of the confined space entry. An Entry Supervisor is a person who is trained and authorized to certify a confined space entry. He or she is responsible for:

- Ensuring requirements for entry have been completed before entry is authorized;
 - Documenting the known hazards at each stilling well with a confined space;
 - Determining if conditions are acceptable for entry;
 - Authorizing entry and overseeing entry operations;
 - Terminating entry procedures as required;
 - Serving as an attendant, as needed;
 - Ensuring measures are in place to keep unauthorized personnel clear of the area;
 - Checking the work at least twice a shift to verify and document that entry requirements are being observed;
- and
- Ensuring that a copy of the Job Hazard Analysis is on site.

4. Employee Entering Confined Space (Entrant) is an employee who is granted permission to enter a confined space. This person may also be the Entry Supervisor if all atmospheric conditions are acceptable and hazards are eliminated before entry. This person should:

- Read and observe the entry requirements including testing the atmospheric conditions;
- Stay alert to the hazards that could be encountered in a confined space;
- Use the required protective equipment; and
- Immediately exit the confined space when:
 - Ordered to do so by the attendant,
 - A danger is perceived, or
 - A physiological stress or change is noticed in either themselves or a co-worker (*e.g.*, dizziness, blurred vision, shortness of breath).
 - The gas meter alarm sounds.

5. Attendant. Although an attendant is *not required for alternate procedures or when the confined space is reclassified to non permit space*, if one is available he or she should:

- Be knowledgeable of, and be able to recognize potential confined space hazards;
- Monitor surrounding activities to ensure the safety of personnel;
- Maintain effective and continuous communication with personnel during confined space entry, work and exit;
- Order personnel to evacuate the confined space if he/she:
 - Notices the entrants acting strangely, possibly as a result of exposure to hazardous substances;
 - Notices a situation outside the confined space, which could endanger personnel;
 - Notices within the confined space a hazard, which has not been previously recognized or taken into consideration;
- Immediately summon the local fire department if crew rescue becomes necessary;
- Assist with rescue from outside the confined space; and
- Keep unauthorized persons out of the confined space, order them out, or notify authorized personnel of the unauthorized entry.

6. Rescue Team Although a rescue team is *not required for alternate procedures or when the confined space is reclassified to non permit space*, it is recommended that entry be coordinated with the local fire department. When possible:

- Allow the local fire department to complete a training drill using mannequins or personnel in a simulation of the confined space prior to the issuance of an entry permit for any confined space and at least annually thereafter; and
- Verify that the local fire department can respond immediately to rescue calls when there is a need for rescue from the confined space.

VII. ATMOSPHERIC TESTING

1. Gas testing

A trained and certified person will perform periodic gas testing of stilling wells before and during forced ventilation. The results of this testing will be documented and used to update the confined space program.

The internal atmosphere should be tested with a calibrated, direct-reading instrument for the following, in the order given:

- Oxygen content,
- Flammable gases and vapors, and
- Potential toxic air contaminants. (Typically these will be carbon monoxide and hydrogen sulfide. However, depending on the location and the potential for vapors to collect in the stilling wells from contaminated water, other chemicals may be tested.)

Testing equipment used in specialty areas will be listed or approved for use in such areas. This listing or approval should be from nationally recognized testing laboratories such as Underwriters Laboratories or Factory Mutual Systems.

The atmosphere in the stilling well should be tested at several locations. Because gases and vapors have different densities, atmospheric testing is usually performed near the bottom of the well, mid point, and near the top of the well. More measurements are recommended if the well is more than 15 feet deep.

A written record of the pre-entry test results will be made and kept at the work site for the duration of the job.

Based upon the results of the pre-entry testing, the employee performing the gas testing will certify in writing that all hazards have been eliminated.

Affected employees may review the testing results.

2. Acceptable Limits

The atmosphere of the confined spaces should be considered within acceptable limits whenever the following conditions are maintained:

- Oxygen - 19.5% to 23.5%,
- Flammability - less than 10% of the Lower Flammable Limit (LFL) or Lower Explosive Limit (LEL), and
- Toxicity - less than published exposure levels such as American Conference of Governmental Industrial Hygienists (ACGIH) threshold value limits (TLVs), OSHA permissible exposure limits (PELs) and NIOSH recommended exposure limits (RELs).

Whenever testing of the atmosphere indicates levels of oxygen, flammability, or toxicity that are not within acceptable limits during forced ventilation, this alternate procedure may no longer be used until the problem is resolved.

VII. ISOLATION AND LOCKOUT/TAGOUT

All energy sources, which are potentially hazardous to confined space entrants should be secured, relieved, disconnected and/or restrained before personnel are permitted to enter the confined space. Equipment systems or processes should be locked out per 29 CFR 1910.147, Control of Hazardous Energy Sources (Lockout/Tagout), prior to allowing entry into the confined space.

VIII. TRAINING

Training will be provided for all employees who work with stilling wells that are confined spaces. Training will be provided to each affected employee:

- Before the employee is first assigned confined space duties;
- Before there is a change in assigned duties;
- Whenever there is a change in confined space operations that presents a hazard for which an employee has not been trained; and
- Whenever the supervisor has reason to believe either that there are deviations from the required entry procedures or that there are inadequacies in the employee's knowledge or use of these procedures.

The training will establish employee proficiency in the duties required by this section and will introduce new or revised procedures, as necessary, for compliance with this section. Prior to performing procedures in a confined space, employees should practice procedures in a safe location and under the supervision of a qualified instructor.

1. General Training

Personnel responsible for supervising, planning, entering or participating in entries into stilling wells that are confined spaces will be adequately trained in their functional duties prior to any confined space entry. Training will include:

- General understanding of the OSHA confined space standard;
- Explanation of the general hazards associated with confined spaces in stilling wells (*i.e.* falls, electrical, thermal stresses);

- Discussion of specific confined space hazards associated with the stilling well, location or operation (*i.e.* rodents, history of low oxygen, located down river from a hazardous waste cleanup);
- Reason for, proper use, and limitations of personal protective equipment and other safety equipment required for entry (*i.e.* gloves, respirators, disposable suits, hard hats, safety goggles or glasses);
- Explanation of procedural requirements for conducting a confined space entry (practice the steps);
- A clear understanding of what conditions would prohibit entry (*i.e.* fire, intruders, gas testing meter failure);
- How to respond to emergencies (who to call and how, what can you do on your own);
- Duties and responsibilities to members of the team;
- Description of how to recognize symptoms of overexposure to probable air contaminants in themselves and co-workers; and
- Method(s) for alerting attendants and/or rescue personnel.

Refresher training will be conducted as needed to maintain employee competence in entry procedures and precautions. Refresher training is recommended at least every three (3) years.

2. Specific Training

Training for atmospheric monitoring personnel (gas testers) should include proper use of monitoring instruments such as:

- Proper use of the equipment and limitations of the equipment;
- Knowledge of calibration;
- Knowledge of sampling strategies and techniques;
- Knowledge of PELs, TLVs, LELs, Upper Explosive Limits (UELs), etc.; and
- Knowledge of conditions that may require different monitoring equipment such as painting or welding.

Training for attendants includes the following:

- Procedures for summoning rescue or other emergency services, and
- Proper utilization of equipment used for communicating with entry and emergency/rescue personnel.

3. Training for emergency response personnel

A rescue team is *not required for alternate procedures or when the confined space is reclassified to non permit space*. However, it is recommended that entry be coordinated with the local fire department.

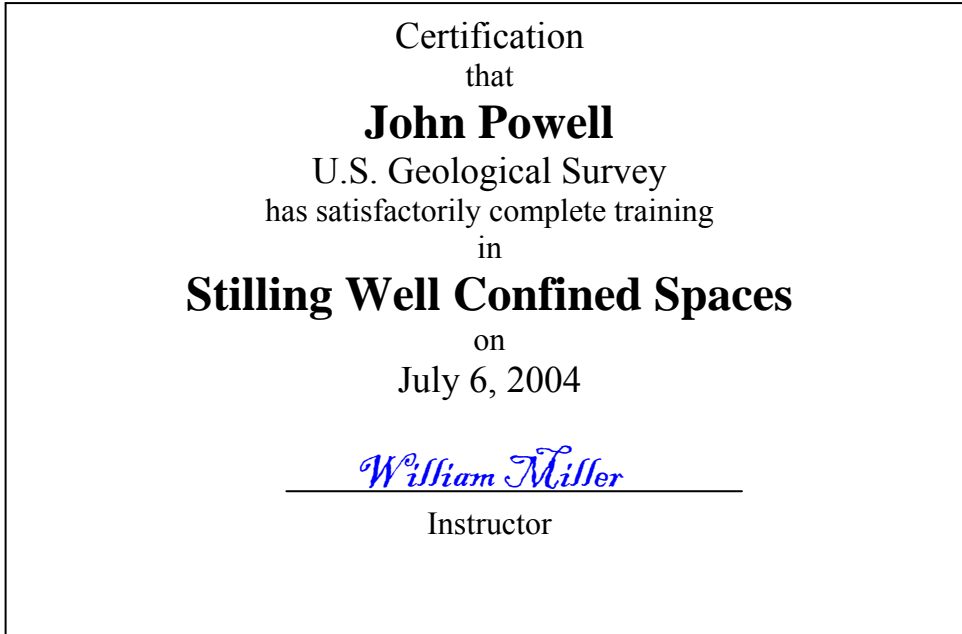
4. Verification of Training

Periodic assessment of the effectiveness of employee training should be conducted by a qualified person. Training sessions should be repeated as often as necessary to maintain an acceptable level of personnel competence.

5. Certification of Training

A certificate that required training was accomplished will be provided to employees. The certification will contain the employee's name, the signatures of the trainers, and the dates of training. The certification will be available for inspection.

Example Certification



IX. EMERGENCY RESPONSE

1. Emergency Response Plan

Although an emergency response plan is not required for the “alternate procedures,” it is a good practice and highly recommended. An emergency could be unrelated to atmospheric hazards in the confined space, such as a fall or heat stress, but still require outside assistance. A plan of action should include provisions to conduct a timely rescue for individuals in a confined space should an emergency arise.

2. Retrieval Systems or Methods to Facilitate Non-entry Rescue

The easiest and safest way to rescue an entrant is using a retrieval system. This allows non-entry rescue. This is much preferred since more “would be rescuers” die trying to perform confined space rescues than entrants. Retrieval systems should have a full body harness and a retrieval line attached at the center of the back near shoulder level or above the head. The retrieval line should be firmly fastened outside the space so that rescue can begin as soon as anyone is aware that retrieval is necessary. **Do not secure it to a vehicle unless the person attached to the line carries the only key.**

Karen D. Baker
Acting Associate Director for Administrative Policy and Services

Date

DEFINITIONS

"Acceptable entry conditions" means the conditions that must exist in a permit space to allow entry and to ensure that employees involved with a permit-required confined space entry can safely enter into and work within the space.

"Attendant" means an individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all attendant's duties assigned in the employer's permit space program.

"Authorized entrant" means an employee who is authorized by the employer to enter a permit space.

"Confined space" means a space that:

- (1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- (2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
- (3) Is not designed for continuous employee occupancy.

"Emergency" means any occurrence (including any failure of hazard control or monitoring equipment) or event internal or external to the permit space that could endanger entrants.

"Engulfment" means the surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

"Entry" means the action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space.

"Entry permit (permit)" means the written or printed document that is provided by the employer to allow and control entry into a permit space and that contains the information specified in 29 CFR 1910.146(f).

"Entry supervisor" means the person (such as the employer, foreman, or crew chief) responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations, and for terminating entry as required by this section. NOTE: An entry supervisor also may serve as an attendant or as an authorized entrant, as long as that person is trained and equipped as required by this section for each role he or she fills. Also, the duties of entry supervisor may be passed from one individual to another during the course of an entry operation.

"GFCI" is Ground Fault Circuit Interrupter.

"Hazardous atmosphere" means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

- (1) Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);
- (2) Airborne combustible dust at a concentration that meets or exceeds its LFL;

NOTE: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 m) or less.

- (3) Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;

(4) Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in 29 CFR 1910 Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, and which could result in employee exposure in excess of its dose or permissible exposure limit; and

NOTE: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.

(5) Any other atmospheric condition that is immediately dangerous to life or health.

NOTE: For air contaminants for which OSHA has not determined a dose or permissible exposure limit, other sources of information, such as Material Safety Data Sheets that comply with the Hazard Communication Standard, 29 CFR 1910.1200, published information, and internal documents can provide guidance in establishing acceptable atmospheric conditions.

"Hot work permit" means the employer's written authorization to perform operations (for example, riveting, welding, cutting, burning, and heating) capable of providing a source of ignition.

"Immediately dangerous to life or health (IDLH)" means any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a permit space. NOTE: Some materials -- hydrogen fluoride gas and cadmium vapor, for example -- may produce immediate transient effects that, even if severe, may pass without medical attention, but are followed by sudden, possibly fatal collapse 12-72 hours after exposure. The victim "feels normal" from recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be "immediately" dangerous to life or health.

"LEL" is Lower Explosive Limit and is the same as Lower Flammable Limit.

"Non-permit confined space" means a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

"Oxygen deficient atmosphere" means an atmosphere containing less than 19.5 percent oxygen by volume.

"Oxygen enriched atmosphere" means an atmosphere containing more than 23.5 percent oxygen by volume.

"PEL" is Permissible Exposure Limit from the Occupational Safety and Health Administration.

"Permit-required confined space (permit space)" means a confined space that has one or more of the following characteristics:

- (1) Contains or has a potential to contain a hazardous atmosphere;
- (2) Contains a material that has the potential for engulfing an entrant;
- (3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
- (4) Contains any other recognized serious safety or health hazard.

"Permit-required confined space program (permit space program)" means the employer's overall program for controlling, and, where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces.

"Permit system" means the employer's written procedure for preparing and issuing permits for entry and for returning the permit space to service following termination of entry.

"Prohibited condition" means any condition in a permit space that is not allowed by the permit during the period when entry is authorized.

"Rescue service" means the personnel designated to rescue employees from permit spaces.

"Retrieval system" means the equipment (including a retrieval line, chest or full-body harness, wristlets, if appropriate, and a lifting device or anchor) used for non-entry rescue of persons from permit spaces.

"Testing" means the process by which the hazards that may confront entrants of a permit space are identified and evaluated. Testing includes specifying the tests that are to be performed in the permit space.

NOTE: Testing enables employers both to devise and implement adequate control measures for the protection of authorized entrants and to determine if acceptable entry conditions are present immediately prior to, and during, entry.

“TLV” is Threshold Limit Value from the American Conference of Governmental Industrial Hygienists.

“UEL” is Upper Explosive Limit and is the same as Upper Flammable Limit.

REFERENCES

[29 CFR 1910.27](#) Fixed ladders

[29 CFR 1910.146](#) Permit-required confined spaces

[29 CFR 1910.147](#) The control of hazardous energy (lockout/tagout)

CDC National Center for Infectious Diseases Special Pathogens Branch
”[All About Hantaviruses](#)”

U.S. Geological Survey Manual [SM 445-2-H CHAPTER 40](#) Confined Spaces

Volume Calculations for Stilling Wells

For one air exchange per minute, the ventilator's flow rate should be at least the volume of the stilling well in cubic feet per minute (CFM).

Round Stilling Wells			Rectangular Stilling Wells			
Height (ft)	Diameter (in)	$(H)(3.14)(D/24)^2$	Height (ft)	Width (ft)	Length (ft)	$(H)(W)(L)$
		Volume (ft3)				Volume (ft3)
6	36	42	6	4	4	96
7	36	49	6	4	6	144
8	36	57	7	4	4	112
9	36	64	7	4	6	168
10	36	71	8	4	4	128
11	36	78	8	4	6	192
12	36	85	9	4	4	144
13	36	92	9	4	6	216
14	36	99	9	6	6	324
15	36	106	10	4	4	160
16	36	113	10	4	6	240
17	36	120	10	4	8	320
18	36	127	10	6	6	360
19	36	134	11	4	4	176
20	36	141	11	4	6	264
21	36	148	11	4	8	352
22	36	156	11	6	6	396
23	36	163	11	6	8	528
24	36	170	12	4	4	192
25	36	177	12	4	6	288
5	42	48	12	4	8	384
6	42	58	12	6	6	432
7	42	67	12	6	8	576
8	42	77	13	4	4	208
9	42	87	13	4	6	312
10	42	96	13	4	8	416
11	42	106	13	6	6	468
12	42	115	13	6	8	624
13	42	125	14	4	4	224
14	42	135	14	4	6	336
15	42	144	14	4	8	448
16	42	154	14	6	6	504
17	42	164	14	6	8	672
18	42	173	15	4	4	240
19	42	183	15	4	6	360
20	42	192	15	4	8	480
21	42	202	15	6	6	540
22	42	212	15	6	8	720
23	42	221	16	4	4	256
24	42	231	16	4	6	384
25	42	241	16	4	8	512

Rectangular Stilling Wells

			(H)(W)(L)
Height (ft)	Width (ft)	Length (ft)	Volume (ft ³)
16	6	6	576
16	6	8	768
16	8	8	1024
16	8	10	1280
17	4	4	272
17	4	6	408
17	4	8	544
17	6	6	612
17	6	8	816
17	8	8	1088
17	8	10	1360
18	4	4	288
18	4	6	432
18	4	8	576
18	6	6	648
18	6	8	864
18	8	8	1152
18	8	10	1440
19	4	4	304
19	4	6	456
19	4	8	608
19	6	6	684
19	6	8	912
19	8	8	1216
19	8	10	1520
20	4	4	320
20	4	6	480
20	4	8	640
20	6	6	720
20	6	8	960
20	8	8	1280
20	8	10	1600