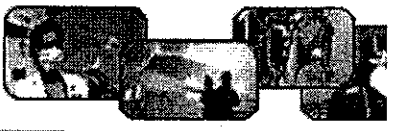

Regulations (Standards - 29 CFR)

Permit-required confined spaces - 1910.146

Regulations (Standards - 29 CFR) - Table of Contents

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• **Subpart:**	J
• **Subpart Title:**	General Environmental Controls
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• **Title:**	Permit-required confined spaces
• **Appendix:**	A, B, C, D, E, F

1910.146(a)

Scope and application. This section contains requirements for practices and procedures to protect employees in general industry from the hazards of entry into permit-required confined spaces. This section does not apply to agriculture, to construction, or to shipyard employment (Parts 1928, 1926, and 1915 of this chapter, respectively).

* NOTE Applicability

1910.146(b)

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.

"Blanking or blinding" means the absolute closure of a pipe, line, or duct by the fastening of a solid plate (such as a spectacle blind or a skillet blind) that completely covers the bore and that is capable of withstanding the maximum pressure of the pipe, line, or duct with no leakage beyond the plate.

"Confined space" means a space that:

(1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and * NOTE

(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.

"Double block and bleed" means the closure of a line, duct, or pipe by closing and locking or tagging two in-line valves and by opening and locking or tagging a drain or vent valve in the line between the two closed valves.

"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 paragraph (f) of this section.

"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.

"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 Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of this Part and which could result in employee exposure in excess of its dose or permissible exposure limit;

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, section 1910.1200 of this Part, 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.

"Inerting" means the displacement of the atmosphere in a permit space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.

NOTE: This procedure produces an IDLH oxygen-deficient atmosphere.

"Isolation" means the process by which a permit space is removed from service and completely protected against the release of energy and material into the space by such means as: blanking or blinding; misaligning or removing sections of lines, pipes, or ducts; a double block and bleed system; lockout or tagout of all sources of energy; or blocking or disconnecting all mechanical linkages.

"Line breaking" means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

"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. * NOTE

"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.

"Permit-required confined space (permit space)" means a confined space that has one or more of the following characteristics: * NOTE YRB meets (1), Air quality, and possibly (4), fall hazard d.o.

(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.

1910.146(c)

General requirements.

1910.146(c)(1)

The employer shall evaluate the workplace to determine if any spaces are permit-required confined spaces.

NOTE: Proper application of the decision flow chart in Appendix A to section 1910.146 would facilitate compliance with this requirement.

1910.146(c)(2)

If the workplace contains permit spaces, the employer shall inform exposed employees, by posting danger signs or by any other equally effective means, of the existence and location of and the danger posed by the permit spaces.

NOTE: A sign reading DANGER -- PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER or using other similar language would satisfy the requirement for a sign.

..1910.146(c)(3)

1910.146(c)(3)

If the employer decides that its employees will not enter permit spaces, the employer shall take effective measures to prevent its employees from entering the permit spaces and shall comply with paragraphs (c)(1), (c)(2), (c)(6), and (c)(8) of this section.

1910.146(c)(4)

If the employer decides that its employees will enter permit spaces, the employer shall develop and implement a written permit space program that complies with this section. The written program shall be available for inspection by employees and their authorized representatives.

* NOTE: NEED PLAN

1910.146(c)(5)

An employer may use the alternate procedures specified in paragraph (c)(5)(ii) of this section for entering a permit space under the conditions set forth in paragraph (c)(5)(i) of this section.

1910.146(c)(5)(i)

An employer whose employees enter a permit space need not comply with paragraphs (d) through (f) and (h) through (k) of this section, provided that:

1910.146(c)(5)(i)(A)

The employer can demonstrate that the only hazard posed by the permit space is an actual or potential hazardous atmosphere;

* NOTE: THERE IS A FALL HAZard

1910.146(c)(5)(i)(B)

The employer can demonstrate that continuous forced air ventilation alone is sufficient to maintain that permit space safe for entry;

1910.146(c)(5)(i)(C)

The employer develops monitoring and inspection data that supports the demonstrations required by paragraphs (c)(5)(i)(A) and (c)(5)(i)(B) of this section;

1910.146(c)(5)(i)(D)

If an initial entry of the permit space is necessary to obtain the data required by paragraph (c)(5)(i)(C) of this section, the entry is performed in compliance with paragraphs (d) through (k) of this section;

1910.146(c)(5)(i)(E)

The determinations and supporting data required by paragraphs (c)(5)(i)(A), (c)(5)(i)(B), and (c)(5)(i)(C) of this section are documented by the employer and are made available to each employee who enters the permit space under the

terms of paragraph (c)(5) of this section or to that employee's authorized representative; and

1910.146(c)(5)(i)(F)

Entry into the permit space under the terms of paragraph (c)(5)(i) of this section is performed in accordance with the requirements of paragraph (c)(5)(ii) of this section.

NOTE: See paragraph (c)(7) of this section for reclassification of a permit space after all hazards within the space have been eliminated.

1910.146(c)(5)(ii)

The following requirements apply to entry into permit spaces that meet the conditions set forth in paragraph (c)(5)(i) of this section.

1910.146(c)(5)(ii)(A)

Any conditions making it unsafe to remove an entrance cover shall be eliminated before the cover is removed.

..1910.146(c)(5)(ii)(B)

1910.146(c)(5)(ii)(B)

When entrance covers are removed, the opening shall be promptly guarded by a railing, temporary cover, or other temporary barrier that will prevent an accidental fall through the opening and that will protect each employee working in the space from foreign objects entering the space.

1910.146(c)(5)(ii)(C)

Before an employee enters the space, the internal atmosphere shall be tested, with a calibrated direct-reading instrument, for oxygen content, for flammable gases and vapors, and for potential toxic air contaminants, in that order. Any employee who enters the space, or that employee's authorized representative, shall be provided an opportunity to observe the pre-entry testing required by this paragraph.

1910.146(c)(5)(ii)(C)(1)

Oxygen content,

1910.146(c)(5)(ii)(C)(2)

Flammable gases and vapors, and

1910.146(c)(5)(ii)(C)(3)

Potential toxic air contaminants.

1910.146(c)(5)(ii)(D)

There may be no hazardous atmosphere within the space whenever any employee is inside the space.

1910.146(c)(5)(ii)(E)

Continuous forced air ventilation shall be used, as follows:

1910.146(c)(5)(ii)(E)(1)

An employee may not enter the space until the forced air ventilation has eliminated any hazardous atmosphere;

1910.146(c)(5)(ii)(E)(2)

The forced air ventilation shall be so directed as to ventilate the immediate areas where an employee is or will be present within the space and shall continue until all employees have left the space;

1910.146(c)(5)(ii)(E)(3)

The air supply for the forced air ventilation shall be from a clean source and may not increase the hazards in the space.

1910.146(c)(5)(ii)(F)

The atmosphere within the space shall be periodically tested as necessary to ensure that the continuous forced air ventilation is preventing the accumulation of a hazardous atmosphere. Any employee who enters the space, or that employee's authorized representative, shall be provided with an opportunity to observe the periodic testing required by this paragraph.

1910.146(c)(5)(ii)(G)

If a hazardous atmosphere is detected during entry:

1910.146(c)(5)(ii)(G)(1)

Each employee shall leave the space immediately;

1910.146(c)(5)(ii)(G)(2)

The space shall be evaluated to determine how the hazardous atmosphere developed; and

1910.146(c)(5)(ii)(G)(3)

Measures shall be implemented to protect employees from the hazardous atmosphere before any subsequent entry takes place.

1910.146(c)(5)(ii)(H)

The employer shall verify that the space is safe for entry and that the pre-entry measures required by paragraph (c)(5)(ii) of this section have been taken, through a written certification that contains the date, the location of the space,

and the signature of the person providing the certification. The certification shall be made before entry and shall be made available to each employee entering the space or to that employee's authorized representative.

1910.146(c)(6)

When there are changes in the use or configuration of a non-permit confined space that might increase the hazards to entrants, the employer shall reevaluate that space and, if necessary, reclassify it as a permit-required confined space.

..1910.146(c)(7)

1910.146(c)(7)

A space classified by the employer as a permit-required confined space may be reclassified as a non-permit confined space under the following procedures:

* NOTE: reclassify upon atmospheric testing.

1910.146(c)(7)(i)

If the permit space poses no actual or potential atmospheric hazards and if all hazards within the space are eliminated without entry into the space, the permit space may be reclassified as a non-permit confined space for as long as the non-atmospheric hazards remain eliminated.

1910.146(c)(7)(ii)

If it is necessary to enter the permit space to eliminate hazards, such entry shall be performed under paragraphs (d) through (k) of this section. If testing and inspection during that entry demonstrate that the hazards within the permit space have been eliminated, the permit space may be reclassified as a non-permit confined space for as long as the hazards remain eliminated.

NOTE: Control of atmospheric hazards through forced air ventilation does not constitute elimination of the hazards. Paragraph (c)(5) covers permit space entry where the employer can demonstrate that forced air ventilation alone will control all hazards in the space.

1910.146(c)(7)(iii)

The employer shall document the basis for determining that all hazards in a permit space have been eliminated, through a certification that contains the date, the location of the space, and the signature of the person making the determination. The certification shall be made available to each employee entering the space or to that employee's authorized representative.

1910.146(c)(7)(iv)

If hazards arise within a permit space that has been declassified to a non-permit space under paragraph (c)(7) of this section, each employee in the space shall exit the space. The employer shall then reevaluate the space and determine whether it must be reclassified as a permit space, in accordance with other applicable provisions of this section.

1910.146(c)(8)

When an employer (host employer) arranges to have employees of another employer (contractor) perform work that involves permit space entry, the host employer shall:

1910.146(c)(8)(i)

Inform the contractor that the workplace contains permit spaces and that permit space entry is allowed only through compliance with a permit space program meeting the requirements of this section;

1910.146(c)(8)(ii)

Apprise the contractor of the elements, including the hazards identified and the host employer's experience with the space, that make the space in question a permit space;

1910.146(c)(8)(iii)

Apprise the contractor of any precautions or procedures that the host employer has implemented for the protection of employees in or near permit spaces where contractor personnel will be working;

1910.146(c)(8)(iv)

Coordinate entry operations with the contractor, when both host employer personnel and contractor personnel will be working in or near permit spaces, as required by paragraph (d)(11) of this section; and

..1910.146(c)(8)(v)

1910.146(c)(8)(v)

Debrief the contractor at the conclusion of the entry operations regarding the permit space program followed and regarding any hazards confronted or created in permit spaces during entry operations.

1910.146(c)(9)

In addition to complying with the permit space requirements that apply to all employers, each contractor who is retained to perform permit space entry operations shall:

1910.146(c)(9)(i)

Obtain any available information regarding permit space hazards and entry operations from the host employer;

1910.146(c)(9)(ii)

Coordinate entry operations with the host employer, when both host employer personnel and contractor personnel will be working in or near permit spaces, as required by paragraph (d)(11) of this section; and

1910.146(c)(9)(iii)

Inform the host employer of the permit space program that the contractor will follow and of any hazards confronted or created in permit spaces, either through a debriefing or during the entry operation.

1910.146(d)

Permit-required confined space program (permit space program). Under the permit space program required by paragraph (c)(4) of this section, the employer shall:

1910.146(d)(1)

Implement the measures necessary to prevent unauthorized entry;

1910.146(d)(2)

Identify and evaluate the hazards of permit spaces before employees enter them;

1910.146(d)(3)

Develop and implement the means, procedures, and practices necessary for safe permit space entry operations, including, but not limited to, the following:

1910.146(d)(3)(i)

Specifying acceptable entry conditions;

1910.146(d)(3)(ii)

Providing each authorized entrant or that employee's authorized representative with the opportunity to observe any monitoring or testing of permit spaces;

1910.146(d)(3)(iii)

Isolating the permit space;

1910.146(d)(3)(iv)

Purging, inerting, flushing, or ventilating the permit space as necessary to eliminate or control atmospheric hazards;

1910.146(d)(3)(v)

Providing pedestrian, vehicle, or other barriers as necessary to protect entrants from external hazards; and

1910.146(d)(3)(vi)

Verifying that conditions in the permit space are acceptable for entry throughout the duration of an authorized entry.

1910.146(d)(4)

Provide the following equipment (specified in paragraphs (d)(4)(i) through (d)(4)(ix) of this section) at no cost to employees, maintain that equipment properly, and ensure that employees use that equipment properly:

..1910.146(d)(4)(i)

1910.146(d)(4)(i)

Testing and monitoring equipment needed to comply with paragraph (d)(5) of this section;

1910.146(d)(4)(ii)

Ventilating equipment needed to obtain acceptable entry conditions;

1910.146(d)(4)(iii)

Communications equipment necessary for compliance with paragraphs (h)(3) and (i)(5) of this section;

1910.146(d)(4)(iv)

Personal protective equipment insofar as feasible engineering and work practice controls do not adequately protect employees;

1910.146(d)(4)(v)

Lighting equipment needed to enable employees to see well enough to work safely and to exit the space quickly in an emergency;

1910.146(d)(4)(vi)

Barriers and shields as required by paragraph (d)(3)(iv) of this section;

1910.146(d)(4)(vii)

Equipment, such as ladders, needed for safe ingress and egress by authorized entrants;

1910.146(d)(4)(viii)

Rescue and emergency equipment needed to comply with paragraph (d)(9) of this section, except to the extent that the equipment is provided by rescue services; and

1910.146(d)(4)(ix)

Any other equipment necessary for safe entry into and rescue from permit spaces.

1910.146(d)(5)

Evaluate permit space conditions as follows when entry operations are conducted:

1910.146(d)(5)(i)

Test conditions in the permit space to determine if acceptable entry conditions exist before entry is authorized to begin, except that, if isolation of the space is infeasible because the space is large or is part of a continuous system (such as a sewer), pre-entry testing shall be performed to the extent feasible before entry is authorized and, if entry is authorized, entry conditions shall be continuously monitored in the areas where authorized entrants are working;

1910.146(d)(5)(ii)

Test or monitor the permit space as necessary to determine if acceptable entry conditions are being maintained during the course of entry operations; and

1910.146(d)(5)(iii)

When testing for atmospheric hazards, test first for oxygen, then for combustible gases and vapors, and then for toxic gases and vapors.

1910.146(d)(5)(iv)

Provide each authorized entrant or that employee's authorized representative an opportunity to observe the pre-entry and any subsequent testing or monitoring of permit spaces;

1910.146(d)(5)(v)

Reevaluate the permit space in the presence of any authorized entrant or that employee's authorized representative who requests that the employer conduct such reevaluation because the entrant or representative has reason to believe that the evaluation of that space may not have been adequate;

1910.146(d)(5)(vi)

Immediately provide each authorized entrant or that employee's authorized representative with the results of any testing conducted in accord with paragraph (d) of this section.

NOTE: Atmospheric testing conducted in accordance with Appendix B to section 1910.146 would be considered as satisfying the requirements of this paragraph. For permit space operations in sewers, atmospheric testing conducted in accordance with Appendix B, as supplemented by Appendix E to section 1910.146, would be considered as satisfying the requirements of this paragraph.

1910.146(d)(6)

Provide at least one attendant outside the permit space into which entry is authorized for the duration of entry operations;

NOTE: Attendants may be assigned to monitor more than one permit space provided the duties described in paragraph (i) of this section can be effectively performed for each permit space that is monitored. Likewise, attendants may be stationed at any location outside the permit space to be monitored as long as the duties described in paragraph (i) of this section can be effectively

performed for each permit space that is monitored.

..1910.146(d)(7)

1910.146(d)(7)

If multiple spaces are to be monitored by a single attendant, include in the permit program the means and procedures to enable the attendant to respond to an emergency affecting one or more of the permit spaces being monitored without distraction from the attendant's responsibilities under paragraph (i) of this section;

1910.146(d)(8)

Designate the persons who are to have active roles (as, for example, authorized entrants, attendants, entry supervisors, or persons who test or monitor the atmosphere in a permit space) in entry operations, identify the duties of each such employee, and provide each such employee with the training required by paragraph (g) of this section;

1910.146(d)(9)

Develop and implement procedures for summoning rescue and emergency services, for rescuing entrants from permit spaces, for providing necessary emergency services to rescued employees, and for preventing unauthorized personnel from attempting a rescue;

1910.146(d)(10)

Develop and implement a system for the preparation, issuance, use, and cancellation of entry permits as required by this section;

1910.146(d)(11)

Develop and implement procedures to coordinate entry operations when employees of more than one employer are working simultaneously as authorized entrants in a permit space, so that employees of one employer do not endanger the employees of any other employer;

1910.146(d)(12)

Develop and implement procedures (such as closing off a permit space and canceling the permit) necessary for concluding the entry after entry operations have been completed;

1910.146(d)(13)

Review entry operations when the employer has reason to believe that the measures taken under the permit space program may not protect employees and revise the program to correct deficiencies found to exist before subsequent entries are authorized; and

NOTE: Examples of circumstances requiring the review of the permit space program are: any unauthorized entry of a permit space, the detection of a permit space hazard not covered by the permit, the detection of a condition

prohibited by the permit, the occurrence of an injury or near-miss during entry, a change in the use or configuration of a permit space, and employee complaints about the effectiveness of the program.

1910.146(d)(14)

Review the permit space program, using the canceled permits retained under paragraph (e)(6) of this section within 1 year after each entry and revise the program as necessary, to ensure that employees participating in entry operations are protected from permit space hazards.

NOTE: Employers may perform a single annual review covering all entries performed during a 12-month period. If no entry is performed during a 12-month period, no review is necessary.

Appendix C to section 1910.146 presents examples of permit space programs that are considered to comply with the requirements of paragraph (d) of this section.

1910.146(e)

Permit system.

1910.146(e)(1)

Before entry is authorized, the employer shall document the completion of measures required by paragraph (d)(3) of this section by preparing an entry permit.

NOTE: Appendix D to section 1910.146 presents examples of permits whose elements are considered to comply with the requirements of this section.

1910.146(e)(2)

Before entry begins, the entry supervisor identified on the permit shall sign the entry permit to authorize entry.

1910.146(e)(3)

The completed permit shall be made available at the time of entry to all authorized entrants or their authorized representatives, by posting it at the entry portal or by any other equally effective means, so that the entrants can confirm that pre-entry preparations have been completed.

..1910.146(e)(4)

1910.146(e)(4)

The duration of the permit may not exceed the time required to complete the assigned task or job identified on the permit in accordance with paragraph (f)(2) of this section.

1910.146(e)(5)

The entry supervisor shall terminate entry and cancel the entry permit when:

1910.146(e)(5)(i)

The entry operations covered by the entry permit have been completed; or

1910.146(e)(5)(ii)

A condition that is not allowed under the entry permit arises in or near the permit space.

1910.146(e)(6)

The employer shall retain each canceled entry permit for at least 1 year to facilitate the review of the permit-required confined space program required by paragraph (d)(14) of this section. Any problems encountered during an entry operation shall be noted on the pertinent permit so that appropriate revisions to the permit space program can be made.

1910.146(f)

Entry permit. The entry permit that documents compliance with this section and authorizes entry to a permit space shall identify:

1910.146(f)(1)

The permit space to be entered;

1910.146(f)(2)

The purpose of the entry;

1910.146(f)(3)

The date and the authorized duration of the entry permit;

1910.146(f)(4)

The authorized entrants within the permit space, by name or by such other means (for example, through the use of rosters or tracking systems) as will enable the attendant to determine quickly and accurately, for the duration of the permit, which authorized entrants are inside the permit space;

NOTE: This requirement may be met by inserting a reference on the entry permit as to the means used, such as a roster or tracking system, to keep track of the authorized entrants within the permit space.

1910.146(f)(5)

The personnel, by name, currently serving as attendants;

1910.146(f)(6)

The individual, by name, currently serving as entry supervisor, with a space for the signature or initials of the entry supervisor who originally authorized entry;

1910.146(f)(7)

The hazards of the permit space to be entered;

1910.146(f)(8)

The measures used to isolate the permit space and to eliminate or control permit space hazards before entry;

NOTE: Those measures can include the lockout or tagging of equipment and procedures for purging, inerting, ventilating, and flushing permit spaces.

1910.146(f)(9)

The acceptable entry conditions;

1910.146(f)(10)

The results of initial and periodic tests performed under paragraph (d)(5) of this section, accompanied by the names or initials of the testers and by an indication of when the tests were performed;

..1910.146(f)(11)

1910.146(f)(11)

The rescue and emergency services that can be summoned and the means (such as the equipment to use and the numbers to call) for summoning those services;

1910.146(f)(12)

The communication procedures used by authorized entrants and attendants to maintain contact during the entry;

1910.146(f)(13)

Equipment, such as personal protective equipment, testing equipment, communications equipment, alarm systems, and rescue equipment, to be provided for compliance with this section;

1910.146(f)(14)

Any other information whose inclusion is necessary, given the circumstances of the particular confined space, in order to ensure employee safety; and (15) Any additional permits, such as for hot work, that have been issued to authorize work in the permit space.

1910.146(g)

Training.

1910.146(g)(1)

The employer shall provide training so that all employees whose work is regulated by this section acquire the understanding, knowledge, and skills necessary for the safe performance of the duties assigned under this section.

1910.146(g)(2)

Training shall be provided to each affected employee:

1910.146(g)(2)(i)

Before the employee is first assigned duties under this section;

1910.146(g)(2)(ii)

Before there is a change in assigned duties;

1910.146(g)(2)(iii)

Whenever there is a change in permit space operations that presents a hazard about which an employee has not previously been trained;

1910.146(g)(2)(iv)

Whenever the employer has reason to believe either that there are deviations from the permit space entry procedures required by paragraph (d)(3) of this section or that there are inadequacies in the employee's knowledge or use of these procedures.

1910.146(g)(3)

The training shall establish employee proficiency in the duties required by this section and shall introduce new or revised procedures, as necessary, for compliance with this section.

1910.146(g)(4)

The employer shall certify that the training required by paragraphs (g)(1) through (g)(3) of this section has been accomplished. The certification shall contain each employee's name, the signatures or initials of the trainers, and the dates of training. The certification shall be available for inspection by employees and their authorized representatives.

1910.146(h)

Duties of authorized entrants. The employer shall ensure that all authorized entrants:

..1910.146(h)(1)

1910.146(h)(1)

Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;

1910.146(h)(2)

Properly use equipment as required by paragraph (d)(4) of this section;

1910.146(h)(3)

Communicate with the attendant as necessary to enable the attendant to monitor entrant status and to enable the attendant to alert entrants of the need to evacuate the space as required by paragraph (i)(6) of this section;

1910.146(h)(4)

Alert the attendant whenever:

1910.146(h)(4)(i)

The entrant recognizes any warning sign or symptom of exposure to a dangerous situation, or

1910.146(h)(4)(ii)

The entrant detects a prohibited condition; and

1910.146(h)(5)

Exit from the permit space as quickly as possible whenever:

1910.146(h)(5)(i)

An order to evacuate is given by the attendant or the entry supervisor,

1910.146(h)(5)(ii)

The entrant recognizes any warning sign or symptom of exposure to a dangerous situation,

1910.146(h)(5)(iii)

The entrant detects a prohibited condition, or

1910.146(h)(5)(iv)

An evacuation alarm is activated.

1910.146(i)

Duties of attendants. The employer shall ensure that each attendant:

1910.146(i)(1)

Knows the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;

1910.146(i)(2)

Is aware of possible behavioral effects of hazard exposure in authorized entrants;

1910.146(i)(3)

Continuously maintains an accurate count of authorized entrants in the permit space and ensures that the means used to identify authorized entrants under paragraph (f)(4) of this section accurately identifies who is in the permit space;

1910.146(i)(4)

Remains outside the permit space during entry operations until relieved by another attendant;

NOTE: When the employer's permit entry program allows attendant entry for rescue, attendants may enter a permit space to attempt a rescue if they have been trained and equipped for rescue operations as required by paragraph (k)(1) of this section and if they have been relieved as required by paragraph (i)(4) of this section.

1910.146(i)(5)

Communicates with authorized entrants as necessary to monitor entrant status and to alert entrants of the need to evacuate the space under paragraph (i)(6) of this section;

..1910.146(i)(6)

1910.146(i)(6)

Monitors activities inside and outside the space to determine if it is safe for entrants to remain in the space and orders the authorized entrants to evacuate the permit space immediately under any of the following conditions;

1910.146(i)(6)(i)

If the attendant detects a prohibited condition;

1910.146(i)(6)(ii)

If the attendant detects the behavioral effects of hazard exposure in an authorized entrant;

1910.146(i)(6)(iii)

If the attendant detects a situation outside the space that could endanger the authorized entrants; or

1910.146(i)(6)(iv)

If the attendant cannot effectively and safely perform all the duties required under paragraph (i) of this section;

1910.146(i)(7)

Summon rescue and other emergency services as soon as the attendant determines that authorized entrants may need assistance to escape from permit space hazards;

1910.146(i)(8)

Takes the following actions when unauthorized persons approach or enter a permit space while entry is underway:

1910.146(i)(8)(i)

Warn the unauthorized persons that they must stay away from the permit space;

1910.146(i)(8)(ii)

Advise the unauthorized persons that they must exit immediately if they have entered the permit space; and

1910.146(i)(8)(iii)

Inform the authorized entrants and the entry supervisor if unauthorized persons have entered the permit space;

1910.146(i)(9)

Performs non-entry rescues as specified by the employer's rescue procedure; and

1910.146(i)(10)

Performs no duties that might interfere with the attendant's primary duty to monitor and protect the authorized entrants.

1910.146(j)

Duties of entry supervisors. The employer shall ensure that each entry supervisor:

1910.146(j)(1)

Knows the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;

1910.146(j)(2)

Verifies, by checking that the appropriate entries have been made on the permit, that all tests specified by the permit have been conducted and that all procedures and equipment specified by the permit are in place before endorsing the permit and allowing entry to begin;

..1910.146(j)(3)

1910.146(j)(3)

Terminates the entry and cancels the permit as required by paragraph (e)(5) of this section;

1910.146(j)(4)

Verifies that rescue services are available and that the means for summoning them are operable;

1910.146(j)(5)

Removes unauthorized individuals who enter or who attempt to enter the permit space during entry operations; and

1910.146(j)(6)

Determines, whenever responsibility for a permit space entry operation is transferred and at intervals dictated by the hazards and operations performed within the space, that entry operations remain consistent with terms of the entry permit and that acceptable entry conditions are maintained.

1910.146(k)

Rescue and emergency services.

1910.146(k)(1)

An employer who designates rescue and emergency services, pursuant to paragraph (d)(9) of this section, shall:

1910.146(k)(1)(i)

Evaluate a prospective rescuer's ability to respond to a rescue summons in a timely manner, considering the hazard(s) identified;

Note to paragraph (k)(l)(i): What will be considered timely will vary according to the specific hazards involved in each entry. For example, §1910.134, Respiratory Protection, requires that employers provide a standby person or persons capable of immediate action to rescue employee(s) wearing respiratory protection while in work areas defined as IDLH atmospheres.

1910.146(k)(1)(ii)

Evaluate a prospective rescue service's ability, in terms of proficiency with rescue-related tasks and equipment, to function appropriately while rescuing entrants from the particular permit space or types of permit spaces identified;

1910.146(k)(1)(iii)

Select a rescue team or service from those evaluated that:

1910.146(k)(1)(iii)(A)

Has the capability to reach the victim(s) within a time frame that is appropriate for the permit space hazard(s) identified;

1910.146(k)(1)(iii)(B)

Is equipped for and proficient in performing the needed rescue services;

1910.146(k)(1)(iv)

Inform each rescue team or service of the hazards they may confront when called on to perform rescue at the site; and

1910.146(k)(1)(v)

Provide the rescue team or service selected with access to all permit spaces from which rescue may be necessary so that the rescue service can develop appropriate rescue plans and practice rescue operations.

Note to paragraph (k)(1): Non-mandatory Appendix F contains examples of criteria which employers can use in evaluating prospective rescuers as required by paragraph (k)(l) of this section.

1910.146(k)(2)

An employer whose employees have been designated to provide permit space rescue and emergency services shall take the following measures:

1910.146(k)(2)(i)

Provide affected employees with the personal protective equipment (PPE) needed to conduct permit space rescues safely and train affected employees so they are proficient in the use of that PPE, at no cost to those employees;

1910.146(k)(2)(ii)

Train affected employees to perform assigned rescue duties. The employer must ensure that such employees successfully complete the training required to establish proficiency as an authorized entrant, as provided by paragraphs (g) and (h) of this section;

1910.146(k)(2)(iii)

Train affected employees in basic first-aid and cardiopulmonary resuscitation (CPR). The employer shall ensure that at least one member of the rescue team or service holding a current certification in first aid and CPR is available; and

1910.146(k)(2)(iv)

Ensure that affected employees practice making permit space rescues at least once every 12 months, by means of simulated rescue operations in which they remove dummies, manikins, or actual persons from the actual permit spaces or from representative permit spaces. Representative permit spaces shall, with respect to opening size, configuration, and accessibility, simulate the types of permit spaces from which rescue is to be performed.

..1910.146(k)(3)

1910.146(k)(3)

To facilitate non-entry rescue, retrieval systems or methods shall be used whenever an authorized entrant enters a permit space, unless the retrieval equipment would increase the overall risk of entry or would not contribute to the rescue of the entrant. Retrieval systems shall meet the following requirements.

1910.146(k)(3)(i)

Each authorized entrant shall use a chest or full body harness, with a retrieval line attached at the center of the entrant's back near shoulder level, above the entrant's head, or at another point which the employer can establish presents a profile small enough for the successful removal of the entrant. Wristlets may be used in lieu of the chest or full body harness if the employer can demonstrate that the use of a chest or full body harness is infeasible or creates a greater hazard and that the use of wristlets is the safest and most effective alternative.

1910.146(k)(3)(ii)

The other end of the retrieval line shall be attached to a mechanical device or fixed point outside the permit space in such a manner that rescue can begin as soon as the rescuer becomes aware that rescue is necessary. A mechanical device shall be available to retrieve personnel from vertical type permit spaces more than 5 feet (1.52 m) deep

1910.146(k)(4)

If an injured entrant is exposed to a substance for which a Material Safety Data Sheet (MSDS) or other similar written information is required to be kept at the worksite, that MSDS or written information shall be made available to the medical facility treating the exposed entrant.

1910.146(l)

Employee participation.

1910.146(l)(1)

Employers shall consult with affected employees and their authorized representatives on the development and implementation of all aspects of the permit space program required by paragraph (c) of this section.

1910.146(l)(2)

Employers shall make available to affected employees and their authorized representatives all information required to be developed by this section.

[58 FR 4549, Jan. 14, 1993; 58 FR 34845, June 29, 1993; 59 FR 26115, May 19, 1994; 63 FR 66038, Dec. 1, 1998]

Next Standard (1910.146 App A)

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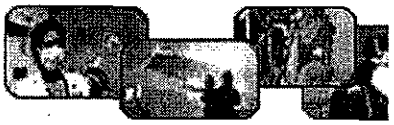


Regulations (Standards - 29 CFR)

Permit-required Confined Space Decision Flow Chart - 1910.146 App A

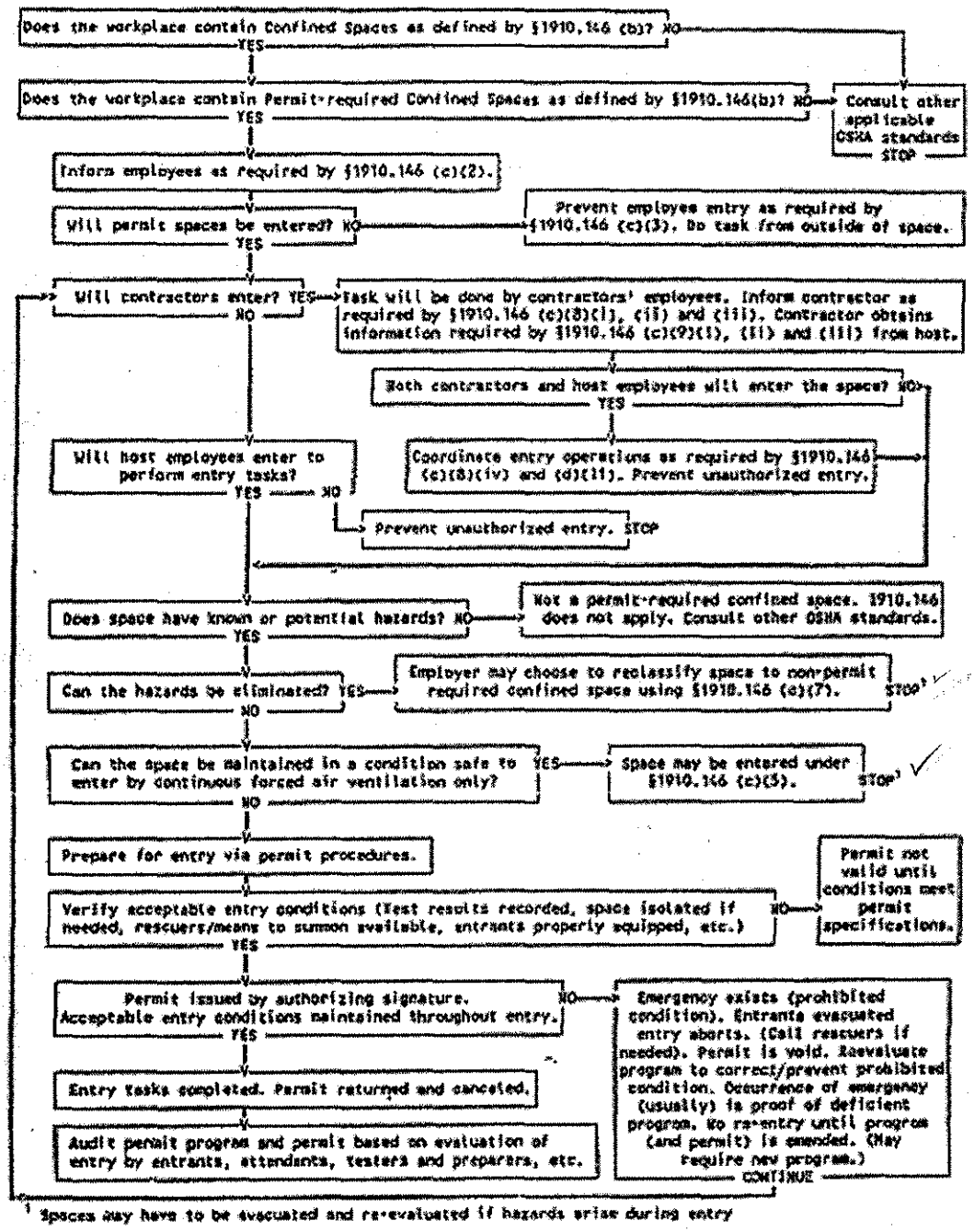
Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1910
- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** J
- **Subpart Title:** General Environmental Controls
- **Standard Number:** 1910.146 App A
- **Title:** Permit-required Confined Space Decision Flow Chart

Appendix A to §1910.146 -- Permit-Required Confined Space Decision Flow Chart

Note: Appendices A through F serve to provide inoformation and non-mandatory guidelines to assist employers and employees in complying with the appropriate requirements of this section.

APPENDIX A TO §1910.146—PERMIT-REQUIRED CONFINED SPACE DECISION FLOW CHART



[1] Spaces may have to be evacuated and re-evaluated if hazards arise during entry

[58 FR 4549, Jan. 14, 1993; 58 FR 34846, June 29, 1993; 63 FR 66039, Dec. 1, 1998]

Next Standard (1910.146 App B)

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Regulations (Standards - 29 CFR)

Procedures for Atmospheric Testing. - 1910.146 App B

Regulations (Standards - 29 CFR) - Table of Contents

• **Part Number:**	1910
• **Part Title:**	Occupational Safety and Health Standards
• **Subpart:**	J
• **Subpart Title:**	General Environmental Controls
• **Standard Number:**	1910.146 App B
• **Title:**	Procedures for Atmospheric Testing.

Atmospheric testing is required for two distinct purposes:

evaluation of the hazards of the permit space and verification that acceptable entry conditions for entry into that space exist.

(1) Evaluation testing. The atmosphere of a confined space should be analyzed using equipment of sufficient sensitivity and specificity to identify and evaluate any hazardous atmospheres that may exist or arise, so that appropriate permit entry procedures can be developed and acceptable entry conditions stipulated for that space. Evaluation and interpretation of these data, and development of the entry procedure, should be done by, or reviewed by, a technically qualified professional (e.g., OSHA consultation service, or certified industrial hygienist, registered safety engineer, certified safety professional, certified marine chemist, etc.) based on evaluation of all serious hazards.

(2) Verification testing. The atmosphere of a permit space which may contain a hazardous atmosphere should be tested for residues of all contaminants identified by evaluation testing using permit specified equipment to determine that residual concentrations at the time of testing and entry are within the range of acceptable entry conditions. Results of testing (i.e., actual concentration, etc.) should be recorded on the permit in the space provided adjacent to the stipulated acceptable entry condition.

(3) Duration of testing. Measurement of values for each atmospheric parameter should be made for at least the minimum response time of the test instrument specified by the manufacturer.

(4) Testing stratified atmospheres. When monitoring for entries involving a descent into atmospheres that may be stratified, the atmospheric envelope should be tested a distance of approximately 4 feet (1.22 m) in the direction of travel and to each side. If a sampling probe is used, the entrant's rate of progress should be slowed to accommodate the sampling speed and detector response.

(5) Order of testing. A test for oxygen is performed first because most combustible gas meters are oxygen dependent and will not provide reliable readings in an oxygen deficient

atmosphere. Combustible gases are tested for next because the threat of fire or explosion is both more immediate and more life threatening, in most cases, than exposure to toxic gases and vapors. If tests for toxic gases and vapors are necessary, they are performed last.

[58 FR 4549, Jan. 14, 1993; 58 FR 34846, June 29, 1993]

Next Standard (1910.146 App C)

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Regulations (Standards - 29 CFR)

Examples of Permit-required Confined Space Programs - 1910.146 App C

Regulations (Standards - 29 CFR) - Table of Contents

• **Part Number:**	1910
• **Part Title:**	Occupational Safety and Health Standards
• **Subpart:**	J
• **Subpart Title:**	General Environmental Controls
• **Standard Number:**	1910.146 App C
• **Title:**	Examples of Permit-required Confined Space Programs

Example 1.

Workplace. Sewer entry.

Potential hazards. The employees could be exposed to the following:

Engulfment.

Presence of toxic gases. Equal to or more than 10 ppm hydrogen sulfide measured as an 8-hour time-weighted average. If the presence of other toxic contaminants is suspected, specific monitoring programs will be developed.

Presence of explosive/flammable gases. Equal to or greater than 10% of the lower flammable limit (LFL).

Oxygen Deficiency. A concentration of oxygen in the atmosphere equal to or less than 19.5% by volume.

A. ENTRY WITHOUT PERMIT/ATTENDANT

NOTE: CN 3

Certification. Confined spaces may be entered without the need for a written permit or attendant provided that the space can be maintained in a safe condition for entry by mechanical ventilation alone, as provided in 1910.146(c)(5). All spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. Any employee required or permitted to pre-check or enter an enclosed/confined space shall have successfully completed, as a minimum, the training as required by the following sections of these procedures. A written copy of operating and rescue procedures as required by these procedures shall be at the work site for the duration of the job. The Confined Space Pre-Entry Check List must be completed by the LEAD WORKER before entry into a confined space. This list verifies completion of items listed below. This check list shall be kept at the job site for duration of the job. If circumstances dictate an interruption in the work, the permit space must be re-evaluated and a new check list must be completed.

Control of atmospheric and engulfment hazards.

Pumps and Lines. All pumps and lines which may reasonably cause contaminants to flow into the space shall be disconnected, blinded and locked out, or effectively isolated by other means to prevent development of dangerous air contamination or engulfment. Not all laterals to sewers or storm drains require blocking. However, where experience or knowledge of industrial use indicates there is a reasonable potential for contamination of air or engulfment into an occupied sewer, then all affected laterals shall be blocked. If blocking and/or isolation requires entry into the space the provisions for entry into a permit-required confined space must be implemented.

Surveillance. The surrounding area shall be surveyed to avoid hazards such as drifting vapors from the tanks, piping, or sewers.

Testing. The atmosphere within the space will be tested to determine whether dangerous air contamination and/or oxygen deficiency exists. Detector tubes, alarm only gas monitors and explosion meters are examples of monitoring equipment that may be used to test permit space atmospheres. Testing shall be performed by the LEAD WORKER who has successfully completed the Gas Detector training for the monitor he will use. The minimum parameters to be monitored are oxygen deficiency, LFL, and hydrogen sulfide concentration. A written record of the pre-entry test results shall be made and kept at the work site for the duration of the job. The supervisor will certify in writing, based upon the results of the pre-entry testing, that all hazards have been eliminated. Affected employees shall be able to review the testing results. The most hazardous conditions shall govern when work is being performed in two adjoining, connecting spaces.

Entry Procedures. If there are no non-atmospheric hazards present and if the pre-entry tests show there is no dangerous air contamination and/or oxygen deficiency within the space and there is no reason to believe that any is likely to develop, entry into and work within may proceed. Continuous testing of the atmosphere in the immediate vicinity of the workers within the space shall be accomplished. The workers will immediately leave the permit space when any of the gas monitor alarm set points are reached as defined. Workers will not return to the area until a SUPERVISOR who has completed the gas detector training has used a direct reading gas detector to evaluate the situation and has determined that it is safe to enter.

Rescue. Arrangements for rescue services are not required where there is no attendant. See the rescue portion of section B., below, for instructions regarding rescue planning where an entry permit is required.

B. ENTRY PERMIT REQUIRED

Permits. Confined Space Entry Permit. All spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. Any employee required or permitted to pre-check or enter a permit-required confined space shall have successfully completed, as a minimum, the training as required by the following sections of these procedures. A written copy of operating and rescue procedures as required by these procedures shall be at the work site for the duration of the job. The Confined Space Entry Permit must be completed before approval can be given to enter a permit-required confined space. This permit verifies completion of items listed below. This permit shall be kept at the job site for the duration of the job. If circumstances cause an interruption in the work or a

change in the alarm conditions for which entry was approved, a new Confined Space Entry Permit must be completed.

Control of atmospheric and engulfment hazards.

Surveillance. The surrounding area shall be surveyed to avoid hazards such as drifting vapors from tanks, piping or sewers.

Testing. The confined space atmosphere shall be tested to determine whether dangerous air contamination and/or oxygen deficiency exists. A direct reading gas monitor shall be used. Testing shall be performed by the SUPERVISOR who has successfully completed the gas detector training for the monitor he will use. The minimum parameters to be monitored are oxygen deficiency, LFL and hydrogen sulfide concentration. A written record of the pre-entry test results shall be made and kept at the work site for the duration of the job. Affected employees shall be able to review the testing results. The most hazardous conditions shall govern when work is being performed in two adjoining, connected spaces.

Space Ventilation. Mechanical ventilation systems, where applicable, shall be set at 100% outside air. Where possible, open additional manholes to increase air circulation. Use portable blowers to augment natural circulation if needed. After a suitable ventilating period, repeat the testing. Entry may not begin until testing has demonstrated that the hazardous atmosphere has been eliminated.

Entry Procedures. The following procedure shall be observed under any of the following conditions: 1.) Testing demonstrates the existence of dangerous or deficient conditions and additional ventilation cannot reduce concentrations to safe levels; 2.) The atmosphere tests as safe but unsafe conditions can reasonably be expected to develop; 3.) It is not feasible to provide for ready exit from spaces equipped with automatic fire suppression systems and it is not practical or safe to deactivate such systems; or 4.) An emergency exists and it is not feasible to wait for pre-entry procedures to take effect.

All personnel must be trained. A self contained breathing apparatus shall be worn by any person entering the space. At least one worker shall stand by the outside of the space ready to give assistance in case of emergency. The standby worker shall have a self contained breathing apparatus available for immediate use. There shall be at least one additional worker within sight or call of the standby worker. Continuous powered communications shall be maintained between the worker within the confined space and standby personnel.

If at any time there is any questionable action or non-movement by the worker inside, a verbal check will be made. If there is no response, the worker will be moved immediately. Exception: If the worker is disabled due to falling or impact, he/she shall not be removed from the confined space unless there is immediate danger to his/her life. Local fire department rescue personnel shall be notified immediately. The standby worker may only enter the confined space in case of an emergency (wearing the self contained breathing apparatus) and only after being relieved by another worker. Safety belt or harness with attached lifeline shall be used by all workers entering the space with the free end of the line secured outside the entry opening. The standby worker shall attempt to remove a disabled worker via his lifeline before entering the space.

When practical, these spaces shall be entered through side openings -- those within 3 1/2 feet

(1.07 m) of the bottom. When entry must be through a top opening, the safety belt shall be of the harness type that suspends a person upright and a hoisting device or similar apparatus shall be available for lifting workers out of the space.

In any situation where their use may endanger the worker, use of a hoisting device or safety belt and attached lifeline may be discontinued.

When dangerous air contamination is attributable to flammable and/or explosive substances, lighting and electrical equipment shall be Class 1, Division 1 rated per National Electrical Code and no ignition sources shall be introduced into the area.

Continuous gas monitoring shall be performed during all confined space operations. If alarm conditions change adversely, entry personnel shall exit the confined space and a new confined space permit issued.

Rescue. Call the fire department services for rescue. Where immediate hazards to injured personnel are present, workers at the site shall implement emergency procedures to fit the situation.

Example 2.

Workplace. Meat and poultry rendering plants.

Cookers and dryers are either batch or continuous in their operation. Multiple batch cookers are operated in parallel. When one unit of a multiple set is shut down for repairs, means are available to isolate that unit from the others which remain in operation.

Cookers and dryers are horizontal, cylindrical vessels equipped with a center, rotating shaft and agitator paddles or discs. If the inner shell is jacketed, it is usually heated with steam at pressures up to 150 psig (1034.25 kPa). The rotating shaft assembly of the continuous cooker or dryer is also steam heated.

Potential Hazards. The recognized hazards associated with cookers and dryers are the risk that employees could be:

1. Struck or caught by rotating agitator;

2. Engulfed in raw material or hot, recycled fat;

3. Burned by steam from leaks into the cooker/dryer steam jacket or the condenser duct system if steam valves are not properly closed and locked out;

4. Burned by contact with hot metal surfaces, such as the agitator shaft assembly, or inner shell of the cooker/dryer;

5. Heat stress caused by warm atmosphere inside cooker/dryer;

6. Slipping and falling on grease in the cooker/dryer;

7. Electrically shocked by faulty equipment taken into the cooker/dryer;

8. Burned or overcome by fire or products of combustion; or

9. Overcome by fumes generated by welding or cutting done on grease covered surfaces.

Permits. The supervisor in this case is always present at the cooker/dryer or other permit entry confined space when entry is made. The supervisor must follow the pre-entry isolation procedures described in the entry permit in preparing for entry, and ensure that the protective clothing, ventilating equipment and any other equipment required by the permit are at the entry site.

Control of hazards. Mechanical. Lock out main power switch to agitator motor at main power panel. Affix tag to the lock to inform others that a permit entry confined space entry is in progress.

Engulfment. Close all valves in the raw material blow line. Secure each valve in its closed position using chain and lock. Attach a tag to the valve and chain warning that a permit entry confined space entry is in progress. The same procedure shall be used for securing the fat recycle valve.

Burns and heat stress. Close steam supply valves to jacket and secure with chains and tags. Insert solid blank at flange in cooker vent line to condenser manifold duct system. Vent cooker/dryer by opening access door at discharge end and top center door to allow natural ventilation throughout the entry. If faster cooling is needed, use an portable ventilation fan to increase ventilation. Cooling water may be circulated through the jacket to reduce both outer and inner surface temperatures of cooker/dryers faster. Check air and inner surface temperatures in cooker/dryer to assure they are within acceptable limits before entering, or use proper protective clothing.

Fire and fume hazards. Careful site preparation, such as cleaning the area within 4 inches (10.16 cm) of all welding or torch cutting operations, and proper ventilation are the preferred controls. All welding and cutting operations shall be done in accordance with the requirements of 29 CFR Part 1910, Subpart Q, OSHA's welding standard. Proper ventilation may be achieved by local exhaust ventilation, or the use of portable ventilation fans, or a combination of the two practices.

Electrical shock. Electrical equipment used in cooker/dryers shall be in serviceable condition.

Slips and falls. Remove residual grease before entering cooker/dryer.

Attendant. The supervisor shall be the attendant for employees entering cooker/dryers.

Permit. The permit shall specify how isolation shall be done and any other preparations needed before making entry. This is especially important in parallel arrangements of cooker/dryers so that the entire operation need not be shut down to allow safe entry into one unit.

Rescue. When necessary, the attendant shall call the fire department as previously arranged.

Example 3.

Workplace. Workplaces where tank cars, trucks, and trailers, dry bulk tanks and trailers, railroad tank cars, and similar portable tanks are fabricated or serviced.

A. During fabrication. These tanks and dry-bulk carriers are entered repeatedly throughout the fabrication process. These products are not configured identically, but the manufacturing processes by which they are made are very similar.

Sources of hazards. In addition to the mechanical hazards arising from the risks that an entrant would be injured due to contact with components of the tank or the tools being used, there is also the risk that a worker could be injured by breathing fumes from welding materials or mists or vapors from materials used to coat the tank interior. In addition, many of these vapors and mists are flammable, so the failure to properly ventilate a tank could lead to a fire or explosion.

Control of hazards.

Welding. Local exhaust ventilation shall be used to remove welding fumes once the tank or carrier is completed to the point that workers may enter and exit only through a manhole. (Follow the requirements of 29 CFR 1910, Subpart Q, OSHA's welding standard, at all times.) Welding gas tanks may never be brought into a tank or carrier that is a permit entry confined space.

Application of interior coatings/linings. Atmospheric hazards shall be controlled by forced air ventilation sufficient to keep the atmospheric concentration of flammable materials below 10% of the lower flammable limit (LFL) (or lower explosive limit (LEL), whichever term is used locally). The appropriate respirators are provided and shall be used in addition to providing forced ventilation if the forced ventilation does not maintain acceptable respiratory conditions.

Permits. Because of the repetitive nature of the entries in these operations, an "Area Entry Permit" will be issued for a 1 month period to cover those production areas where tanks are fabricated to the point that entry and exit are made using manholes.

Authorization. Only the area supervisor may authorize an employee to enter a tank within the permit area. The area supervisor must determine that conditions in the tank trailer, dry bulk trailer or truck, etc. meet permit requirements before authorizing entry.

Attendant. The area supervisor shall designate an employee to maintain communication by employer specified means with employees working in tanks to ensure their safety. The attendant may not enter any permit entry confined space to rescue an entrant or for any other reason, unless authorized by the rescue procedure and, even then, only after calling the rescue team and being relieved by an attendant or another worker.

Communications and observation. Communications between attendant and entrant(s) shall be maintained throughout entry. Methods of communication that may be specified by the permit include voice, voice powered radio, tapping or rapping codes on tank walls, signalling tugs on a rope, and the attendant's observation that work activities such as chipping, grinding, welding, spraying, etc., which require deliberate operator control continue normally. These activities often generate so much noise that the necessary hearing protection makes communication by voice difficult.

Rescue procedures. Acceptable rescue procedures include entry by a team of employee-rescuers, use of public emergency services, and procedures for breaching the tank. The area permit specifies which procedures are available, but the area supervisor makes the final decision based on circumstances. (Certain injuries may make it necessary to breach the tank to remove a person rather than risk additional injury by removal through an existing manhole. However, the supervisor must ensure that no breaching procedure used for rescue would violate terms of the entry permit. For instance, if the tank must be breached by cutting with a torch, the tank surfaces to be cut must be free of volatile or combustible coatings within 4 inches (10.16 cm) of the cutting line and the atmosphere within the tank must be below the LFL.

Retrieval line and harnesses. The retrieval lines and harnesses generally required under this standard are usually impractical for use in tanks because the internal configuration of the tanks and their interior baffles and other structures would prevent rescuers from hauling out injured entrants. However, unless the rescue procedure calls for breaching the tank for rescue, the rescue team shall be trained in the use of retrieval lines and harnesses for removing injured employees through manholes.

B. Repair or service of "used" tanks and bulk trailers.

Sources of hazards. In addition to facing the potential hazards encountered in fabrication or manufacturing, tanks or trailers which have been in service may contain residues of dangerous materials, whether left over from the transportation of hazardous cargoes or generated by chemical or bacterial action on residues of non-hazardous cargoes.

Control of atmospheric hazards. A "used" tank shall be brought into areas where tank entry is authorized only after the tank has been emptied, cleansed (without employee entry) of any residues, and purged of any potential atmospheric hazards.

Welding. In addition to tank cleaning for control of atmospheric hazards, coating and surface materials shall be removed 4 inches (10.16 cm) or more from any surface area where welding or other torch work will be done and care taken that the atmosphere within the tank remains well below the LFL. (Follow the requirements of 29 CFR 1910, Subpart Q, OSHA's welding standard, at all times.)

Permits. An entry permit valid for up to 1 year shall be issued prior to authorization of entry into used tank trailers, dry bulk trailers or trucks. In addition to the pre-entry cleaning requirement, this permit shall require the employee safeguards specified for new tank fabrication or construction permit areas.

Authorization. Only the area supervisor may authorize an employee to enter a tank trailer, dry bulk trailer or truck within the permit area. The area supervisor must determine that the entry permit requirements have been met before authorizing entry.

[58 FR 4549, Jan. 14, 1993; 58 FR 34846, June 29, 1993]

Next Standard (1910.146 App D)

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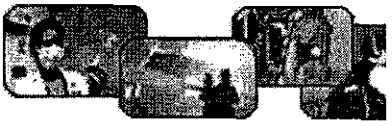

Regulations (Standards - 29 CFR)

Confined Space Pre-Entry Check List - 1910.146 App D

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1910
- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** J
- **Subpart Title:** General Environmental Controls
- **Standard Number:** 1910.146 App D
- **Title:** Confined Space Pre-Entry Check List

Appendix D to §1910.146 -- Sample Permits

Appendix D-1

Confined Space Entry Permit
Date and Time Issued: _____ Date and Time Expires: _____
Job site/Space I.D.: _____ Job Supervisor: _____
Equipment to be worked on: _____ Work to be performed: _____

Stand-by personnel: _____ _____ _____

1. Atmospheric Checks: Time _____
Oxygen _____%
Explosive _____% L.F.L.
Toxic _____PPM

2. Tester's signature: _____

3. Source isolation (No Entry):

	N/A	Yes	No
Pumps or lines blinded,	( )	( )	( )
disconnected, or blocked	( )	( )	( )

4. Ventilation Modification:

	N/A	Yes	No
Mechanical	( )	( )	( )
Natural Ventilation only	( )	( )	( )

5. Atmospheric check after isolation and Ventilation:

Oxygen _____%	>	19.5	%
Explosive _____% L.F.L	<	10	%
Toxic _____PPM	<	10	PPM H(2)S

Time _____
Testers signature: _____

6. Communication procedures: _____
_____

7. Rescue procedures: _____
_____

8. Entry, standby, and back up persons:	Yes	No
Successfully completed required training?		
Is it current?	( )	( )

9. Equipment:	N/A	Yes	No
Direct reading gas monitor - tested	( )	( )	( )
Safety harnesses and lifelines for entry and standby persons	( )	( )	( )
Hoisting equipment	( )	( )	( )
Powered communications	( )	( )	( )
SCBA's for entry and standby persons	( )	( )	( )
Protective Clothing	( )	( )	( )
All electric equipment listed Class I, Division I, Group D and Non-sparking tools	( )	( )	( )

10. Periodic atmospheric tests:

Oxygen	____%	Time ____	Oxygen	____%	Time ____
Oxygen	____%	Time ____	Oxygen	____%	Time ____
Explosive	____%	Time ____	Explosive	____%	Time ____
Explosive	____%	Time ____	Explosive	____%	Time ____
Toxic	____%	Time ____	Toxic	____%	Time ____
Toxic	____%	Time ____	Toxic	____%	Time ____

We have reviewed the work authorized by this permit and the information contained here-in. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit Prepared By: (Supervisor)_____
Approved By: (Unit Supervisor)_____
Reviewed By (Cs Operations Personnel) :

_____ _____
(printed name) (signature)

This permit to be kept at job site. Return job site copy to Safety Office following job completion.

Copies: White Original (Safety Office)
Yellow (Unit Supervisor)
Hard(Job site)

Appendix D - 2

ENTRY PERMIT

PERMIT VALID FOR 8 HOURS ONLY. ALL COPIES OF PERMIT WILL REMAIN AT JOB SITE UNTIL JOB IS COMPLETED

DATE: - - SITE LOCATION and DESCRIPTION _____
PURPOSE OF ENTRY _____
SUPERVISOR(S) in charge of crews Type of Crew Phone #

COMMUNICATION PROCEDURES _____

RESCUE PROCEDURES (PHONE NUMBERS AT BOTTOM) _____

* BOLD DENOTES MINIMUM REQUIREMENTS TO BE COMPLETED AND REVIEWED PRIOR TO ENTRY*

REQUIREMENTS COMPLETED	DATE	TIME
Lock Out/De-energize/Try-out		
Line(s) Broken-Capped-Blanked		
Purge-Flush and Vent		
Ventilation		
Secure Area (Post and Flag)		
Breathing Apparatus		
Resuscitator - Inhalator		
Standby Safety Personnel		
Full Body Harness w/"D" ring		
Emergency Escape Retrieval Equip		
Lifelines		
Fire Extinguishers		
Lighting (Explosive Proof)		
Protective Clothing		
Respirator(s) (Air Purifying)		
Burning and Welding Permit		

Note: Items that do not apply enter N/A in the blank.

**RECORD CONTINUOUS MONITORING RESULTS EVERY 2 HOURS

CONTINUOUS MONITORING** TEST(S) TO BE TAKEN	Permissible Entry Level	_____
PERCENT OF OXYGEN	19.5% to 23.5%	___ ___ ___ ___ ___ ___ ___ ___
LOWER FLAMMABLE LIMIT	Under 10%	___ ___ ___ ___ ___ ___ ___ ___
CARBON MONOXIDE	+35 PPM	___ ___ ___ ___ ___ ___ ___ ___
Aromatic Hydrocarbon	+ 1 PPM * 5PPM	___ ___ ___ ___ ___ ___ ___ ___
Hydrogen Cyanide	(Skin) * 4PPM	___ ___ ___ ___ ___ ___ ___ ___
Hydrogen Sulfide	+10 PPM *15PPM	___ ___ ___ ___ ___ ___ ___ ___
Sulfur Dioxide	+ 2 PPM * 5PPM	___ ___ ___ ___ ___ ___ ___ ___
Ammonia	*35PPM	___ ___ ___ ___ ___ ___ ___ ___

* Short-term exposure limit: Employee can work in the area up to 15 minutes.

+ 8 hr. Time Weighted Avg.: Employee can work in area 8 hrs (longer with appropriate respiratory protection).

REMARKS: _____

GAS TESTER NAME & CHECK #	INSTRUMENT(S) USED	MODEL &/OR TYPE	SERIAL &/OR UNIT #

SAFETY STANDBY PERSON IS REQUIRED FOR ALL CONFINED SPACE WORK

SAFETY STANDBY PERSON(S)	CHECK #	CONFINED SPACE ENTRANT(S)	CHECK #	CONFINED SPACE ENTRANT(S)	CHECK #

SUPERVISOR AUTHORIZING - ALL CONDITIONS SATISFIED _____

DEPARTMENT/PHONE _____

AMBULANCE 2800 FIRE 2900 Safety 4901 Gas Coordinator 4529/5387

[58 FR 4549, Jan. 14, 1993; 58 FR 34846, June 29, 1993]

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Regulations (Standards - 29 CFR)

Sewer System Entry. - 1910.146 App E

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1910
- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** J
- **Subpart Title:** General Environmental Controls
- **Standard Number:** 1910.146 App E
- **Title:** Sewer System Entry.

Sewer entry differs in three vital respects from other permit entries; first, there rarely exists any way to completely isolate the space (a section of a continuous system) to be entered; second, because isolation is not complete, the atmosphere may suddenly and unpredictably become lethally hazardous (toxic, flammable or explosive) from causes beyond the control of the entrant or employer, and third, experienced sewer workers are especially knowledgeable in entry and work in their permit spaces because of their frequent entries. Unlike other employments where permit space entry is a rare and exceptional event, sewer workers' usual work environment is a permit space.

(1) Adherence to procedure. The employer should designate as entrants only employees who are thoroughly trained in the employer's sewer entry procedures and who demonstrate that they follow these entry procedures exactly as prescribed when performing sewer entries.

(2) Atmospheric monitoring. Entrants should be trained in the use of, and be equipped with, atmospheric monitoring equipment which sounds an audible alarm, in addition to its visual readout, whenever one of the following conditions are encountered: Oxygen concentration less than 19.5 percent; flammable gas or vapor at 10 percent or more of the lower flammable limit (LFL); or hydrogen sulfide or carbon monoxide at or above 10 ppm or 35 ppm, respectively, measured as an 8-hour time-weighted average. Atmospheric monitoring equipment needs to be calibrated according to the manufacturer's instructions. The oxygen sensor/broad range sensor is best suited for initial use in situations where the actual or potential contaminants have not been identified, because broad range sensors, unlike substance-specific sensors, enable employers to obtain an overall reading of the hydrocarbons (flammables) present in the space. However, such sensors only indicate that a hazardous threshold of a class of chemicals has been exceeded. They do not measure the levels of contamination of specific substances. Therefore, substance-specific devices, which measure the actual levels of specific substances, are best suited for use where actual and potential contaminants have been identified. The measurements obtained with substance-specific devices are of vital importance to the employer when decisions are made concerning the measures necessary to protect entrants (such as ventilation or personal protective equipment) and the setting and attainment of appropriate entry conditions. However, the sewer environment may suddenly and unpredictably change, and the substance-specific devices may not detect the potentially lethal atmospheric hazards which may enter the sewer environment.

Although OSHA considers the information and guidance provided above to be appropriate and useful in most sewer entry situations, the Agency emphasizes that each employer must consider the unique circumstances, including the predictability of the atmosphere, of the sewer permit spaces in the employer's workplace in preparing for entry. Only the employer can decide, based upon his or her knowledge of, and experience with permit spaces in sewer systems, what the best type of testing instrument may be for any specific entry operation.

The selected testing instrument should be carried and used by the entrant in sewer line work to monitor the atmosphere in the entrant's environment, and in advance of the entrant's direction of movement, to warn the entrant of any deterioration in atmospheric conditions. Where several entrants are working together in the same immediate location, one instrument, used by the lead entrant, is acceptable.

(3) Surge flow and flooding. Sewer crews should develop and maintain liaison, to the extent possible, with the local weather bureau and fire and emergency services in their area so that sewer work may be delayed or interrupted and entrants withdrawn whenever sewer lines might be suddenly flooded by rain or fire suppression activities, or whenever flammable or other hazardous materials are released into sewers during emergencies by industrial or transportation accidents.

(4) Special Equipment. Entry into large bore sewers may require the use of special equipment. Such equipment might include such items as atmosphere monitoring devices with automatic audible alarms, escape self-contained breathing apparatus (ESCBA) with at least 10 minute air supply (or other NIOSH approved self-rescuer), and waterproof flashlights, and may also include boats and rafts, radios and rope stand-offs for pulling around bends and corners as needed.

[58 FR 4549, Jan. 14, 1993; 58 FR 34845, June 29, 1993; 59 FR 26115, May 19, 1994]

Next Standard (1910.146 App F)

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Regulations (Standards - 29 CFR)

Non-Mandatory Appendix F -- Rescue Team or Rescue Service Evaluation Criteria - 1910.146 App F

Regulations (Standards - 29 CFR) - Table of Contents

• **Part Number:**	1910
• **Part Title:**	Occupational Safety and Health Standards
• **Subpart:**	J
• **Subpart Title:**	General Environmental Controls
• **Standard Number:**	1910.146 App F
• **Title:**	Non-Mandatory Appendix F -- Rescue Team or Rescue Service Evaluation Criteria

Non-Mandatory Appendix F -- Rescue Team or Rescue Service Evaluation Criteria

(1) This appendix provides guidance to employers in choosing an appropriate rescue service. It contains criteria that may be used to evaluate the capabilities both of prospective and current rescue teams. Before a rescue team can be trained or chosen, however, a satisfactory permit program, including an analysis of all permit- required confined spaces to identify all potential hazards in those spaces, must be completed. OSHA believes that compliance with all the provisions of §1910.146 will enable employers to conduct permit space operations without recourse to rescue services in nearly all cases. However, experience indicates that circumstances will arise where entrants will need to be rescued from permit spaces. It is therefore important for employers to select rescue services or teams, either on-site or off-site, that are equipped and capable of minimizing harm to both entrants and rescuers if the need arises.

(2) For all rescue teams or services, the employer's evaluation should consist of two components: an initial evaluation, in which employers decide whether a potential rescue service or team is adequately trained and equipped to perform permit space rescues of the kind needed at the facility and whether such rescuers can respond in a timely manner, and a performance evaluation, in which employers measure the performance of the team or service during an actual or practice rescue. For example, based on the initial evaluation, an employer may determine that maintaining an on-site rescue team will be more expensive than obtaining the services of an off-site team, without being significantly more effective, and decide to hire a rescue service. During a performance evaluation, the employer could decide, after observing the rescue service perform a practice rescue, that the service's training or preparedness was not adequate to effect a timely or effective rescue at his or her facility and decide to select another rescue service, or to form an internal rescue team.

A. Initial Evaluation

I. The employer should meet with the prospective rescue service to facilitate the evaluations required by §1910.146(k)(1)(i) and §1910.146(k)(1)(ii). At a minimum, if an off-site rescue service is being considered, the employer must contact the service to plan and coordinate the

evaluations required by the standard. Merely posting the service's number or planning to rely on the 911 emergency phone number to obtain these services at the time of a permit space emergency would not comply with paragraph (k)(1) of the standard.

II. The capabilities required of a rescue service vary with the type of permit spaces from which rescue may be necessary and the hazards likely to be encountered in those spaces. Answering the questions below will assist employers in determining whether the rescue service is capable of performing rescues in the permit spaces present at the employer's workplace.

1. What are the needs of the employer with regard to response time (time for the rescue service to receive notification, arrive at the scene, and set up and be ready for entry)? For example, if entry is to be made into an IDLH atmosphere, or into a space that can quickly develop an IDLH atmosphere (if ventilation fails or for other reasons), the rescue team or service would need to be standing by at the permit space. On the other hand, if the danger to entrants is restricted to mechanical hazards that would cause injuries (e.g., broken bones, abrasions) a response time of 10 or 15 minutes might be adequate.

2. How quickly can the rescue team or service get from its location to the permit spaces from which rescue may be necessary? Relevant factors to consider would include: the location of the rescue team or service relative to the employer's workplace, the quality of roads and highways to be traveled, potential bottlenecks or traffic congestion that might be encountered in transit, the reliability of the rescuer's vehicles, and the training and skill of its drivers.

3. What is the availability of the rescue service? Is it unavailable at certain times of the day or in certain situations? What is the likelihood that key personnel of the rescue service might be unavailable at times? If the rescue service becomes unavailable while an entry is underway, does it have the capability of notifying the employer so that the employer can instruct the attendant to abort the entry immediately?

4. Does the rescue service meet all the requirements of paragraph (k)(2) of the standard? If not, has it developed a plan that will enable it to meet those requirements in the future? If so, how soon can the plan be implemented?

5. For off-site services, is the service willing to perform rescues at the employer's workplace? (An employer may not rely on a rescuer who declines, for whatever reason, to provide rescue services.)

6. Is an adequate method for communications between the attendant, employer and prospective rescuer available so that a rescue request can be transmitted to the rescuer without delay? How soon after notification can a prospective rescuer dispatch a rescue team to the entry site?

7. For rescues into spaces that may pose significant atmospheric hazards and from which rescue entry, patient packaging and retrieval cannot be safely accomplished in a relatively short time (15-20 minutes), employers should consider using airline respirators (with escape bottles) for the rescuers and to supply rescue air to the patient. If the employer decides to use SCBA, does the prospective rescue service have an ample supply of replacement cylinders and procedures for rescuers to enter and exit (or be retrieved) well within the SCBA's air supply limits?

8. If the space has a vertical entry over 5 feet in depth, can the prospective rescue service properly perform entry rescues? Does the service have the technical knowledge and equipment to perform rope work or elevated rescue, if needed?

9. Does the rescue service have the necessary skills in medical evaluation, patient packaging and emergency response?

10. Does the rescue service have the necessary equipment to perform rescues, or must the equipment be provided by the employer or another source?

B. Performance Evaluation

Rescue services are required by paragraph (k)(2)(iv) of the standard to practice rescues at least once every 12 months, provided that the team or service has not successfully performed a permit space rescue within that time. As part of each practice session, the service should perform a critique of the practice rescue, or have another qualified party perform the critique, so that deficiencies in procedures, equipment, training, or number of personnel can be identified and corrected. The results of the critique, and the corrections made to respond to the deficiencies identified, should be given to the employer to enable it to determine whether the rescue service can quickly be upgraded to meet the employer's rescue needs or whether another service must be selected. The following questions will assist employers and rescue teams and services evaluate their performance.

1. Have all members of the service been trained as permit space entrants, at a minimum, including training in the potential hazards of all permit spaces, or of representative permit spaces, from which rescue may be needed? Can team members recognize the signs, symptoms, and consequences of exposure to any hazardous atmospheres that may be present in those permit spaces?

2. Is every team member provided with, and properly trained in, the use and need for PPE, such as SCBA or fall arrest equipment, which may be required to perform permit space rescues in the facility? Is every team member properly trained to perform his or her functions and make rescues, and to use any rescue equipment, such as ropes and backboards, that may be needed in a rescue attempt?

3. Are team members trained in the first aid and medical skills needed to treat victims overcome or injured by the types of hazards that may be encountered in the permit spaces at the facility?

4. Do all team members perform their functions safely and efficiently? Do rescue service personnel focus on their own safety before considering the safety of the victim?

5. If necessary, can the rescue service properly test the atmosphere to determine if it is IDLH?

6. Can the rescue personnel identify information pertinent to the rescue from entry permits, hot work permits, and MSDSs?

7. Has the rescue service been informed of any hazards to personnel that may arise from outside the space, such as those that may be caused by future work near the space?

8. If necessary, can the rescue service properly package and retrieve victims from a permit space that has a limited size opening (less than 24 inches (60.9 cm) in diameter), limited internal space, or internal obstacles or hazards?

9. If necessary, can the rescue service safely perform an elevated (high angle) rescue?

10. Does the rescue service have a plan for each of the kinds of permit space rescue operations at the facility? Is the plan adequate for all types of rescue operations that may be needed at the facility? Teams may practice in representative spaces, or in spaces that are "worst-case" or most restrictive with respect to internal configuration, elevation, and portal size. The following characteristics of a practice space should be considered when deciding whether a space is truly representative of an actual permit space:

(1) Internal configuration.

(a) Open -- there are no obstacles, barriers, or obstructions within the space. One example is a water tank.

(b) Obstructed -- the permit space contains some type of obstruction that a rescuer would need to maneuver around. An example would be a baffle or mixing blade. Large equipment, such as a ladder or scaffold, brought into a space for work purposes would be considered an obstruction if the positioning or size of the equipment would make rescue more difficult.

(2) Elevation.

(a) Elevated -- a permit space where the entrance portal or opening is above grade by 4 feet or more. This type of space usually requires knowledge of high angle rescue procedures because of the difficulty in packaging and transporting a patient to the ground from the portal.

(b) Non-elevated -- a permit space with the entrance portal located less than 4 feet above grade. This type of space will allow the rescue team to transport an injured employee normally.

(3) Portal size.

(a) Restricted -- A portal of 24 inches or less in the least dimension. Portals of this size are too small to allow a rescuer to simply enter the space while using SCBA. The portal size is also too small to allow normal spinal immobilization of an injured employee.

(b) Unrestricted -- A portal of greater than 24 inches in the least dimension. These portals allow relatively free movement into and out of the permit space.

(4) Space access.

(a) Horizontal -- The portal is located on the side of the permit space. Use of retrieval lines could be difficult.

(b) Vertical -- The portal is located on the top of the permit space, so that rescuers must climb down, or the bottom of the permit space, so that rescuers must climb up to enter the

space. Vertical portals may require knowledge of rope techniques, or special patient packaging to safely retrieve a downed entrant.

[63 FR 66039, Dec. 1, 1998]

Next Standard (1910.147)

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Regulations (Standards - 29 CFR)

Safety training and education. - 1926.21

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** C
- **Subpart Title:** General Safety and Health Provisions
- **Standard Number:** 1926.21
- **Title:** Safety training and education.

1926.21(a)

General requirements. The Secretary shall, pursuant to section 107(f) of the Act, establish and supervise programs for the education and training of employers and employees in the recognition, avoidance and prevention of unsafe conditions in employments covered by the act.

1926.21(b)

mployer responsibility.

1926.21(b)(1)

The employer should avail himself of the safety and health training programs the Secretary provides.

1926.21(b)(2)

The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.

1926.21(b)(3)

Employees required to handle or use poisons, caustics, and other harmful substances shall be instructed regarding the safe handling and use, and be made aware of the potential hazards, personal hygiene, and personal protective measures required.

1926.21(b)(4)

1926.21(b)(4)

In job site areas where harmful plants or animals are present, employees who may be exposed shall be instructed regarding the potential hazards, and how to avoid injury, and the first aid procedures to be used in the event of injury.

1926.21(b)(5)

Employees required to handle or use flammable liquids, gases, or toxic materials shall be instructed in the safe handling and use of these materials and made aware of the specific requirements contained in Subparts D, F, and other applicable subparts of this part.

1926.21(b)(6)

1926.21(b)(6)(i)

All employees required to enter into confined or enclosed spaces shall be instructed as to the nature of the hazards involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required. The employer shall comply with any specific regulations that apply to work in dangerous or potentially dangerous areas.

1926.21(b)(6)(ii)

For purposes of paragraph (b)(6)(i) of this section, "confined or enclosed space" means any space having a limited means of egress, which is subject to the accumulation of toxic or flammable contaminants or has an oxygen deficient atmosphere. Confined or enclosed spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than 4 feet in depth such as pits, tubs, vaults, and vessels.

Next Standard (1926.22)

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Regulations (Standards - 29 CFR)

Fire prevention. - 1926.352

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** J
- **Subpart Title:** Welding and Cutting
- **Standard Number:** 1926.352
- **Title:** Fire prevention.

1926.352(a)

When practical, objects to be welded, cut, or heated shall be moved to a designated safe location or, if the objects to be welded, cut, or heated cannot be readily moved, all movable fire hazards in the vicinity shall be taken to a safe place, or otherwise protected.

1926.352(b)

If the object to be welded, cut, or heated cannot be moved and if all the fire hazards cannot be removed, positive means shall be taken to confine the heat, sparks, and slag, and to protect the immovable fire hazards from them.

1926.352(c)

No welding, cutting, or heating shall be done where the application of flammable paints, or the presence of other flammable compounds, or heavy dust concentrations creates a hazard.

1926.352(d)

Suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained in a state of readiness for instant use.

..1926.352(e)

1926.352(e)

When the welding, cutting, or heating operation is such that normal fire prevention precautions are not sufficient, additional personnel shall be assigned to guard against fire while the actual welding, cutting, or heating operation is being performed, and for a sufficient period of time after completion of the work to ensure that no possibility of fire exists. Such personnel shall be instructed as to the specific anticipated fire hazards and how the firefighting equipment provided is to be used.

1926.352(f)

When welding, cutting, or heating is performed on walls, floors, and ceilings, since direct penetration of sparks or heat transfer may introduce a fire hazard to an adjacent area, the same precautions shall be taken on the opposite side as are taken on the side on which the welding is being performed.

1926.352(g)

For the elimination of possible fire in enclosed spaces as a result of gas escaping through leaking or improperly closed torch valves, the gas supply to the torch shall be positively shut off at some point outside the enclosed space whenever the torch is not to be used or whenever the torch is left unattended for a substantial period of time, such as during the lunch period. Overnight and at the change of shifts, the torch and hose shall be removed from the confined space. Open end fuel gas and oxygen hoses shall be immediately removed from enclosed spaces when they are disconnected from the torch or other gas-consuming device.

1926.352(h)

Except when the contents are being removed or transferred, drums, pails, and other containers which contain or have contained flammable liquids shall be kept closed. Empty containers shall be removed to a safe area apart from hot work operations or open flames.

..1926.352(i)

1926.352(i)

Drums containers, or hollow structures which have contained toxic or flammable substances shall, before welding, cutting, or heating is undertaken on them, either be filled with water or thoroughly cleaned of such substances and ventilated and tested. For welding, cutting and heating on steel pipelines containing natural gas, the pertinent portions of regulations issued by the Department of Transportation, Office of Pipeline Safety, 49 CFR Part 192, Minimum Federal Safety Standards for Gas Pipelines, shall apply.

1926.352(j)

Before heat is applied to a drum, container, or hollow structure, a vent or opening shall be provided for the release of any built-up pressure during the application of heat.

Next Standard (1926.353)

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Regulations (Standards - 29 CFR)

Ventilation and protection in welding, cutting, and heating. - 1926.353

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** J
- **Subpart Title:** Welding and Cutting
- **Standard Number:** 1926.353
- **Title:** Ventilation and protection in welding, cutting, and heating.

1926.353(a)

Mechanical ventilation. For purposes of this section, mechanical ventilation shall meet the following requirements:

1926.353(a)(1)

Mechanical ventilation shall consist of either general mechanical ventilation systems or local exhaust systems.

1926.353(a)(2)

General mechanical ventilation shall be of sufficient capacity and so arranged as to produce the number of air changes necessary to maintain welding fumes and smoke within safe limits, as defined in Subpart D of this part.

1926.353(a)(3)

Local exhaust ventilation shall consist of freely movable hoods intended to be placed by the welder or burner as close as practicable to the work. This system shall be of sufficient capacity and so arranged as to remove fumes and smoke at the source and keep the concentration of them in the breathing zone within safe limits as defined in Subpart D of this part.

1926.353(a)(4)

Contaminated air exhausted from a working space shall be discharged into the open air or otherwise clear of the source of intake air.

1926.353(a)(5)

All air replacing that withdrawn shall be clean and respirable.

..1926.353(a)(6)

1926.353(a)(6)

Oxygen shall not be used for ventilation purposes, comfort cooling, blowing dust from clothing, or for cleaning the work area.

1926.353(b)

Welding, cutting, and heating in confined spaces.

1926.353(b)(1)

Except as provided in paragraph (b)(2) of this section, and paragraph (c)(2) of this section, either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section shall be provided whenever welding, cutting, or heating is performed in a confined space.

1926.353(b)(2)

When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by air line respirators in accordance with the requirements of Subpart E of this part, and an employee on the outside of such a confined space shall be assigned to maintain communication with those working within it and to aid them in an emergency.

1926.353(b)(3)

"Lifelines." Where a welder must enter a confined space through a manhole or other small opening, means shall be provided for quickly removing him in case of emergency. When safety belts and lifelines are used for this purpose they shall be so attached to the welder's body that his body cannot be jammed in a small exit opening. An attendant with a pre-planned rescue procedure shall be stationed outside to observe the welder at all times and be capable of putting rescue operations into effect.

1926.353(c)

Welding, cutting, or heating of metals of toxic significance.

..1926.353(c)(1)

1926.353(c)(1)

Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section:

1926.353(c)(1)(i)

Zinc-bearing base or filler metals or metals coated with zinc-bearing materials;

1926.353(c)(1)(ii)

Lead base metals;

1926.353(c)(1)(iii)

Cadmium-bearing filler materials;

1926.353(c)(1)(iv)

Chromium-bearing metals or metals coated with chromium-bearing materials.

1926.353(c)(2)

Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with local exhaust ventilation in accordance with the requirements of paragraph (a) of this section, or employees shall be protected by air line respirators in accordance with the requirements of Subpart E of this part:

1926.353(c)(2)(i)

Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;

1926.353(c)(2)(ii)

Cadmium-bearing or cadmium-coated base metals;

1926.353(c)(2)(iii)

Metals coated with mercury-bearing metals;

..1926.353(c)(2)(iv)

1926.353(c)(2)(iv)

Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.

1926.353(c)(3)

Employees performing such operations in the open air shall be protected by filter-type respirators in accordance with the requirements of Subpart E of this part, except that employees performing such operations on beryllium-containing base or filler metals shall be protected by air line respirators in accordance with the requirements of Subpart E of this part.

1926.353(c)(4)

Other employees exposed to the same atmosphere as the welders or burners shall be protected in the same manner as the welder or burner.

1926.353(d)

Inert-gas metal-arc welding.

1926.353(d)(1)

Since the inert-gas metal-arc welding process involves the production of ultra-violet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process until the following special precautions have been taken:

1926.353(d)(1)(i)

The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.

..1926.353(d)(1)(ii)

1926.353(d)(1)(ii)

Employees in the area not protected from the arc by screening shall be protected by filter lenses meeting the requirements of Subpart E of this part. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type, meeting the requirements of Subpart E of this part, shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.

1926.353(d)(1)(iii)

Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and free of highly reflective surfaces.

1926.353(d)(1)(iv)

When inert-gas metal-arc welding is being performed on stainless steel, the requirements of paragraph (c)(2) of this section shall be met to protect against dangerous concentrations of nitrogen dioxide.

1926.353(e)

General welding, cutting, and heating.

1926.353(e)(1)

Welding, cutting, and heating, not involving conditions or materials described in paragraph (b), (c), or (d) of this section, may normally be done without mechanical ventilation or respiratory protective equipment, but where, because of unusual physical or atmospheric conditions, an unsafe accumulation of contaminants exists, suitable mechanical ventilation or respiratory protective equipment shall be provided.

1926.353(e)(2)

Employees performing any type of welding, cutting, or heating shall be protected by suitable eye protective equipment in accordance with the requirements of Subpart E of this part.

[44 FR 8577, Feb. 9, 1979; 44 FR 20940, Apr. 6, 1979, as amended at 55 FR 42328, Oct. 18, 1990; 58 FR 35179, June 30, 1993]

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NIOSH

CRITERIA FOR A
RECOMMENDED STANDARD. . .

WORKING in CONFINED SPACES

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

criteria for a recommended standard. . .

WORKING in CONFINED SPACES

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
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December 1979

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DHEW (NIOSH) Publication No. 80–106

PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards in their workplace.

The National Institute for Occupational Safety and Health (NIOSH) evaluates all available research data and criteria and recommends standards for safe work practices and occupational exposure to toxic substances. The Secretary of Labor will weigh these recommendations along with other considerations, such as feasibility and means of implementation, in promulgating regulatory standards.

NIOSH will periodically review the recommended standards to ensure continuing protection of workers and will make successive reports as new research and epidemiologic studies are completed and as engineering controls for the workers safety are developed.

The contributions to this document on working in confined spaces by members of the NIOSH staff, other Federal agencies or departments, the review consultants, and Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, are gratefully acknowledged.

The views and conclusions expressed in this document, together with the recommendations for a standard, are those of NIOSH. They are not necessarily those of the consultants, the reviewers selected by professional and trade associations, or other Federal agencies. However, all comments, whether or not incorporated, were considered carefully and were sent with the criteria document to the Occupational Safety and Health Administration for consideration in setting the standard. The review consultants and the Federal agencies which received the document for review appear on pages v and vi respectively.

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Occupational Safety and Health

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CONTENTS

I. RECOMMENDATIONS FOR A STANDARD FOR WORKING IN CONFINED SPACES

NIOSH recommends the procedures set forth in the following sections as a means of protecting the health, and significantly reducing accidental injury and death associated with entering, working in, and exiting from confined spaces. The standard is designed not only to make the confined space safe for the worker, but also to make the worker cognizant of the hazards associated with this work area and the safe work practices necessary to deal with these hazards. The criteria and standard will be reviewed and revised as necessary.

Section 1 - Definitions - For Purposes of this Document

Atmosphere	Refers to the gases, vapors, mists, fumes, and dusts within a confined space.
Ceiling Level	The maximum airborne concentration of a toxic agent to which an employee may be exposed for a specified period of time.
Combustible Dust	A dust capable of undergoing combustion or of burning when subjected to a source of ignition.
Confined Space	Refers to a space which by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which is not intended for continuous employee occupancy. Confined spaces include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.
Confined Space, Class "A"	A confined space that presents a situation that is immediately dangerous to life or health (IDLH). These include but are not limited to oxygen deficiency, explosive or flammable atmospheres, and/or concentrations of toxic substances.
Confined Space, Class "B"	A confined space that has the potential for causing injury and illness, if preventive measures are not used, but not immediately dangerous to life and health.
Confined Space, Class "C"	A confined space in which the potential hazard would not require any special modification of the work procedure.

Hot Work	Any work involving burning, welding, riveting, or similar fire producing operations, as well as work which produces a source of ignition, such as drilling, abrasive blasting, and space heating.
Inerting	Displacement of the atmosphere by a non-reactive gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.
Isolation	A process whereby the confined space is removed from service and completely protected against the inadvertent release of material by the following: blanking off (skillet type metal blank between flanges), misaligning sections of all lines and pipes, a double block and bleed system, electrical lockout of all sources of power, and blocking or disconnecting all mechanical linkages.
Lower Flammable Limit (LFL)	The minimum concentration of a combustible gas or vapor in air (usually expressed in percent by volume at sea level), which will ignite if an ignition source (sufficient ignition energy) is present.
Oxygen Deficiency	Refers to an atmosphere with a partial pressure of oxygen (PO_2) less than 132 mm Hg. Normal air at sea level contains approximately 21% oxygen at a PO_2 of 160 mm Hg. At an altitude of 5,280 feet normal air contains approximately 21% O_2 at a PO_2 of 132 mm Hg.
Oxygen Enriched Atmosphere	Any oxygen concentration greater than 25% (PO_2 - 190 mm Hg) at normal atmospheric pressure.
Permissible Exposure Limit (PEL)	The maximum 8-hour time weighted average of any airborne contaminant to which an employee may be exposed. At no time shall the exposure level exceed the ceiling concentration for that contaminant as listed in 29 CFR Part 1910 Sub Part Z.
Purging	The method by which gases, vapors, or other airborne impurities are displaced from a confined space.
Qualified Person	A person designated by the employer, in writing, as capable (by education and/or specialized training) of anticipating, recognizing, and evaluating employee

	exposure to hazardous substances or other unsafe conditions in a confined space. This person shall be capable of specifying necessary control and/or protective action to insure worker safety.
Respirator (Approved)	A device which has met the requirements of 30 CFR Part 11 and is designed to protect the wearer from inhalation of harmful atmospheres and has been approved by the Bureau of Mines and the National Institute for Occupational Safety and Health, and Mine Safety and Health Administration (formerly, Mining Enforcement and Safety Administration).
Standby Person	A person trained in emergency rescue procedures and assigned to remain on the outside of the confined space and to be in communication with those working inside.

Section 2 - Entry and Rescue

The Confined Space Classification Table on page 4 is based on existing or potential hazards relative to the confined space. The classification is based upon the characteristics of the confined space, oxygen level, flammability and toxicity. If any of the hazards present a situation which is immediately dangerous to life or health (IDLH), the confined space shall be designated Class A. The classification shall be determined by the most hazardous condition of entering, working in, and exiting a confined space. Class B confined space has the potential for causing injury and illness but is not immediately dangerous to life and health. A Class C entry would be one in which the hazard potential would not require any special modification of the work procedure.

The Check List of Consideration on page 5 delineates the minimum preparation required for each class of confined space entry. In the recommended standard where specific procedures, activities or requirements are correlated with a classification: the procedure, activity or requirement is mandatory. As an example, Section 3 - Permit System (Class A, B and C) means that a permit is mandatory for Class A, B, and C confined space entry.

CONFINED SPACE CLASSIFICATION TABLE

Parameters	Class A	Class B	Class C
Characteristics	immediately dangerous to life - rescue procedures require the entry of more than one individual fully equipped with life support equipment - maintenance of communication requires an additional standby person stationed within the confined space	dangerous, but not immediately life threatening - rescue procedures require the entry of no more than one individual fully equipped with life support equipment - indirect visual or auditory communication with workers	potential hazard - requires no modification of work procedures - standard rescue procedures - direct communication with workers, from outside the confined space
Oxygen	16% or less *(122 mm Hg) or greater than 25% *(190 mm Hg)	16.1% to 19.4% *(122 - 147 mm Hg) or 21.5% to 25% (163 - 190 mm Hg)	19.5% - 21.4% *(148 - 163 mm Hg)
Flammability Characteristics	20% or greater of LFL	10% - 19% LFL	10% LFL or less
Toxicity	**IDLH	greater than contamination level, referenced in 29 CFR Part 1910 Sub Part Z - less than **IDLH	less than contamination level referenced in 29 CFR Part 1910 Sub Part Z

*Based upon a total atmospheric pressure of 760 mm Hg (sea level)
**Immediately Dangerous to Life or Health - as referenced in NIOSH Registry of Toxic and Chemical Substances, Manufacturing Chemists data sheets, industrial hygiene guides or other recognized authorities.

CHECK LIST OF CONSIDERATIONS FOR ENTRY, WORKING IN AND EXITING CONFINED SPACES

ITEM	CLASS A	CLASS B	CLASS C
1. Permit	X	X	X
2. Atmospheric Testing	X	X	X
3. Monitoring	X	0	0
4. Medical Surveillance	X	X	0
5. Training of Personnel	X	X	X
6. Labeling and Posting	X	X	X
7. Preparation			
Isolate/lockout/tag	X	X	0
Purge and ventilate	X	X	0
Cleaning Processes	0	0	0
Requirements for special equipment/tools	X	X	0
8. Procedures			
Initial plan	X	X	X
Standby	X	X	0
Communications/observation	X	X	X
Rescue	X	X	X
Work	X	X	X
9. Safety Equipment and Clothing			
Head protection	0	0	0
Hearing protection	0	0	0
Hand protection	0	0	0
Foot protection	0	0	0
Body protection	0	0	0
Respiratory protection	0	0	
Safety belts	X	X	X
Life lines, harness	X	0	
10. Rescue Equipment	X	X	X
11. Recordkeeping/Exposure	X	X	

X - indicates requirement
0 - indicates determination by the qualified person

If the work practice involved in the confined space has the potential to increase existing hazards or generate additional ones, it shall be necessary to frequently evaluate the space to determine if a classification change is warranted.

Rescue procedures shall be specifically designed for each entry. If a confined space has an A or B Classification, there shall be a trained standby person assigned to that confined space with a fully charged, positive pressure, self-contained breathing apparatus (SCBA) at hand. Additional duties of the standby person are to maintain unobstructed life lines and communications to all workers within the confined space, and to summon rescue personnel if necessary. Under no circumstances will the standby person enter the confined space until he is relieved and is assured that adequate assistance is present. However, while awaiting rescue personnel the standby person will make rescue attempts utilizing the life lines from outside the confined space. Rescue teams entering a Class A or B confined space shall be equipped with all the aforementioned safety equipment of the standby person and required life lines.

In the event of a Class C confined space rescue, a supplied-air respirator or a self-contained breathing apparatus shall be used. A person summoned or one who recognizes the need for rescue shall summon assistance and await their arrival outside the confined space. Respirators and life lines shall be donned by rescue personnel with necessary equipment for removal of the victim(s).

Section 3 - Permit System (Class A, B, and C)

Entry into a confined space shall be by permit only. The permit is an authorization and approval in writing that specifies the location and type of work to be done, and certifies that all existing hazards have been evaluated by the qualified person, and necessary protective measures have been taken to insure the safety of each worker.

The supervisor or a qualified person shall be responsible for securing the permit and both shall sign off when the following areas and actions have been reviewed and confirmed:

(a) Location and description of the work to be done.
(Class A, B, and C)

(b) Hazards that may be encountered.
(Class A, B, and C)

(c) Complete isolation checklist.
(Class A, B, and C)

(1) Blanking and/or disconnecting.

(2) Electrical lockout.

(3) Mechanical lockout.

(d) Special clothing and equipment.
(Class A and B)

(1) Personal protective equipment and clothing

(2) Safety harness and/or lines.

(3) Tools approved for use in accordance with the Hazardous Location Classification (NEC-1978).

(4) Approved electrical equipment.

(e) Atmospheric test readings.
(Class A, B, and C)

(1) Oxygen level.

(2) Flammability and/or explosive levels.

(3) Toxic substance levels.

(f) Atmospheric monitoring while work is being performed.
(Class A on a continuous basis and Class B as determined by the Qualified Person)

(g) Personnel training and complete understanding of the hazards.
(Class A, B, and C)

(h) Standby person(s) as named on the permit.
(Class A and B)

(i) Emergency procedures and location of first aid equipment.
(Class A, B and C)

(j) Confined space classification A, B, and C.

This permit shall be dated and carry an expiration time that will be valid for one shift only. The permit shall be updated for each shift with the same requirements.

The permit for a Class A or B confined space shall be posted in a conspicuous place, close to the entrance, with a copy on file with the employer.

The sample permit in Appendix III should serve as a guide and not be limited to the areas mentioned. The training requirements of personnel entering and/or working in confined spaces shall be suitable for the nature of the hazard and the work to be performed and will therefore vary with the confined space classification. The permit will vary among different industrial activities. However, it should serve the same purpose for all industries, to insure the safety of the worker.

Section 4 - Medical (Class A, B)

(a) Workers who enter a Class A or B confined space shall have a pre-placement physical examination made available to them. The employer shall provide to the physician performing or responsible for the medical surveillance program information such as the type of confined space the employee may be required to enter, the type of substances the employee may encounter, and a description of any protective devices or equipment the employee may be required to use. The physical examination shall include:

(1) A demonstration of the worker's ability to use negative and positive pressure respirators as cited in 29 CFR 1910.134.

(2) A demonstration of the workers ability to see and hear warnings, such as flashing lights, buzzers or sirens.

(3) The examination should place emphasis on general evaluations of the employee's ability to carry out his assigned duties and the detection of any diseases or abnormalities which may make it difficult to work within confined spaces.

(b) Following completion of the examinations, the physician shall give to the employer a written statement specifying any condition or abnormality found which would increase risk to the employee's health by working in confined spaces.

(c) Periodic medical examinations shall be made available to employees required to work in Class A or B confined spaces.

(d) First Aid Provisions

(1) For Class A and B entry there shall always be someone readily available in the area of the confined space who is currently trained in cardio-pulmonary resuscitation (CPR) and basic first-aid procedures.

(2) Employees shall be aware of the location of the nearest first-aid equipment, and how to obtain emergency assistance and medical attention. An adequate supply of first-aid equipment shall be within easy access of the confined space.

(e) Records of exposure to known health hazards shall be included in that employee's medical record. These records shall be made available to the designated medical representatives of the Secretary of Health, Education and Welfare, of the Secretary of Labor, of the employer and of the employee or former employee.

Section 5 - Training (Class A, B, and C)

The employer shall be responsible for training personnel and for the safety of the entire operation. Personnel who work in the vicinity of confined spaces shall be made aware of the hazards associated with confined spaces during orientation. Personnel who are required to work in a confined space, or in support of those working in a confined space shall have additional training in the following areas:

(a) Emergency entry and exit procedures (Class A, B, and C);

(b) Use of applicable respirators (Class A, B, and C);

(c) First aid (Class A, B);

(d) Lockout procedures (Class A, B, and C);

(e) Safety equipment use (Class A, B, and C);

(f) Rescue and training drills designed to maintain proficiency shall be given initially to new employees, and thereafter, at least annually, or at lesser intervals as determined necessary by the judgment of the employer (Class A, B, and C);

(g) Permit system (Class A, B and C); and

(h) Work practices as recommended in Section 9 of this proposed standard. (Class A, B and C)

Training shall not be considered as complete until the supervisor or other employer-designated official, safety or training officer, judges that the employee has attained an acceptable degree of proficiency for entering and working in confined spaces. The trainee's judgment of the adequacy of his training should be properly considered.

Section 6 - Testing and Monitoring (Class A, B, and C)

Entry into a confined space is prohibited until initial testing of the atmosphere has been done from the outside . Appropriate tests shall be made to insure that the atmosphere is safe. The tests performed shall include those for oxygen content, flammability, and toxic materials. Any necessary additional tests will be selected and performed to the satisfaction of the qualified person. Monitoring of a Class A confined space shall be done on a continuous basis. Class B and C shall be monitored as determined by the qualified person.

Entry into a confined space for any type of hot work shall be prohibited when tests indicate the concentration of flammable gases in the atmosphere is greater than 10% of the lower flammability limit (LFL). It is necessary to determine the oxygen level (by appropriate testing) prior to measuring the range of flammability to make necessary corrections in the flammability measurement. Monitoring of the atmosphere shall be performed in accordance with the permit. Equipment for continuous monitoring of gases and vapors shall be explosion proof and equipped with an audible alarm or danger signaling device that will alert employees when a hazardous condition develops. Instruments used for testing the atmosphere in a confined space shall be selected for their functional ability to measure hazardous concentrations. Instruments shall be calibrated in accordance with the manufacturer's guidelines or manuals. Each calibration shall be recorded, filed by the employer, and available for inspection for 1 year after the last calibration date.

In any confined space classified as a Class II or Class III hazardous location according to the 1978 National Electrical Code, Article 500 Sections 5 and 6, a fire watch shall be established as part of the entry procedure. In such areas surface dust and fibers shall be removed and no hot work shall be initiated until the airborne particulate level is below 10% of the LFL for the material. When combustible dusts or ignitable fibers/flyings are present, all equipment and ventilation systems used in the confined space shall comply with Articles 502 and 503 of the National Electrical Code.

The percentage of oxygen for entry into a confined space shall be no less than 19.5% nor greater than 25% at 760 mm Hg. At sea level the normal atmospheric pressure for air (20.9% O_2 + 78.1% N_2 + 1% Ar + trace amounts of various inert gases) is 14.7 psi or 760 mm Hg absolute. The partial pressure of oxygen (PO_2) at sea level will be approximately 160 mm Hg. PO_2 can be reduced by reducing the O_2 level in air at a given elevation or through increasing altitude. If tests indicate the oxygen level to be greater than 25% hot work is prohibited until ventilating techniques have reduced the oxygen level to approximately 21%. If the percentage of oxygen falls below 19.5% approved respiratory equipment shall be used in accordance with Section 8 and Appendix II.

When the contaminants in the atmosphere cannot be kept within permissible exposure levels as set down in 29 CFR Part 1910 Sub Part Z, then the employee shall wear an approved respirator.

Section 7 - Labeling and Posting (Class A, B, and C)

(a) All warning signs shall be printed both in English and in the predominant language of non-English reading workers. Where established symbols exist, they shall also be used. Workers unable to read labels and posted signs shall receive information regarding hazardous areas and shall be informed of the instructions printed on the signs.

(b) All entrances to any confined space shall be posted. Signs shall include but not necessarily be limited to the following information:

DANGER

CONFINED SPACE

ENTRY BY PERMIT
ONLY

(c) When a specific work practice is performed or specific safety equipment is necessary, the following statement shall be added, in large letters, to the warning sign:

RESPIRATOR REQUIRED
FOR ENTRY

LIFELINE REQUIRED
FOR ENTRY

HOT WORK PERMITTED
OR
NO HOT WORK

(d) Emergency procedures, including phone numbers of fire departments and emergency medical services shall be posted conspicuously within the immediate area of the confined space, or at the telephone from which help would be summoned.

Section 8 - Safety Equipment and Clothing (Class A, B, and C)

The entry permit shall include a list of necessary protective equipment to be used in the confined space as determined by the qualified person. The employer shall be responsible for the proper use of the safety equipment, and the inspection and maintenance procedures performed on the safety equipment. The type of protective equipment required, will be determined by the qualified person.

Those items normally used to protect against traumatic injury include: safety glasses, hardhats, footwear and protective clothing.

(a) Eye and Face Protection - For persons who wear corrective spectacles, either prescription ground safety glasses or plano-goggles shall be provided. Additionally if eye-irritating chemicals, vapors, or dusts are present, safety goggles shall be required, and if both the face and eyes are exposed to a hazard, as during scrapping scale or cutting rivets, a full coverage face shield with goggles shall be used. During welding operations the special goggles or shields required shall be in accordance with 29 CFR 1910.252.

(b) Head Protection - Hard hats shall meet the requirements cited in 29 CFR 1910.135.

(c) Foot Protection - All foot protection shall meet or exceed the requirements cited in 29 CFR 1910.136 and shall provide, in addition to protection from falling objects, protection from any other hazard identified by the qualified person.

(d) Body Protection - All personnel entering a confined space shall wear full coverage work clothing as specified by the qualified person. Gloves and clothing made of impervious rubber or similar material are to be worn to protect against toxic or irritating materials. If the hazards of heat or cold stress exist in the confined space, clothing which has been tested to provide protection from over-exposure to these hazards shall be worn. Other body protection required in specific operations such as welding (flame proofed), riveting (heat resistant) and abrasive blasting (abrasion resistant) shall be provided to insure worker safety.

(e) Hearing Protection - Shall be required when engineering technology is insufficient to control the noise level, and the ambient exposure limit exceeds those allowed in Table G-16 of 29 CFR 1910.95. Emergency alarms shall be distinguishable when hearing protection is worn. The sound level meters used to measure noise levels shall be certified by NIOSH in accordance with 24 CFR 82. Where the potential for explosion exists, the sound level meters shall be of an explosion proof design.

(f) Respiratory Protection - Shall be determined by the qualified person based upon conditions and test results of the confined space, and the work activity to be performed. Halfmask respirators are not recommended for use in any atmosphere greater than 10 x PEL because of the probability of accidently breaking the facepiece to face seal due to the work condition in a confined space. Also, gas masks designed for the same respiratory protection may be substituted for chemical cartridge respirators in the table (see Appendix II), but they are more cumbersome and restrictive to movement. The minimum service time of self-contained breathing apparatus shall be calculated on the entry time, plus the maximum work period, plus twice the estimated escape time for safety margin.

The respirators used shall be NIOSH and MSHA approved devices and shall be fitted and maintained in accordance with 29 CFR 1910.134. However, supplied-air respirators purchased before 1975 and bearing Bureau of Mines approval may be used until March 31, 1980. Self-contained breathing apparatus, with audible alarms and all gas masks, approved by the Bureau of Mines may be used until further notice.

(g) Hand Protection - If hands are exposed to rough surfaces or sharp edges, the degree of protection can range from canvas to metal mesh gloves, depending on the material handled. Gloves made of impervious rubber or similar material are to be worn to protect against toxic or irritating materials. Heat protective gloves are required when employees handle objects with temperatures greater than 60 C (140 F). Where a current flow through the body of more than 5 milliamperes may result from contact with energized electrical equipment, employees shall wear insulating gloves that have been visually inspected before each use. Above 5,000 volts, rubber gloves in accordance with 29 CFR 1910.137 shall be worn.

Additional safety equipment that is necessary to protect the worker in the environment of a confined space: a safety belt with "D" rings for attaching a life line shall be worn at all times; the combination of a body harness and/or safety belt with life line shall be used when an employee is required to enter to complete the gas analysis; when an employee is working in an area where entry for purposes of rescue would be contraindicated (special limitations or fire hazard); when any failure of ventilation would allow the build-up of toxic or explosive gases within the time necessary to evacuate the area, or when the atmosphere is immediately dangerous to life and health. Safety belts may be used as the primary means of suspension for the life line only when rescue may be made by keeping the disabled body in a position that will maintain easy passage through exit openings. If the exit opening is less than 18 inches (45 cm) in diameter, then a wrist type harness shall be used. When it is determined by the qualified person that none of the special hazards associated with confined spaces pose an immediate threat to life, as in a Class C entry, then life lines shall be readily available but not used during entry and work procedures.

Other protective measures shall include: safety nets used to protect employees working 10 feet (3 m) above ground or grade level when other protective devices are impractical; life jackets worn if the workers are exposed to falls into liquid over 4 feet (1.2 m) in depth; and insulated floor mats when hot work requires use of electrical energy.

When employees enter a confined space, a barricade shall be erected if inadvertent entry poses a problem. The barricade shall have a mechanism to prevent closure of the escapeway, signs warning of the danger present, a physical barrier (fence) to keep the area clear, and an adequate platform (3 feet x 3 feet as a minimum) for entry or exit. Such added features as a tripod with block and tackle for safety lines and communication equipment should be considered when the entry plan is formulated. The employer shall be responsible for maintenance of the barricade system.

Section 9 - Work Practices (Class A, B, and C)

Before entering a confined space, employees shall review the specific guidelines appropriate for safe entry and emergency exit. These guidelines or standards shall be compiled by the qualified person and be definitive on all the possible hazards. Areas covered by such guidelines shall follow this recommended standard.

(a) Purging and Ventilating (Class A, B)

Environmental control within a confined space is accomplished by purging and ventilating. The method used will be determined by the potential hazards that arise due to the product stored or produced, suspected contaminants, the work to be performed, and the design of the confined space. When ventilating and/or purging operations are to be performed, the blower controls shall be at a safe distance from the confined space. In a Class A entry, an audible warning device shall be installed in all equipment to signal when there is a ventilation failure. When a ventilation system is operational, air flow measurements shall be made before each workshift to ensure that a safe environmental level is maintained. Initial testing of the atmosphere shall be performed from outside the confined space before ventilation begins to determine what precautions are necessary in purging and ventilating. Testing of more remote regions within the confined space may be performed once the immediate area within the confined space has been made safe. Exhaust systems shall be designed to protect workers in the surrounding area from contaminated air. If flammable concentrations are present all electrical equipment shall comply with the requirements of NEC (NFPA no. 70) hazardous locations, and the bonding requirements of Article 250 of NEC, 1978. Where continuous ventilation is not a part of the operating procedure, the atmosphere shall be tested until continuous acceptable levels of oxygen and contaminants are maintained for three tests at 5-minute intervals. Care shall be taken to prevent recirculation of contaminated air and interaction of airborne contaminants.

Continuous general ventilation shall be maintained where toxic atmospheres are produced as part of a work procedure, such as welding or painting, or where a toxic atmosphere may develop due to the nature of the confined space, as in the case of desorption from walls, or evaporation of residual chemicals. General ventilation is an effective procedure for distributing contaminants

from a local generation point throughout the work space to obtain maximum dilution. However, special precautions shall be taken if the ventilating system partially blocks the exit opening. These precautions include a method for providing respirable air to each worker for the time necessary for exit, and a method of maintaining communications.

Local exhaust ventilation shall be provided when general ventilation is not effective due to restrictions in the confined space or when high concentrations of contaminants occur in the breathing zone of the worker. Local high concentrations of contaminants may occur during work activities such as welding, painting, and chemical cleaning. The worker shall not be exposed to concentrations of contaminants in excess of those specified in 29 CFR Part 1910 Sub Part Z. Therefore, respiratory protection, as recommended in Section 8, may be needed in addition to engineering controls. The use of respiratory protection will be determined by the qualified person. However, when fumes may be generated that contain highly toxic or other airborne metal contaminants, the provisions of 29 CFR 1910.252 shall be observed. When freely moving exhaust hoods are used to provide control of fumes generated during welding, such hoods shall maintain a velocity of 100 feet per/minute in the zone of the welding. The effective force of freely moving exhaust hoods is decreased by approximately 90% at a distance of one duct diameter from the plane of the exhaust opening. Therefore, to obtain maximum effectiveness the welder shall re-position the exhaust hood as he changes welding locations to keep the hood in close proximity to the fume source.

Special precautions shall be taken when outgassing or vaporization of toxic and/or flammable substances are likely. If the vapor-generating rate can be determined, the exhaust rate required can be calculated to dilute the atmosphere below the PEL and/or 10% of the LFL, whichever is the lower. This shall be the lowest acceptable ventilation rate. If the area of concern is relatively small, diffusion of the contaminants may be controlled by enclosure with a relatively low volume exhaust for control, or by exhaust hoods located as close as possible to the area of vaporization or outgassing. If the area to be ventilated is too extensive to be controlled by local exhaust, then general ventilation procedures shall be used to control the contaminant level. When the problem of outgassing is due to the application of protective coatings or paint, ventilation shall be continued until the build-up of a flammable and/or toxic atmosphere is no longer possible.

There are three components necessary for combustion: fuel, oxygen, and a source of ignition. If work with fire becomes necessary in a confined space and the source of fuel cannot be controlled, then the atmosphere shall be inerted. This is a highly hazardous work situation, and continuous monitoring of the inert make-up ventilation is mandatory. Monitoring shall include flow measurement as well as gas analysis. The inerting operation shall be continuously monitored and supervised by the qualified person. Since every confined space will have its own infiltration rate, inerting shall continue for the entire duration of the work at a rate that will prevent air from entering the confined space.

(b) Isolation/Lockout/Tagging (Class A, B)

The isolation procedures shall be specific for each type of confined space. Safety equipment required during this procedure shall be designated by the qualified person and be dependent upon the potential hazards involved. A

Class A or B confined space shall be completely isolated from all other systems by physical disconnection, double block and bleed, or blanking off all lines. In continuous systems, where complete isolation is not possible, such as sewers or utility tunnels, specific written safety procedures that are approved and enforced by the employer shall be used. Blanks used to seal off lines shall be capable of withstanding the maximum working pressure or load of the line (with a minimum safety factor of 4), be provided with a gasket on the pressure side to insure a leakproof seal, and be made of chemically non-reactive material. Shutoff valves serving the confined space, shall be locked in the closed position and tagged for identification. In addition to blanking, pumps and compressors serving these lines entering the confined space shall be locked out to prevent accidental activation.

All blanks for that specific confined space shall be recorded on the entry permit and recorded in the employer's file, which shall be available for inspection.

If a drain line is located within the confined space, provision shall be made when necessary to tag it and leave it open. This shall also be recorded on the entry permit.

Additional procedures, which are necessary when the confined space is of a double wall type construction, eg, water jacketed or similar type, shall be determined by the qualified person and noted on the entry permit.

Electrical isolation of the confined space to prevent accidental activation of moving parts that would be hazardous to the worker is achieved by locking circuit breakers and/or disconnects in the open (off) position with a key-type padlock. The only key is to remain with the person working inside the confined space. If more than one person is inside the confined space, each person shall place his own lock on the circuit breaker. In addition to the lockout system, there must be an accompanying tag that identifies the operation and prohibits use.

Mechanical isolation of moving parts can be achieved by disconnecting linkages, or removing drive belts or chains. Equipment with moving mechanical parts shall also be blocked in such a manner that there can be no accidental rotation.

(c) Cleaning (Class A, B, and C)

Procedures and processes used to clean the inside of a confined space shall be reviewed and authorized by the qualified person. The method to be prescribed shall be dependent upon the product in the space. If the confined space contains a flammable atmosphere above the upper flammable limit, it shall be purged with an inert gas to remove the flammable substance before ventilating with air. Initial cleaning shall be done from outside the tank if at all possible.

Special procedures should be adopted to handle the hazards created by the cleaning process itself. For example: if the tank is steamed, (1) it shall be allowed to cool prior to entry; (2) ventilation shall be maintained during neutralization procedures to prevent build-up of toxic materials; (3) steaming shall not be used as a cleaning method when the product stored was a liquid with an autoignition temperature 120% or less of the steam temperature, and

(4) the pipe or nozzle of the steam hose shall be bonded to the tank to decrease the generation of static electricity that could accumulate in tanks during steaming procedures. These and other hazards and controls shall be evaluated by the qualified person.

(d) Equipment and Tools (Class A, B, and C)

Equipment and tools to be used in a confined space shall be carefully inspected and shall meet the following requirements:

(1) Hand tools shall be kept clean and in good repair.

(2) Portable electric tools, equipment, and lighting shall be approved in accordance with 29 CFR Part 1910 Sub Part S and be equipped with a ground fault circuit interrupter that meets the requirements of 29 CFR 1910.309. All grounds shall be checked before electrical equipment is used in a confined space.

(3) All electrical cords, tools, and equipment shall be of heavy duty type with heavy duty insulation and inspected for visually detectable defects before use in a confined space.

(4) Air driven power tools shall be used when flammable liquids are present. The use of air driven power tools will reduce the risk of explosion, not eliminate it. Explosions can arise by tools overheating (drilling), sparks produced by striking (percussion), grinding or discharge of accumulated electrostatic charges developed from the flow of compressed air.

(5) Lighting used in Class A and B confined spaces shall be of explosion proof design and where necessary, equipped with guards. Only equipment listed by the Underwriters Laboratories for use in Division 1, atmospheres of the appropriate class and group, or approved by U.S. Bureau of Mines or Mining Enforcement and Safety Administration or Mine Safety and Health Administration, or the US Coast Guard shall be used. Lighting shall not be hung by electric cords, unless specifically designed for that purpose. The illumination of the work area shall be sufficient to provide for safe work conditions as referenced in the ANSI standard A11-1-1965, or the revision, 1970. Under no circumstances will matches or open flames be used in a confined space for illumination.

(6) Cylinders of compressed gases shall never be taken into a confined space, and shall be turned off at the cylinder valve when not in use. Exempt from this rule are cylinders that are part of self-contained breathing apparatus or resuscitation equipment.

(7) Ladders shall be adequately secured, or of a permanent type which provides the same degree of safety as cited in 29 CFR Part 1910 Sub Part D.

(8) Scaffolding and staging shall be properly designed to carry maximum expected load (safety factor of 4), be equipped with traction type planking, and meet the requirements of 29 CFR 1910.28.

(9) Electrical lines, junctions and appurtenances will be in accordance with National Electrical Code (NEC) and National Fire code (NFC) as cited in 29 CFR 1910.309.

(10) Only hose lines and components designed specially for the compressed gas and working pressure shall be used, and such systems shall have a pressure relief valve outside the confined space.

(11) All equipment that may be used in a flammable atmosphere shall be approved as explosion proof or intrinsically safe for the atmosphere involved by a recognized testing laboratory such as the US Bureau of Mines, MESA, or MSHA for methane and by the Underwriters Laboratories or by Factory Mutual for all cases.

(e) Recordkeeping (Class A, B)

The employer shall maintain a written record of training including safety drills, inspections, tests, and maintenance. The records shall be retained 1 year after the last date of training, inspection, test, or maintenance. In the event of separation of the employee, disposal of equipment or appliance, records may be disposed of after 1 year.

Where atmospheric testing indicates the presence of a toxic substance, records shall be maintained in accordance with the existing Federal regulation(s). These records shall include the dates and times of measurements, duties and location of the employees within the confined space, sampling and analytical methods used, number, duration, and results of the samples taken, PEL concentrations estimated from these samples, type of personal protective equipment used, if any, and employees' names. These records shall be made available to the designated representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

II. INTRODUCTION

This document presents the criteria and the recommended standard based thereon that were prepared to meet the need for preventing occupational injuries and deaths associated with persons entering, working in, and exiting confined spaces. This document does not address the specialized areas of radiation, inert atmospheres or hyperbaric atmospheres; except to recognize they do exist and represent a potential hazard. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(2) of the Occupational Safety and Health Act of 1970 to "...develop and establish recommended occupational safety and health standards."

After reviewing data and consulting with others, NIOSH developed criteria upon which standards can be established to protect the health and to provide for the safety of workers exposed to occupational hazards. It should be noted that criteria for a recommended standard should enable management and labor to develop better work practices and more appropriate training programs that will result in safer work environments. Simply complying with the recommended standard should not be the final goal.

The worker who enters a confined space may be, or often is exposed to multiple hazards due primarily either to ignorance of the potential hazards or negligence in the enforcement of safety regulations. Ignorance and negligence have led to deaths by asphyxiation, by fire and explosion, and by fatal exposure to toxic materials. NIOSH is aware that a number of deaths occur each year when workers must enter and work in a confined space, and it recognizes that due to current data collection methods, an estimate of the injuries and deaths which do occur will be inaccurate. Also, since there is no specific Standard Industrial Classification where these injuries and deaths are recorded for confined spaces, they are recorded in several different categories, thereby giving the appearance of a limited exposure to the hazard.

These criteria for a standard are a part of a continuing series of documents published by NIOSH. The proposed standard applies only to entering into, working in, and exiting from confined spaces as applicable under the Occupational Safety and Health Act of 1970.

The method used in this study consisted of developing, evaluating, and recording information from extensive literature searches, site visits to various industries, and consultation with reviewers knowledgeable on the subject of confined spaces.

Standards covering issues of occupational safety and health that are of general application without regard to any specific industry are intended to be applicable to this recommended standard even though no specific reference is made to them. Examples of these general areas are: exposure to toxic chemicals, noise, temperature extremes, and general duty requirements.

III. CONFINED SPACE HAZARDS

Overview and Magnitude of the Problem

(a) Overview

The hazards encountered and associated with entering and working in confined spaces are capable of causing bodily injury, illness, and death to the worker. Accidents occur among workers because of failure to recognize that a confined space is a potential hazard. It should therefore be considered that the most unfavorable situation exists in every case and that the danger of explosion, poisoning, and asphyxiation will be present at the onset of entry.

Before forced ventilation is initiated, information such as restricted areas within the confined space, voids, the nature of the contaminants present, the size of the space, the type of work to be performed, and the number of people involved should be considered. The ventilation air should not create an additional hazard due to recirculation of contaminants, improper arrangement of the inlet duct, or by the substitution of anything other than fresh (normal) air (approximately 20.9% oxygen, 79.1% nitrogen by volume). The terms air and oxygen are sometimes considered synonymous. However, this is a dangerous assumption, since the use of oxygen in place of fresh (normal) air for ventilation will expand the limits of flammability and increase the hazards of fire and explosion.

Hazardous conditions to be discussed in this Chapter include: Hazardous Atmospheres (flammable, toxic, irritant, and asphyxiating), and General Safety Hazards (mechanical, communications, entry and exit, and physical).

An estimation of the number of workers potentially exposed to confined spaces would be difficult to produce. A report prepared under contract for NIOSH [1] shows that the rate of confined space related injuries in the shipbuilding and repair industry is 4.8%. Projected on a national level, 2,448 accidents per year may be attributed to the hazards of working in confined spaces in this single industry. The Bureau of Labor Statistics shows that the Standard Industrial Classification (SIC) 373, Shipbuilding and Repair Industry, has a 23.9% injury rate. Based on this injury rate 5% of all accidents in the Shipbuilding and Repair Industry occur while working in and around confined spaces. Because of the lack of data it is not possible at this time to project this proportion of confined space related injuries to other industries [2]. Based on the total working population of selected specific SIC codes, and a rough estimate of the percentage of each category who may work in confined spaces at some time, NIOSH estimates that millions of workers may be exposed to hazards in confined spaces each year.

(b) Types of Confined Spaces

Confined spaces can be categorized generally as those with open tops and with a depth that will restrict the natural movement of air, and enclosed spaces with very limited openings for entry [3]. In either of these cases the space may contain mechanical equipment with moving parts. Any combination of these parameters will change the nature of the hazards encountered. Degreasers, pits, and certain types of storage tanks may be classified as open

topped confined spaces that usually contain no moving parts. However, gases that are heavier than air (butane, propane, and other hydrocarbons) remain in depressions and will flow to low points where they are difficult to remove [4]. Open topped water tanks that appear harmless may develop toxic atmospheres such as hydrogen sulfide from the vaporization of contaminated water [5]. Therefore, these gases (heavier than air) are a primary concern when entry into such a confined space is being planned. Other hazards may develop due to the work performed in the confined space or because of corrosive residues that accelerate the decomposition of scaffolding supports and electrical components.

Confined spaces such as sewers, casings, tanks, silos, vaults, and compartments of ships usually have limited access. The problems arising in these areas are similar to those that occur in open topped confined spaces. However, the limited access increases the risk of injury. Gases which are heavier than air such as carbon dioxide and propane, may lie in a tank or vault for hours or even days after the containers have been opened [6]. Because some gases are odorless, the hazard may be overlooked with fatal results. Gases that are lighter than air may also be trapped within an enclosed type confined space, especially those with access from the bottom or side.

Hazards specific to a confined space are dictated by: (1) the material stored or used in the confined space; as an example, damp activated carbon in a filtration tank will absorb oxygen thus creating an oxygen deficient atmosphere [7]; (2) the activity carried out, such as the fermentation of molasses that creates ethyl alcohol vapors and decreases the oxygen content of the atmosphere [8]; or (3) the external environment, as in the case of sewer systems that may be affected by high tides, heavier than air gases, or flash floods [9].

The most hazardous kind of confined space is the type that combines limited access and mechanical devices. All the hazards of open top and limited access confined spaces may be present together with the additional hazard of moving parts. Digesters and boilers usually contain power-driven equipment which, unless properly isolated, may be inadvertently activated after entry. Such equipment may also contain physical hazards that further complicate the work environment and the entry and exit process.

(c) Reasons for Entering Confined Spaces

Entering a confined space as part of the industrial activity may be done for various reasons. It is done usually to perform a necessary function, such as inspection, repair, maintenance (cleaning or painting), or similar operations which would be an infrequent or irregular function of the total industrial activity [10].

Entry may also be made during new construction. Potential hazards should be easier to recognize during construction since the confined space has not been used. The types of hazards involved will be limited by the specific work practices. When the area meets the criteria for a confined space, all ventilation and other requirements should be enforced.

One of the most difficult entries to control is that of unauthorized entry, especially when there are large numbers of workers and trades involved, such as welders, painters, electricians, and safety monitors.

A final and most important reason for entry would be emergency rescue. This, and all other reasons for entry, must be well planned before initial entry is made and the hazards must be thoroughly reviewed. The standby person and all rescue personnel should be aware of the structural design of the space, emergency exit procedures, and life support systems required.

Hazardous Atmospheres

Hazardous atmospheres encountered in confined spaces can be divided into four distinct categories: (a) Flammable, (b) Toxic, (c) Irritant and/or Corrosive, and (d) Asphyxiating.

(a) Flammable Atmosphere

A flammable atmosphere generally arises from enriched oxygen atmospheres, vaporization of flammable liquids, byproducts of work, chemical reactions, concentrations of combustible dusts, and desorption of chemicals from inner surfaces of the confined space.

Alther [11] reported on a case involving workers in an enriched oxygen atmosphere. Two men entered a newly constructed tank to repair a bulge which had formed after the flange of the manhole was welded to the tank. The planned repair procedure was to have two men enter the tank with a jack to force the flange of the manhole into place while a third worker heated the bulge from the outside. To accomplish this procedure the men had to close the manhole. To improve the air within the tank, oxygen used for welding was blown in through an opening. A worker on the outside noticed through the opening that the hair of one of the workmen inside was on fire. The cover was immediately removed and one of the workers managed to escape, his clothing was burning rapidly, the second worker had collapsed and remained unconscious inside. It became necessary to invert the tank to remove the unconscious workman. Both workmen who were doing the work inside suffered serious burns. One died a short time later; the second was hospitalized for several months. A rescuer in the operation was burned on the hands.

Investigation of the accident revealed the use of oxygen in place of normal air increased the flammability range of combustibles. Enrichment of the atmosphere with only a few percent of oxygen above 21% will cause an increase in the range of flammability, hair as well as clothing will absorb the oxygen and burn violently. Enriched oxygen atmospheres which expand the region of flammability could be the result of improper blanking off of oxygen lines, chemical reactions which liberate oxygen, or inadvertently purging the space with oxygen in place of air [11].

An atmosphere becomes flammable when the ratio of oxygen to combustible material in the air is neither too rich nor too lean for combustion to occur. Combustible gases or vapors will accumulate when there is inadequate ventilation in areas such as a confined space. Flammable gases such as acetylene, butane, propane, hydrogen, methane, natural or manufactured gases or vapors from liquid hydrocarbons can be trapped in confined spaces, and

since many gases are heavier than air, they will seek lower levels as in pits, sewers, and various types of storage tanks and vessels [12,13]. In a closed top tank, it should also be noted that lighter than air gases may rise and develop a flammable concentration if trapped above the opening.

The byproducts of work procedures can generate flammable or explosive conditions within a confined space. Specific kinds of work such as spray painting can result in the release of explosive gases or vapors [14]. Table III-3 shows that approximately one-third of the events identified as "atmospheric condition" were the result of the victims performing activities that generated fumes or depleted the oxygen supply. The most common of these activities was welding in a confined space. Welding in a confined space was a major cause for explosions in areas that contained combustible gas [1].

Chemical reactions forming flammable atmospheres occur when surfaces are initially exposed to the atmosphere, or when chemicals combine to form flammable gases. This condition arises when dilute sulfuric acid reacts with iron to form hydrogen or when calcium carbide makes contact with water to form acetylene. Other examples of spontaneous chemical reactions that may produce explosions from small amounts of unstable compounds are acetylene-metal compounds, peroxides, and nitrates. In a dry state these compounds have the potential to explode upon percussion or exposure to increased temperature. Another class of chemical reactions that form flammable atmospheres arise from deposits of pyrophoric substances (carbon, ferrous oxide, ferrous sulfate, iron, etc) that can be found in tanks used by the chemical and petroleum industry. These tanks containing flammable deposits, will spontaneously ignite upon exposure to air [15].

Combustible dust concentrations are usually found during the process of loading, unloading, and conveying grain products, nitrated fertilizers, finely ground chemical products, and any other combustible material. It has been reported that high charges of static electricity, which rapidly accumulate during periods of relatively low humidity (below 50%), can cause certain substances to accumulate electrostatic charges of sufficient energy to produce sparks and ignite a flammable atmosphere [14]. These sparks may also cause explosions when the right air or oxygen to dust or gas mixture is present.

Desorption of chemicals from the inner surfaces of a confined space is another process that may produce a flammable atmosphere. This is often a natural phenomenon in which the partial pressure at the interface between the surfaces and the stored chemical is radically reduced. For example, after liquid propane is removed from a storage tank the walls of the vessel may desorb the remaining gas from the porous surface of the confined space.

Dorias [16] reported on an explosive gas-air mixture in a horizontal cylindrical container (1000 m3), which had contained liquid propane. The cylinder was emptied to check for stress cracking. The space was to be filled with water to expell the gas, and drained so it could automatically fill with normal air. The container was presumably filled full of water and drained. The gas analysis of the resulting space showed an explosive gas-air mixture. The procedure of filling with water and draining was repeated and the test results were the same, an explosive gas-air mixture. To speed up the process, a man climbed into the cylinder and sprayed the interior with water for 3 hours, and allowed the interior to air dry. On the 4th day, a mechanic entered the tank and prepared the areas to be inspected for stress. Following

this, a man entered the tank with a test device and a Katel lamp (220 volts not of an explosion-proof design). There was a sudden explosion and flame streamed out of the entry manhole. The man who was testing the atmosphere suffered severe injuries from which he died 6 days later. Investigation of the events revealed that the tanks were filled only 50% full the first time and only 80-90% full the second time. Therefore, it was concluded the space was never thoroughly emptied of all gas. Reconstruction of the operation showed that the spraying operation did not remove all the propane, and left a gas-air mixture of approximately 5% propane by volume, an extremely explosive condition [16].

(b) Toxic Atmospheres

The substances to be regarded as toxic in a confined space can cover the entire spectrum of gases, vapors, and finely-divided airborne dust in industry [17]. The sources of toxic atmospheres encountered may arise from the following:

(1) The manufacturing process (for example, in producing polyvinyl chloride, hydrogen chloride is used as well as vinyl chloride monomer which is carcinogenic).

(2) The product stored (removing decomposed organic material from a tank can liberate toxic substances such as H_2S).

(3) The operation performed in the confined space (for example, welding or brazing with metals capable of producing toxic fumes).

Zavon [18] reported, in 1970, that four employees of a local utility were repairing a water meter in an underground vault 18 feet x 6 feet x 5 feet with an opening 24 inches in diameter. To make the repairs, it was necessary to cut 26 cadmium plated bolts with an oxygen propane torch. Two men worked in the vault with one man cutting and the other standing beside him. Neither man wore a respirator and no ventilation was provided. Two other men remained on the surface. During the cutting of the bolts with the oxygen propane torch, a "heavy blue smoke" filled the vault. This smoke was exhausted after the cutting was completed.

The 56-year-old man who had cut the bolts died 17 days after exposure. He became nauseated shortly after the job and was seen by his family physician the next day for fever (102-103 F), chest pain, cough, and sore throat. On the 4th day following the incident he was in greater distress and was hospitalized. Death occurred in 2 weeks and was attributed to massive coronary infarction and corpulmonale. The 29-year-old assistant complained of chills, nausea, cough and difficulty in breathing. He was treated for pneumonia and made a slow recovery. A reenactment of the work demonstrated that the exposure to cadmium was well above the threshold limit value of "0.1 mg/m3" [18]. Symptoms attributed to cadmium poisoning include: severe labored breathing and wheezing, chest pain, persistent cough, weakness and malaise, and loss of appetite. The clinical course is similar in most cases. The injured frequently are well enough to work the day after exposure, but their conditions deteriorate until approximately the 5th day. At this point, the exposed worker will either get much worse or begin to improve [19].

Toxic gases may be evolved when acids are used for cleaning. Hydrochloric acid can react chemically with iron sulfide to produce hydrogen sulfide [20]. Iron sulfide is formed on the walls of cooling jackets when only several parts per million sulfide are in the water used in the cooling process. As an example, 5 men were overcome while cleaning a heat exchanger using a hydrochloric acid solution [20].

Another area where the hydrogen sulfide hazard exists is in the tanning industry. Lime pits used in the process of removing hair from the hides contain in addition to lime, a 1% solution of sodium sulfate (Na_2SO_4). Acid dichromate solution is also used in the tanning process. If these two solutions (sodium sulfate and acid dichromate) are combined accidentally, hydrogen sulfide (H_2S) will be produced. One such incident occurred when several unused pits at a tannery were being cleaned. Sludge had formed on the bottom of the pit due to drainage from the hides when they had been treated with lime and acid dichromate. When men entered the pit to clear the drain line, they were overcome. Because of the high specific gravity of hydrogen sulfide, the gas formed by the sodium sulfide-dichromate reaction had settled in the pit, and when the sludge was stirred the released gas overcame the workers. In this instance, 5 men became unconscious and two died [21]. The particular hazard associated with hydrogen sulfide at higher concentrations is due to its physiological effect of anesthetizing the olfactory nerves and can also cause a loss of reasoning, paralysis of the respiratory system, unconsciousness, and death [22,23].

During loading, unloading, formulation, and production, mechanical and/or human error may also produce toxic gases which are not part of the planned operation.

Toxic solvents, which present problems [24], such as trichloroethylene, methyl chloroform, and dichloromethane, are used in industry for cleaning and degreasing. Acrylonitrile, infrequently used, has been encountered as an ingredient in a protective coating applied to tank interiors [17].

Trichloroethane and dichloroethane are widely used in industry as cleaning solvents because they are among the least toxic of the chlorinated aliphatic hydrocarbons. These solvents have been used as a replacement for carbon tetrachloride and trichloroethylene [25-27].

In a case report by Hatfield and Maykoski [28] trichloroethane, also known as methyl chloroform was substituted for trichloroethylene because of the high toxicity of the latter. A radiator and metal tank repairman was involved in an aircraft tip tank cleaning and assembly operation. The technique of cleaning the interior of the tanks varied among workers. Some workmen would moisten a pad with solvent and would hand wipe the metal surfaces by reaching through an opening on the end of the tank; some would use pads on the end of a shaft, while others would climb inside and clean. One particular worker would saturate a pad with solvent and lower himself head first into the down-tilted tip of the tank and clean as fast as possible. This worker was found with his legs protruding from the upper end of the 450 gallon tank and was unresponsive. He was removed immediately and was given artificial respiration until a physician arrived and pronounced him dead.

Reconstruction of the fatal accident revealed the concentration of methyl chloroform in the tank had reached 62,000 ppm. The workers assumed that since

the new cleaning solvent was less toxic than the one previously used, there was less danger. However, the new cleaning solvent, methyl chloroform, is a potent anesthetic at 30,000 ppm, which was less than half the concentration level in the worker's breathing zone.

The compatibility of materials must be considered when structural members and equipment are introduced in confined spaces. The previous history of the confined space must be carefully evaluated to avoid reactions with residual chemicals, wall scale, and sludge which can be highly reactive. One such case was reported in May of 1968, when an aluminum ladder was used for entry into a chemical evaporating tank which had contained aqueous sodium arsenite ($Na\ AsO_2$ H_2O) and sodium hydroxide (NaOH). The aluminum reacted with the $NaAsO_2$ and the NaOH to liberate hydrogen, which in turn reacted with the arsenic to form arsine [29]. Other cases of incompatability arise from the use of chemical cleaning agents. The initial step in chemical cleaning usually is the conversion of the scale or sludge into a liquid state which may cause poisonous gases to be liberated. In 1974, several employees who were cleaning a boiler tank prior to repairing a leak used a cleaning fluid, Vestan 675. The cleaning action caused the release of ammonia fumes that were not properly exhausted. The men were hospitalized with severe chest pains, but recovered [29].

Another hazardous gas that may build up in a confined space is carbon monoxide (CO). This odorless colorless gas that has approximately the same density of air is formed from incomplete combustion of organic materials such as wood, coal, gas, oil, and gasoline [30]; it can be formed from microbial decomposition of organic matter in sewers, silos, and fermentation tanks. Carbon monoxide is an insidious toxic gas because of its poor warning properties. Early stages of carbon monoxide intoxication are nausea and headache. Carbon monoxide may be fatal at 1000 ppm in air, and is considered dangerous at 200 ppm, because it forms carboxyhemoglobin in the blood which prevents the distribution of oxygen in the body.

Carbon monoxide (CO) is a relatively abundant colorless, odorless gas, therefore, any untested atmosphere must be suspect. It must also be noted that a safe reading on a combustible gas indicator does not ensure that CO is not present [14]. Carbon monoxide must be tested for specifically. The formation of CO may result from chemical reactions or work activities, therefore, fatalities due to CO poisoning are not confined to any particular industry. There have been fatal accidents in sewage treatment plants [8] due to decomposition products and lack of ventilation in confined spaces. Another area where CO results as a product of decomposition is in the formation of silo gas in grain storage elevators [8]. In another area, the paint industry, varnish is manufactured by introducing the various ingredients into a kettle, and heating them in an inert atmosphere, usually town gas, which is a mixture of carbon dioxide and nitrogen. In one accident report, a maintenance engineer entered a kettle that had been vented for 12-24 hours to check a blocked sampling tube. He was found dead some time later. Death was due to carbon monoxide poisoning. Investigation into the inert gas supply system revealed that the CO content of the town gas was over 1% (10,000 ppm), and that there were minor faults in the protective valves into the kettle so that a small leak was occurring. The employee had entered an atmosphere of reduced oxygen partial pressure containing CO and had succumbed before he could save himself [21]. In many cases CO poisoning occurs because of poor work practices.

In welding operations, oxides of nitrogen and ozone are gases of major toxicologic importance, and incomplete oxidation may occur and carbon monoxide can form as a byproduct [31]. One such case, documented in the Pennsylvania Occupational Injury Files of 1975, involved an employee who was overcome by carbon monoxide while welding inside a copper heat-treating oven with the door partially closed.

Another poor work practice, which has led to fatalities, is the recirculation of diesel exhaust emissions [32]. Tests have shown that although the initial hazard due to exhaust toxicants may be from increased CO_2 levels (or depleted O_2), the most immediate hazard to life processes is CO [33]. Increased CO levels can only be prevented by strict control of the ventilation or the use of catalytic convertors.

(c) Irritant (Corrosive) Atmosphere

Irritant or corrosive atmospheres can be divided into primary and secondary groups. The primary irritants exert no systemic toxic effects because the products formed by them on tissues of the respiratory tract are non-irritant, and other irritant effects are so violent as to obscure any systemic toxic action. Examples of primary irritants are chlorine (Cl_2), ozone (O_3), hydrochloric acid (HCl), hydrofluoric acid (HF), sulfuric acid (H_2SO_4), nitrogen dioxide (NO_2), ammonia (NH_3), and sulfur dioxide (SO_2). A secondary irritant is one that may produce systemic toxic effects in addition to surface irritation. Examples of secondary irritants include benzene (C_6H_6), carbon tetrachloride (CCl_4), ethyl chloride (CH_3CH_2Cl), trichloroethane (CH_3CCl_3), trichloroethylene ($CHClCCl_2$), and chloropropene (allyl chloride-CH_2CHCH_2Cl) [34].

Irritant gases vary widely among all areas of industrial activity. They can be found in plastics plants, chemical plants, the petroleum industry, tanneries, refrigeration industries, paint manufacturing, and mining operations [17].

Prolonged exposure at irritant or corrosive concentrations in a confined space may produce little or no evidence of irritation. This has been interpreted to mean that the worker has become adapted to the harmful agent involved. In reality, it means there has been a general weakening of the defense reflexes from changes in sensitivity, due to damage of the nerve endings in the mucous membranes of the conjunctivae and upper respiratory tract. The danger in this situation is that the worker is usually not aware of any increase in his exposure to toxic substances [17].

(d) Asphyxiating Atmosphere

The normal atmosphere is composed approximately of 20.9% oxygen and 78.1% nitrogen, and 1% argon with small amounts of various other gases. Reduction of oxygen (O_2) in a confined space may be the result of either consumption or displacement [35].

The consumption of oxygen takes place during combustion of flammable substances, as in welding, heating, cutting, and brazing. A more subtle consumption of oxygen occurs during bacterial action, as in the fermentation process. Oxygen may also be consumed during chemical reactions as in the formation of rust on the exposed surface of the confined space (iron oxide).

The number of people working in a confined space and the amount of their physical activity will also influence the oxygen consumption rate.

A second factor in oxygen deficiency is displacement by another gas. Examples of gases that are used to displace air, and therefore reduce the oxygen level are helium, argon, and nitrogen. Carbon dioxide may also be used to displace air and can occur naturally in sewers, storage bins, wells, tunnels, wine vats, and grain elevators. Aside from the natural development of these gases, or their use in the chemical process, certain gases are also used as inerting agents to displace flammable substances and retard pyrophoric reactions. Gases such as nitrogen, argon, helium, and carbon dioxide, are frequently referred to as non-toxic inert gases but have claimed many lives [36]. The use of nitrogen to inert a confined space has claimed more lives than carbon dioxide. The total displacement of oxygen by nitrogen will cause immediate collapse and death. Carbon dioxide and argon, with specific gravities of 1.53 and 1.38, respectively, (air = 1) may lie in a tank or manhole for hours or days after opening [36]. Since these gases are colorless and odorless, they pose an immediate hazard to health unless appropriate oxygen measurements and ventilation are adequately carried out.

In a report by the Ontario (Canada) Health Department, an underground oil storage tank which required cleaning, had been blanketed with nitrogen to prevent oxidation of the oil. The man assigned to clean the tank dropped an air hose into the tank before entering. As he reached the bottom of the ladder, he passed out. His helper outside the tank went in to help and feeling faint, left without getting the man out. He went to get assistance from a nearby maintenance shop. Three men came to the tank and climbed down and all were overcome. Finally, after about 20 minutes, all four men were recovered with the help of the fire department. The only reason that there were no fatalities was that an airline in the tank was blowing air into the vicinity of the fallen workers [37].

Oxygen deprivation is one form of asphyxiation. While it is desirable to maintain the atmospheric oxygen level at 21% by volume, the body can tolerate deviation from this ideal. When the oxygen level falls to 17%, the first sign of hypoxia is a deterioration to night vision which is not noticeable until a normal oxygen concentration is restored. Physiologic effects are increased breathing volume and accelerated heartbeat. Between 14-16% physiologic effects are increased breathing volume, accelerated heartbeat, very poor muscular coordination, rapid fatigue, and intermittent respiration. Between 6-10% the effects are nausea, vomiting, inability to perform, and unconsciousness. Less than 6%, spasmatic breathing, convulsive movements, and death in minutes [12,38].

In discussing oxygen and what constitutes an oxygen deficient atmosphere from a physiologic view, one must address the concept of partial pressures. At sea level the normal atmospheric pressure for air (20.9% O_2 + 78.1% N_2 + 1% Ar + trace amounts of various inert gases) is 14.7 psi or 760 mm Hg absolute. The partial pressure of O_2 (PO_2) at sea level will be approximately 160 mm Hg. The concept of partial pressures is that in any mixture of gases, the total gas pressure is the sum of the partial pressures of all the gases [39].

The PO_2 in ambient air can be decreased by a reduction in the O_2 level at constant pressure or by maintaining the percentage of O_2 constant and decreasing the total atmospheric pressure as in the case at high altitudes.

It is important not only to know the O_2 percent by volume, but to understand the relationship of O_2 to altitude and the concept of partial pressure. For example, 20.9% O_2 in air at sea level constitutes a greater PO_2 than 20.9% O_2 at 5,000 feet because the total atmospheric pressure at 5,000 feet is less. As the PO_2 in the atmosphere drops, the volume of air required to maintain a PO_2 of 60 mm Hg in the alveolar space of the lungs increases. A PO_2 below 60 mm Hg in the alveolar space is considered oxygen deficient [39].

Absorption of oxygen by the vessel or the product stored therein is another mechanism by which the PO_2 may be reduced and result in an oxygen deficient atmosphere. For example, activated carbon, usually considered as an innocuous material free of occupational hazard and toxicity, was responsible for two fatalities in a carbon filtration tank. Damp activated carbon absorbs oxygen and has been known to decrease the oxygen level from 21% to 4% in a closed vessel [7].

Montgomery et al [7] reported on two fatalities caused by the use of activated carbon in a water filtration vessel, (12.5 feet in diameter and 17 feet high). The space was newly constructed, filled halfway with granular carbon in a slurry form (water medium), the water was drained off through a bottom drain, and the tank was closed off to protect it from the weather. The next morning two workers entered the filtration vessel to perform necessary adjustments to the carbon bed and the interior sprinkler mechanism. When the workmen failed to appear at lunch time, they were found dead on the carbon bed. However, a rescuer entered the tank without any type of respiratory protection and with no ill affects. Tests of the atmosphere revealed no cause of death, the oxygen level was 21%, hydrocarbon and hydrogen sulfide tests were negative.

The investigation of the fatalities revealed the following: the tank was re-closed and re-opened the following day. No toxic gases were found; however, the oxygen level had dropped from 21% to 12% by volume. Other vessels checked at this location which had been closed for several weeks revealed the oxygen level was down to 2%.

In summary, it was discovered that dry carbon would not reduce the oxygen level significantly. Damp activated carbon, however, supposedly an innocuous material and free from toxicity, contributed to the death of two workers as a result of selective absorption of oxygen in a confined space with no ventilation.

General Safety Hazards

(a) Mechanical

If activation of electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated to prevent inadvertent activation before workers enter or while they work in a confined space. [12,40]. The interplay of hazards associated with a confined space, such as the potential of flammable vapors or gases being present, and the build-up of static charge due to mechanical cleaning, such as abrasive blasting, all influence the precautions which must be taken.

To prevent vapor leaks, flashbacks, and other hazards, workers should completely isolate the space [41]. To completely isolate a confined space the closing of valves is not sufficient. All pipes must be physically disconnected or isolation blanks bolted in place [5]. Other special precautions must be taken in cases where flammable liquids or vapors may re-contaminate the confined space. The pipes blanked or disconnected should be inspected and tested for leakage to check the effectiveness of the procedure. Other areas of concern are steam valves, pressure lines, and chemical transfer pipes. A less apparent hazard is the space referred to as a void, such as double walled vessels, which must be given special consideration in blanking off and inerting.

(b) Communication Problems

Communication between the worker inside and the standby person outside is of utmost importance. If the worker should suddenly feel distressed and not be able to summon help, an injury could become a fatality. Frequently, the body positions that are assumed in a confined space make it difficult for the standby person to detect an unconscious worker [10]. When visual monitoring of the worker is not possible because of the design of the confined space or location of the entry hatch, a voice or alarm-activated explosion proof type of communication system will be necessary [15].

Suitable illumination of an approved type is required to provide sufficient visibility for work in accordance with the recommendations made in the Illuminating Engineering Society Lighting Handbook.

(c) Entry and Exit

Entry and exit time is of major significance as a physical limitation and is directly related to the potential hazard of the confined space. The extent of precautions taken and the standby equipment needed to maintain a safe work area will be determined by the means of access and rescue. The following should be considered: type of confined space to be entered, access to the entrance, number and size of openings, barriers within the space, the occupancy load, and the time requirement for exiting in event of fire, or vapor incursion, and the time required to rescue injured workers [41].

(d) Physical

The hazards described in this section include non-chemical, physiologic stressors. These include thermal effects (heat and cold), noise, vibration, radiation, and fatigue while working in a confined space.

(1) Thermal Effects

Four factors influence the interchange of heat between man and his environment. They are: (1) air temperature, (2) air velocity, (3) moisture contained in the air, and (4) radiant heat [42,43]. Because of the nature and design of most confined spaces, moisture content and radiant heat are difficult to control. As the body temperature rises progressively, workers will continue to function until the body temperature reaches 38.3 - 39.4 C. When this body temperature is exceeded, the workers are less efficient, and are prone to heat exhaustion, heat cramps, or heat stroke [44]. In a cold environment certain physiologic mechanisms come into play, which

tend to limit heat loss and increase heat production. The most severe strain in cold conditions is chilling of the extremities so that activity is restricted [42]. Special precautions must be taken in cold environments to prevent frostbite, trench foot, and general hypothermia.

Protective insulated clothing for both hot and cold environments will add additional bulk to the worker and must be considered in allowing for movement in the confined space and exit time. Therefore, air temperature of the environment becomes an important consideration when evaluating working conditions in confined spaces.

(2) Noise

Noise problems are usually intensified in confined spaces because the interior tends to cause sound to reverberate and thus expose the worker to higher sound levels than those found in an open environment. This intensified noise increases the risk of hearing damage to workers which could result in temporary or permanent loss of hearing. Noise in a confined space which may not be intense enough to cause hearing damage may still disrupt verbal communication with the emergency standby person on the exterior of the confined space. If the workers inside are not able to hear commands or danger signals due to excessive noise, the probability of severe accidents can increase [42].

(3) Vibration

Wholebody vibration may be regarded as a "generalized stressor" and may affect multiple body parts and organs depending upon the vibration characteristics. Segmental vibration, unlike wholebody vibration, appears to be more localized in creating injury to the fingers and hands of workers using tools, such as pneumatic hammers, rotary grinders or other hand tools which cause vibration [42].

(4) General/Physical

Some physical hazards cannot be eliminated because of the nature of the confined space or the work to be performed. These hazards include such items as scaffolding, surface residues, and structural hazards. The use of scaffolding in confined spaces has contributed to many accidents caused by workers or materials falling, improper use of guard rails, and lack of maintenance to insure worker safety. The choice of material used for scaffolding depends upon the type of work to be performed, the calculated weight to be supported, the surface on which the scaffolding is placed, and the substance previously stored in the confined space.

Surface residues in confined spaces can increase the already hazardous conditions of electrical shock, reaction of incompatible materials, liberation of toxic substances, and bodily injury due to slips and falls. Without protective clothing, additional hazards to health may arise due to surface residues.

Structural hazards within a confined space such as baffles in horizontal tanks, trays in vertical towers, bends in tunnels, overhead structural members, or scaffolding installed for maintenance constitute physical hazards, which are exacerbated by the physical surroundings. In dealing with

structural hazards, workers must review and enforce safety precautions to assure safety.

Rescue procedures may require withdrawal of an injured or unconscious person. Careful planning must be given to the relationship between the internal structure, the exit opening, and the worker. If the worker is above the opening, the system must include a rescue arrangement operated from outside the confined space, if possible, by which the employee can be lowered and removed without injury

Statistical Data

Accidents in confined spaces, like all others, are required by Federal regulations to be reported only if medical attention or loss of time from work, or death is involved. Some states and workers' compensation carriers have slightly more stringent requirements, but none require the reporting of incidents which can be considered near misses. The report by Safety Sciences prepared under contract for NIOSH [1] tended to show that fatalities occurred more frequently in confined spaces. For example, death by asphyxiation would be reported; however, if an employee experienced shortness of breath or dizziness, but managed to escape the confined space, and was not treated by a physican, this would probably not be a reported case.

The criteria used in selecting cases was based on the definition published in the Federal Register 42:213, November 4, 1977 and specific circumstances likely to be found on injury and fatality records.

Table III-1 shows the number of "events", injuries, and fatalities from each data source. "Events" refers to the number of separate occasions in which one or more confined space-related injuries or illnesses occurred [1].

Table III-2 shows the number of events, injuries and fatalities obtained for each of the 15 basic accident and illness types which are described in Appendix 4 of this document. A total of 276 confined space related events were identified, which resulted in a total of 234 injuries and 193 fatalities. The table shows that the most hazardous conditions in a confined space are a result of atmospheric related events [1].

Table III-3 shows the number of events by SIC code for each of the 15 confined space-related accident and illness types [1].

TABLE III-1

NUMBER OF CONFINED SPACE-RELATED CASES OBTAINED BY DATA SOURCE

Data Source	Approx. No. of Cases Reviewed	No. of Events	No. of Injuries	No. of Fatalities
1. First Reports from Previous NIOSH Study 1974-75	20,000	67	66	1
2. OSHA 36's 1976-77	6,000	132	130	143
3. Equifax, Inc. "Occupational Death Reports" 8/76-12/76	1,700	41	2	49
4. Shipbuilding and Repair Cases 1976-77	750	36	36	0
Totals	28,450	276	234	193

Safety Sciences, San Diego, California - 1977 [1]

TABLE III-2

ACCIDENT AND ILLNESS TYPE
CONFINED SPACE (CS)

Ref. No.	Accident and Illness Type	Events	Injuries	Fatalities
1	Atmospheric Condition in CS	80	72	78
2	Explosion or Fire in CS	15	49	15
3	Explosion or Fire at Point-of-Entry to CS	23	20	32
4	Electrocution or Electrical Shock	11	2	9
5	Caught In/Crushing of CS	10	3	10
6	Trapped in Unstable Materials in CS	16	0	16
7	Struck by Falling Objects in CS	15	1	14
8	Falls (while in CS; not into CS)	27	26	1
9	Ingress/Egress of CS	33	30	3
10	Insufficient Maneuverability in CS	15	15	0
11	Eye Injury in CS	10	10	0
12	Contact with Temperature Extreme in CS	7	4	3
13	Noise in CS	1	1	0
14	Vibration in CS	1	1	0
15	Stress from Excess Exertion in CS	12	0	12
Totals		276	234	193

Safety Sciences, San Diego, California - 1977 [1]

TABLE III-3

CONFINED SPACE EVENTS BY SIC CODE AND ACCIDENT/ILLNESS TYPE

SIC	Name of Industry	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	*15
01	Agricultural Products - Crops	4			1		1	1								1
02	Agricultural Products - Livestock						1									
07	Agricultural Services						1									
09	Fishing, Hunting, and Trapping		1													
13	Oil and Gas Extraction	6	1					1		1						
15	Building Construction	2		2	2			1			3					1
16	Construction Other Than Building Construction	6		3				1		2			1			3
17	Construction - Special Trade Contractors	8	4		1			1		1	3					2
20	Food and Kindred Products	1	1	1	1	2	2	1	3	1						1
23	Apparel			3												
24	Lumber and Wood Products, Except Furniture	1		3						1						
25	Furniture and Fixtures	1														
26	Paper and Allied Products	1							3	1	1	2	1			
28	Chemicals and Allied Products	8	2	2	2				1		1					1
29	Petroleum Refining and Related Industries		1													
30	Rubber and Misc. Plastic Products	1								2						
31	Leather and Leather Products	1			1											
32	Stone, Clay, Glass, and Concrete Products					1	3		1	2						
33	Primary Metal Industries	1		1		1		1	3	1	1	2	1			
34	Fabricated Metal Products, Ex. Machinery and Transportation Equip.	4			1		1	1			1					1

TABLE III-3 (CONTINUED)

CONFINED SPACE EVENTS BY SIC CODE AND ACCIDENT/ILLNESS TYPE

SIC	Name of Industry	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	*15
35	Machinery, Except Electrical	2	1	1				2	2		1	1				
36	Electrical and Electronic Equip.	1			1				1	1						
37	Transportation Equip.	3	2	1					2	4	1		1		1	1
3731	Shipbuilding	4			1	1			8	13	7	1		1		
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, and Optical Goods; Watches and Clocks					1		1								
42	Motor Freight Transportation and Warehousing	3	1				3	1								
44	Water Transportation	3						1					1			
45	Transportation by Air	1						1								
47	Transportation Services	1		1												
48	Communication	3														
49	Electric, Gas, and Sanitary Services	3		1			1									
50	Wholesale Trade - Durable Goods	1		2		4			1							
51	Wholesale Trade - Nondurable Goods	1		2			1	1								1
54	Food Stores								1				2			
55	Auto Dealers and Gas Stations								1							
58	Eating and Drinking Places									1						
59	Misc. Retail						1									
65	Real Estate	1														

TABLE III-3 (CONTINUED)

CONFINED SPACE EVENTS BY SIC CODE AND ACCIDENT/ILLNESS TYPE

SIC	Name of Industry	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	*15
70	Hotels, Camps, and Other Lodging Places	1														
73	Business Services	1														
75	Automotive Repair		1	1												
76	Misc. Repair Services	1		2												
82	Educational Services	1														
91	Executive, Legislative, and General Government	1														
93	Public Finance, Taxation, and Monetary Policy	1														
	Unknown	1														

*1 - Atmospheric Condition
*2 - Explosion or Fire
*3 - Explosion or Fire at Point-of-Entry
*4 - Electrocution or Electrical Shock
*5 - Caught In/Crushing
*6 - Trapped in Unstable Materials
*7 - Struck by Falling Objects
*8 - Falls
*9 - Ingress/Egress
*10 - Insufficient Maneuverability
*11 - Eye Injury
*12 - Contact with Temperature Extreme
*13 - Noise
*14 - Vibration
*15 - Stress from Excess Exertion

Safety Sciences, San Diego, California - 1977 [1]

IV. DEVELOPMENT OF THE STANDARD

Previous Standards

The basis for most of the previous standards were safety codes designed for specific industrial activities, and dealt with areas such as open surface tanks, welding and cutting, and the pulp and paper, and shipping industries.

The most recent standard published on confined spaces is the 12-year effort compiled by the American National Standards Institute, Z117.1-1977. Despite the effort, the ANSI standard does not address the vitally important areas of training of personnel and specific recommendations for the safety equipment required in a confined space. All personal protective equipment is referenced to different ANSI Standards, which are broad based and do not address the specific problems of confined spaces.

The ANSI Standard also accepts the use of tagging as a reliable method of locking out a potentially hazardous situation. The tagging system as a substitute for locking out all lines or pipes, or de-energizing systems of a confined space does not provide sufficient protection to the worker against accidental activation.

The ANSI Standard does mention the use of life lines; however, the only recommendation is for their use in an oxygen deficient atmosphere.

The General Industry Safety and Health Standards of the Occupational Safety and Health Administration (OSHA) address safety in confined spaces in over 50 different sections of 29 CFR 1910. The defining parameters of a confined space as given in the OSHA regulations are: (1) limited means of exit, (2) a space subject to accumulation of toxic or flammable contaminants or, (3) one where an oxygen deficient atmosphere may develop. It includes but is not limited to such spaces as storage tanks, process vessels, bins, boilers and open top spaces more than 4 feet in depth. This is essentially the same definition used to establish the scope of this recommended criteria. However the "Classification of open-surface tank operation" (1910.94(d) (2) (i-ii)) differs from the classification system proposed in this document. This proposed classification system is intended to apply to all confined spaces and is based upon the evaluation of several additional parameters. Such a classification will allow the application of a wider range of safety measures and ease the enforcement of the OSHA regulation. The confined space classification system was designed to create a focal point by drawing together over 140 references in the OSHA standards. For example, the use of life lines in all confined spaces, has been addressed in this document and a solution to their excessive use has been proposed. The two documents agree on many areas of good work practices, such as the use of standby personnel, blanked-off lines, and main shutoff valves. Another area of agreement is the acceptance of 19.5% as the minimal oxygen level for safe work practice. There are some areas of the OSHA regulations that appear to accept tagging as a sufficient measure to ensure against opening of valves or energizing equipment during entry or while working in confined spaces. The proposed standard is more stringent in that only locking-out, blanking-off or disconnection are acceptable.

Canadian [45] and Australian [46,47] regulations and standards on confined space entry were reviewed. The Canadian Standard uses a hazard evaluation report, which appears to be a condensed form of the recommended permit system. The Canadian Standard also relies on the qualified person to make decisions for entry and necessary precautions for working in and for making emergency escape. A minimum safe level of oxygen for entry is not stated, only what is considered an oxygen deficient atmosphere (less than 17% by volume). The Australian Standard, which comes under the Factories' Regulations, states the confined space shall be emptied and flushed of hazardous substances and be ventilated with fresh air before entry. The Australian Standard is concerned primarily with entry and exit, not with isolation or safe oxygen level. The Australian Standard does; however, refer to a competent person similar to the qualified person for testing the atmosphere for flammable level. Other countries [14,48-50] published guidelines or standards for entering and working in confined spaces. Many of those reviewed follow recommendations similar to the Australian and Candadian standards. Therefore, it would be redundant to make a lengthy comparative list of standards. The state standards reviewed [8,12,51-54] and those from industry [40,55-68] were also closely evaluated. The number of references involved prohibits the citing of each one, although valuable concepts were obtained.

Basis for the Recommended Standard

Workers who enter and work in confined spaces are confronted with many potentially hazardous conditions. The hazards can range from an oxygen deficient atmosphere or liberation of a toxic agent, to mechanical equipment accidentally energized. The hazardous atmospheres that can be encountered in a confined space are; flammable, toxic, irritant and/or corrosive, and asphyxiation. These atmospheric conditions are discussed in Chapter III, along with cited accident cases to emphasize the hazards involved with confined space entry.

The limited statistical data available on accidents and injuries directly related to confined spaces indicate a very high mortality level. This disproportionately high mortality level for the number of reported accidents and injuries could be the result of inadequate reporting methods, as not reporting a near miss with death, or data collection systems failing to list a confined space as a causative or other factor in traumatic accidents. In the accident and injury cases tabulated for this document, atmospheric conditions in confined spaces were responsible for the most frequent accident type in terms of events and number of persons killed or injured [1].

The work practices section in Chapter I of the recommended standard was developed after extensive review of published literature, [2,11,15-17,31,33,36,55-92] the current Federal, State, and local applicable codes, [8,12,51-54,93-101], international codes or recommendations [3,45-50,102], and site visits to facilities where working in confined spaces is part of the industrial activity.

(a) Testing and Monitoring

Prior to entry into a confined space, workers should know the space's potential hazards. Deaths have occurred because a presumably safe space was not tested prior to initial entry [7,13]. The various tests to be performed

prior to entry shall include tests for flammability, toxic agents, oxygen deficiency, and harmful physical agents. Specific instruments are required for testing the atmosphere for flammability, oxygen deficiency, carbon monoxide, and physical agents. For example, combustible gas indicators are designed for the purpose of measuring the concentration of flammable gases, and will not measure or indicate the presence of carbon monoxide at toxic levels, conversely a carbon monoxide detector is designed for the measurement of carbon monoxide only. It should be noted that combustible gas indicators respond differently to different flammable hydrocarbons and should be calibrated for the specific contaminant if known. The flammability measurement may be erroneous if the oxygen level is less or greater than normal atmospheric concentrations. Therefore, it is recommended that the oxygen level be determined prior to flammability testing to make any necessary corrections in the flammability measurement.

When the materials may form a combustible dust mixture, special precautions must be taken to prevent an explosive atmosphere from developing. There are numerous instruments available for measuring airborne dust concentrations; however, none appear to have automatic alarm systems and would require constant personal monitoring. The only practical approach to the control of combustible dusts is to eliminate the hazard by preventive measures, such as, (1) engineering controls, (2) good housekeeping, (3) elimination of ignition sources, (4) isolation of dust producing operations and, (5) training and education of the employees.

The oxygen deficiency measuring instrument is designed to measure the volume of oxygen present, usually scaled with a range of 0.0-25%. If the percentage of oxygen in a confined space atmosphere is less than 19.5% or greater than 25%, special precautions, as determined by the qualified person, shall be taken. In accordance with OSHA Safety and Health Standard 29 CFR Part 1910 and other references [12,33,51,76,87], a minimum oxygen level of 19.5% has been adopted for worker safety. The upper oxygen limit has been set at 25% because an increase above this level will greatly increase the rate of combustion of flammable materials [11].

Continuous and/or frequent monitoring becomes necessary in cases where the work being performed within the confined space has the potential of generating toxic agents [4,5,14,54,58,64,74,81,83,84,86,87]. Data collected for NIOSH by Safety Sciences [1] shows that in 28 out of 80 accident events, the toxic gas or oxygen deficiency was not in the confined space at the time of entry, but was either generated by the work occurring in the space, or by gas being unexpectedly admitted into the confined space after the worker had entered. In these cases, only continuous and/or frequent monitoring would be a possible countermeasure.

(b) Medical

Medical requirements for workers who might enter a confined space should take into consideration the increased hazard potential of confined spaces. In this setting, the workers must rely more heavily upon their physical, mental, and sensory attributes, especially under emergency conditions. Workers should be evaluated by competent medical personnel to insure that they are physically and mentally able to wear respirators under simulated and actual working conditions. Because of the additional stress placed on the cardiopulmonary system, some pathologic conditions, such as cardiovascular diseases or those

associated with hypoxemia, should preclude the use of respiratory protective devices [101].

In areas where the hazard potential is high, a person certified in CPR and first aid should be in attendance. Since irreversible brain damage can occur in approximately 4 minutes in an oxygen deficient atmosphere, it is essential that resuscitation attempts occur within that time [102].

(c) Safety Equipment and Clothing

Many cases of accidental dermal exposure, respiratory distress, and traumatic injury due to falling objects have occurred in confined spaces; therefore, a general safety standard should address the problem of whole body protection [3]. Another area of concern is the use of life lines in all confined spaces. Part of the recommended standard should be an evaluation of the confined space to define when life lines shall be used and when a safety belt with D rings for attaching life lines would be sufficient [12,14,17,53,58,61,73,93,97,103,104].

(d) Training

Training of employees for entering and working in confined spaces is essential because of the potential hazards and the use of life saving equipment. To insure worker safety, the training program should be especially designed for the type of confined space involved and the problems associated with entry and exit. If different types of confined spaces are involved, this will require additional training. Areas that should be covered in an effective training program are:

1. Emergency entry and exit procedures
2. Use of applicable respiratory equipment
3. First Aid and Cardio-Pulmonary Resuscitation (CPR)
4. Lockout procedures
5. Safety equipment use
6. Rescue drills
7. Fire protection
8. Communications

Training of employees should be done by the qualified person or someone knowledgeable in all relevant aspects of confined space entry, hazard recognition, use of safety equipment, and rescue [3,33,53,58,63,68,84,90,97].

For training to be effective, classroom sessions, on-the-job training, or simulated conditions, appear to be the most satisfactory methods. Classroom sessions should include all applicable Federal, state, and local regulations that govern the specific industrial activity in which the employee will be working, as well as the hazards of a confined space (physical and chemical). The training guidelines in Chapter V can be used as a format for additional classroom activity. On-the-job training should be closely supervised until the employee has a complete understanding of all potential hazards. Testing of the employee should take place to evaluate the person's competency and determine if retraining is necessary.

(e) Work Practices

(1) Purging and ventilation - poor natural ventilation is one of the defining parameters of a confined space, therefore purging and mechanical ventilation must be closely evaluated when safe work practices are developed for entering and working in confined spaces. Purging is the initial step in adjusting the atmosphere in a confined space to acceptable standards (PEL's, LEL's, and LFL's). This is accomplished either by displacing the atmosphere in the confined space with fluid or vapor (inert gas, water, steam and/or cleaning solution), or by forced air ventilation. According to the literature [11] 20 air changes should bring the atmosphere in the confined space into equilibrium with the external environment.

After purging, one establishes general and/or local exhaust ventilation to maintain a safe uncontaminated level. Guidelines for establishing ventilation rates are referenced in the ANSI Standard Z9.2-1972 [105] and NIOSH Recommended Industrial Ventilation Guidelines [106]. In addition, other information applicable to the special problems of confined spaces must be considered such as the Occupational Safety and Health Standard 29 CFR 1915.31(b) [31,45,69,107-109]. Entering into an inert atmosphere is one of the most hazardous activities associated with working in a confined space. Work in an inert atmosphere is usually performed by employees of companies who specialize in this because of the high degree of training and expertise needed to perform inert entry operations safely. The scope of this document deals with the necessary precautions but does not cover the specialized training for entry into a confined space containing an inert atmosphere [11,106].

(2) Isolation/Lockout/Tagging - a review of the statistical data provided to NIOSH [1] demonstrated an obvious need for lockout procedures. The use of tags, while valuable for identification and/or information purposes, appears to have been inadequate in preventing accidents. A review of the literature has shown that proper isolation and lockout procedures are more effective than tagging [5,6,12,45,55,57,61,64,88,103].

(3) Cleaning - decontaminating a space by cleaning is necessary to provide for worker safety. However, it must be recognized that the cleaning process itself can generate additional hazards. Continuous and/or frequent monitoring is required during this process to determine that flammable mixtures and hazardous concentrations of contaminants are adequately diluted before safe entry can be made [3,5,15,20,48,49,59,61,79,80,91].

(4) Equipment and tools - the literature reviewed [15,58,63,64,109], has shown the potential for explosion is greatly increased when explosion proof equipped tools and equipment are not used or improperly maintained. Also the potential for electrocution is increased when low voltage or ground fault circuit interrupters are not used.

(5) Permit System - the inherent dangers associated with a confined space clearly indicate the need for strict control measures of employees and equipment. The literature has shown [50,52,55,56,63,69,77,86,88,90] that the use of a permit system is a very effective method of attaining control. The permit provides written authorization for entering and working in confined spaces, clearly states all known or potential hazards, and identifies the safety equipment required to insure the safety of the worker.

(6) Entry and Rescue - the potential hazards associated with a confined space must be evaluated prior to entry. These hazards would include the following: oxygen level, flammability characteristics, toxic agents, and physical hazards ie, limited openings and communications. To simplify entry and rescue it would appear logical to set up a classification table for easy reference. The literature reviewed [5,12,51,63,69,76] has provided necessary information to set up an entry classification table and allow for flexibility in the selection of personal protective equipment.

It is essential that well planned rescue procedures and the proper use of personal protective equipment be followed. The literature and data reviewed have shown a very poor record in successful rescue efforts. Spontaneous reaction instead of well planned and executed rescue procedures has led to multiple fatalities in confined spaces. In 19 of the 25 cases in which rescue was attempted, the rescuers were injured or killed. These cases resulted in 13 deaths and 30 injuries to rescuers, even though only 5 victims were successfully saved. One particular case resulted in injury to 15 rescuers; however, they were successful in saving 3 lives [1]. Therefore, the standby and/or rescue team shall be properly equipped and trained in all aspects of rescue.

(7) Recordkeeping - from a review of the limited data available (no SIC code for confined spaces) and the information collected from the plant site visits on accidents in confined spaces, it is apparent that recordkeeping systems must be changed to identify areas where accidents occur, so that underlying causes can be determined. The records to be kept by the employer should contain such information as employee name, age, training, job description, number of years on the job, accident location and severity, underlying causes, and action taken to insure future worker safety.

V. TRAINING GUIDELINES

The very nature of the hazards encountered in a confined space is of paramount importance in structuring an effective training program which will provide for safe work practices and techniques. The training program should be based on the specific hazards to be encountered, approved by a trained safety person and given to all individuals who will perform the work or may be assigned as standby or rescue persons.

(a) Qualifications of Training Personnel

It is essential that the person in charge of training know the relevant aspects of safety as they relate to confined spaces. The instructor(s) must have a thorough working knowledge of the following:

(1) Type(s) of confined spaces associated with the industrial activity.

(2) Hazards involved

(A) Chemical

(B) Physical

(3) Work practices and techniques

(4) Testing requirements, PEL's, etc.

(5) Safety equipment

(A) Respirators

(B) Clothing

(C) Other protection (shields, helmets, etc)

(6) Rescue procedures

(7) Knowledge of applicable Federal, state, and local regulations

(8) Evaluation and test methods

(b) Training methods

The method and approach of training will be determined by the previous experience and skills of the employee, with the exception of a newly hired person who should receive a complete and thorough safety orientation. Basic types of training prescribed are:

(1) Orientation of all new employees. This type of training would consist of classroom sessions along with a walk-through of the physical plant layout to give the trainee a basic understanding of the industrial activity.

(2) On-the-job training. This would be a second phase of training. After classroom sessions and after the trainee has gained a basic understanding of the operation and hazards involved, on-the-job instruction should include observation and closely supervised participation in actual work practices or simulated conditions.

(3) Retraining. This should be performed periodically and as frequently as needed. Many industrial activities are quite complex and operations are frequently updated to keep up with modern innovations. It is necessary, therefore, for a formal retraining program to be planned so that all personnel concerned may be kept abreast of changes. Retraining should also be considered necessary if a supervisor notices a weakness in employee performance.

(c) Training Evaluation

The effectiveness of the training program can be determined by observation of the employee by the qualified person to see if safe work practices are being followed, testing the employee for knowledge of the operations and hazards, and a reduction in the accident rate due to safe work practices and techniques which have been learned and are being practiced.

(d) Training Program

The work practices section presented in Chapter I was designed to set a formalized standard that could, when complied with, eliminate or minimize accidents and injuries occurring in confined spaces. The standard would not be sufficient without a formal written training program and job planning to convey safe work practices and their relationship to the entire operation.

The employer is responsible for ensuring that each employee is adequately trained and given refresher courses in assigned duties, and that the employee understands and applies safe work practices. The following are recommended areas that should be covered thoroughly in training:

(1) The types of confined spaces that are found in the industrial complex. This should cover physical location, size, and any pertinent information that would inform the worker of its function.

(2) Physical and chemical hazards involved. The physical hazards would include structural members within a confined space, equipment that will be used, eg, scaffolding or ladders, size of openings, flooring, and other. Chemical hazards discussed will cover the product which has been stored, chemical cleaners used, and air contaminants which can be liberated due to the work practices.

(3) Atmospheric testing of the confined space. This phase of the instruction should emphasize the contaminants which should be tested for and the safe levels for entry.

(4) Cleaning and purging. Cleaning methods to be discussed should include steaming, water rinses, chemical cleaners, or other specific processes used.

(5) Ventilation of the space by mechanical methods to reduce or eliminate toxic airborne contaminants. This category should be covered sufficiently to alert the employee of potential hazards, and the need for warning devices to signal when there is a ventilation failure.

(6) Isolation and lockout of the confined space. The worker should be able to recognize a hazard by visual observation of the connecting lines to a confined space. The lockout of electrical circuits and mechanical disconnects to complete confined space isolation should be explained as should the employees' responsibilities in this area.

(7) Safety equipment and clothing. The worker should be aware of the proper use and care required for his personal protective equipment. This should include the type of protective shoes, gloves, face protection, protective clothing, head protection, and safety belts and harnesses that are to be worn as well as the rationale for their use. A major area in this section will be the use of respirators: the types required, their use, quantitative fit (test), respirator cleaning procedures, and proper storage. It should be emphasized that different type respirators are required for different atmospheres and the dangers involved when the wrong type is used [39]. The mandatory wearing of safety belts should be stressed. The use of safety belts and harnesses should be demonstrated so that each individual understands the importance of having the rescue system available, and operative, and is constantly aware of the necessity of keeping life lines clear to the point of exit.

(8) Buddy system and use of a standby person.

(9) Communication systems and emergency signals.

(10) Rescue procedures. All employees working in or around a confined space should be fully trained in emergency entry and exit procedures and be trained in first aid and CPR. This should include on-site entry and rescue drills.

(11) Permit system used by the employer. Information covered on the permit should include: purpose of the permit; location where permit will be posted; responsible persons; emergency information, and hazards to be encountered.

(12) Documentation of Training. Satisfactory completion of this safety training, and refresher courses, should be entered into the employee's permanent record.

VI. RESEARCH NEEDS

The primary research need in the area of confined spaces is the development of a data system that would have the capability of recording injury and mortality information specific to the causative factor eg, confined space and be readily accessible. It is now impossible to retrieve data directly related to confined space injuries and mortality, since data are currently collected by general classifications, such as SIC codes. Feasibility studies are being done by NIOSH on a system that could correct this weakness in data recording and retrieval and provide a more accurate picture in areas such as confined space hazards. These data are essential to the proper evaluation of the causes of injuries and deaths. Specific data will provide a base for establishing training programs and standards aimed toward the more hazardous areas and permit the evaluation of current standards. These data would also provide a background for analyzing unusual accidents to establish causal factors and prevent recurrence.

A final step that would be accomplished by an approved data base on confined spaces would be to standardize the degree of hazards throughout industry and provide justification for a uniform standard. This uniform standard would serve as the basis for a training program, which could be tailored to meet the needs of large as well as small industries.

The second area of research needed is development of more adequate methods for preventing and detecting gas leaks into confined spaces. Many accidents have occurred because the atmosphere in a confined space, which was presumed to be safe by the nature of the contents or obvious safe history of the confined space, had suddenly become lethal. Historical cases reported have shown that faulty seals in storage or processing vessels may allow seepage from an external source, which could be naturally lethal or could form a lethal substance when combined with residual material in the tank.

A third area for research is the analytical devices used in confined spaces, such as intrinsically safe continuous monitors for gases as well as explosive dusts, personal dosimeters, and test meters designed to withstand rugged field use and maintain their integrity. It becomes difficult to calibrate a gas detection meter after continued field use and to be sure of its accuracy. The instrument, for field use, should be of the internal calibration type that will allow for more accurate testing.

A fourth area of research is the need to define and evaluate the stresses on employees who are required to work in confined spaces. This evaluation should include physical stressors (eg heat stress, cold stress) and sensory deprivation with respect to the work practice and length of work period.

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VIII. APPENDIX I

CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Confined Space Definition	1926.21(b)(6)(ii) 1915.2(n) 1916.2(n) 1917.2(n) Standards Notice 20
Training of Personnel	1926.21(b)(6)(i)
Isolation, Lockout, and Tagging	1910.252(d)(3)(i) 1910.261(b)(5) 1910.261(e)(12)(iii) 1910.261(f)(6)(i) 1910.261(g)(4)(ii) 1910.261(g)(15) 1910.261(j)(5)(iii) 1910.261(j)(6)(i) 1910.262(p) and (g) 1910.263(d)(6)(ii) 1910.263(l)(3)(iii)
Cleaning	1910.252(d)(2)(vi)(c) 1910.261(g)(4)(i)
Testing	1910.94(d)(11)(iii) 1915.11 1917.11 1915.33(c) 1916.33(c) 1917.33(c) 1915.33(d) 1916.33(d) 1915.33(e) 1916.33(e) 1926.651(v) 1926.850(e) 1926.956(a)(3)(i) 1926.956(a)(3)(ii) 1926.956(b)(3)

APPENDIX I (CONTINUED)
CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Ventilation and Purging	1910.94(d)(11)(iv) 1910.252(e)(4)(ii) 1910.252(f)(2)(i) 1910.252(f)(2)(ii) 1910.252(f)(3)(i) 1910.252(f)(3)(ii) 1910.252(f)(4)(i) 1910.252(f)(4)(ii) 1910.252(f)(5)(ii) 1910.261(g)(4)(i) 1910.261(g)(6) 1910.261(g)(15) 1910.261(g)(22) 1910.265(f)(4) 1915.31(b) 1916.31(b) 1917.31(b) 1918.93 1926.154(a)(2) 1926.353(b)(1) 1926.353(b)(2) 1926.353(c)(1) 1926.353(c)(2) 1926.651 (v) 1926.850 (e) 1926.956(a)(3)(i) 1926.956(a)(3)(ii) 1926.956(a)(3)(iii) 1926.956(b)(2)
Equipment and Tools	1910.252(a)(1)(ii) 1910.252(e)(4)(iii) 1910.261(g)(15) 1910.261(j)(6)(iii) 1910.263(d)(6)(iii) 1910.265(f)(4) 1915.35(b)(4) 1916.35(b)(4) 1917.35(b)(4) 1915.32(g) 1916.32(g) 1917.32(a) 1926.350(b)(4) 1926.352(g)

APPENDIX I (CONTINUED)
CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Personal Protective Equipment	1910.94(a)(5) 1910.94(d)(9)(vi) 1910.94(d)(11)(v) 1910.134(e)(3) 1910.134(e)(3)(iii) 1910.252(e)(4)(iv) 1910.252(f)(4)(ii) 1910.252(f)(4)(iii) 1910.252(f)(4)(iv) 1910.261(b)(5) 1910.261(g)(2)(iii) 1910.261(g)(4)(i) 1910.261(g)(6) 1910.261(g)(8) 1910.261(g)(15) 1910.261(j)(5)(ii) 1915.23(a)(4) 1916.23(a)(4) 1915.23(b) 1916.23(b) 1917.23(b) 1915.24(a) 1916.24(a) 1916.82 1917.82 1918.82 1926.21(b)(6)(i) 1926.103(b)(3) 1926.104(a) 1926.104(b) 1926.104(d) 1926.104(f) 1926.250(b)(2) 1926.353(b)(2) 1926.353(c)(2) 1926.354(c) 1926.651(v) 1926.957(h)(2)
Standby Person and Rescue	1910.134(e)(3) 1910.134(e)(3)(i) 1910.134(e)(3)(ii) 1910.134(e)(3)(iii) 1910.252(e)(4)(iv) 1910.252(f)(4)(iv) 1910.261(b)(5) 1910.261(f)(6)(ii)

APPENDIX I (CONTINUED)
CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Standby Person and Rescue	1910.261(g)(4)(ii) 1910.261(g)(8) 1910.261(j)(5)(ii) 1910.268(o)(1)(i) 1910.268(o)(1)(ii) 1910.268(o)(2)(i) 1910.268(o)(2)(ii) 1910.268(o)(2)(iii) 1910.268(o)(3) 1910.268(o)(4) 1910.268(o)(5)(i) 1910.268(o)(5)(ii) 1915.46(b) 1916.46(b) 1917.46(b) 1915.54 1916.54 1917.54 1926.353(b)(2) 1926.956(b)(1)

IX. APPENDIX II

RECOMMENDED RESPIRATORY SELECTION GUIDE

Hazard	Concentration* Less Than or Equal To	Respirator**
particulate	5 x PEL	single use respirator***
particulate	10 x PEL	any dust respirator***
particulate	50 x PEL	full facepiece respirator with high efficiency filter(s) or self-contained breathing apparatus with full facepiece operated in the demand mode
particulate	2000 x PEL	supplied-air respirator with full facepiece operated in any positive pressure mode
particulate	greater than 2000 x PEL	self-contained breathing apparatus with full facepiece operated in the pressure demand mode or a supplied-air respirator with full facepiece operated in any positive pressure mode with an auxiliary self-contained breathing apparatus
known gas or vapor contaminant****	50 x PEL	chemical cartridge respirator with full facepiece and cartridges approved for the specific contaminant(s) or a full facepiece self-contained breathing apparatus operated in the demand mode

APPENDIX II (CONTINUED)

Hazard	Concentration* Less Than or Equal To	Respirator**
known gas or vapor contaminant***	2000 x PEL	Supplied-air respirator with full facepiece operated in any positive pressure mode
	greater than 2000 x PEL	Self-contained breathing apparatus with full facepiece operated in the pressure-demand mode or combination supplied-air respirator with full facepiece operated in any positive pressure mode with an auxillary self-contained breathing apparatus
combination of particulates and gases or vapors****	50 x PEL	a full facepiece combination respirator approved for dusts and mists and the specific contaminant(s) (gases or vapors)
	1000 x PEL	powered air-purifying full facepiece combination respirator with high efficiency filter and chemical cartridge approved for the specific gas or vapor
	2000 x PEL	supplied-air respirator with full facepiece operated in any positive pressure mode
	greater than 2000 x PEL	self contained breathing apparatus with full facepiece operated in the pressure-demand mode or combination supplied-air respirator with full facepiece operated in any positive pressure mode with an auxilary self-contained breathing apparatus

APPENDIX II (CONTINUED)

Hazard	Concentration* Less Than or Equal To	Respirator**
unknown contaminant	undetermined	self-contained breathing apparatus with full facepiece operated in the positive pressure mode or a supplied-air respirator with full facepiece operated in any positive pressure mode with an auxilary self-contained breathing apparatus
inert and other atmospheres where the oxygen level is below 17%		self-contained breathing apparatus with full facepiece operated in the pressure demand mode or a combination supplied air respirator with full facepiece operated in any positive pressure mode with an auxillary self-contained breathing apparatus
emergency entry	unknown	self-contained breathing apparatus with full facepiece operated in the pressure demand mode or a combination supplied-air respirator with full facepiece operated in any positive pressure mode with an auxilary self-contained breathing apparatus

*If the concentration forms a flammable atmosphere only the self-contained breathing apparatus with full facepiece operated in the pressure-demand mode may be used.
**Any respirator recommended for a higher concentration may be used at a lower concentration.
***These respirators may not be used if the toxic material is carcinogenic.
****If the concentration forms an atmosphere which is immediately dangerous to life then only the self-contained breathing apparatus operated in the pressure mode or the combination supplied-air respirator with full facepiece operated in any positive mode with an auxilary self-contained breathing apparatus may be used.

X. APPENDIX III

SAMPLE PERMIT

CONFINED SPACE ENTRY

CLASS ____

Location of Work: _____
Description of Work (Trades): _____
Employees Assigned: _____
Entry Date: _____ Entry Time: _____
Outside Contractors: _____

Isolation Checklist:

- Blanking and/or Disconnecting
- Electrical
- Mechanical
- Other

Hazardous Work:

- Burning
- Welding
- Brazing
- Open Flame
- Other

Hazards Expected:

- Corrosive Materials
- Hot Equipment
- Flammable Materials
- Toxic Materials
- Drains Open
- Cleaning (Ex: chemical or water lance)
- Spark Producing Operations
- Spilled Liquids
- Pressure Systems
- Other

Vessel Cleaned:

- Deposits _____
- Method _____
- Inspection _____
- Neutralized with _____ _____

Fire Safety Precautions: _____
_____

Personal Safety:

Ventilation Requirements
Respirators
Clothing
Head, Hand, and Foot Protection
Shields
Life Lines and Harness
Lighting
Communications
Employee Qualified
Buddy System
Standby Person
Emergency Egress Procedures
Training Sign Off (Supervisor or Qualified Person)_____
Remarks: _____

Atmospheric Gas Tests

	Tests Performed	- Location	- Reading
Example:	(Oxygen)	_____	(19.5%)
Example:	(Flammability)	_____	(Less than 10% LFL)
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____

Remarks: _____

Test Performed By: _____
Signature

Time: _____

Authorizations:

Supervisor: _____
Prod Supervisor: _____
Line Supervisor: _____
Safety Supervisor: _____
Etc.: _____

Entry and Emergency Procedures Understood:

Standby Person _____
Rescue _____
Telephone _____

Permit Expires: _____

Classification: _____

XI. APPENDIX IV

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
1	Atmospheric Condition in CS	Toxic levels in CS of substances: - contained in CS - from decomposition of substances in CS - from mixture of substances in CS - substances being used in CS, eg, cleaning solvents - catalytic heaters - vapors left from previously emptied CS - welding fumes Oxygen deficiency, due to: - fermentation - rust - use of other gases, eg, nitrogen to clear combustible gases - welding in CS Includes cases in which the employee was at the point of entry to the CS (eg, leaning into CS to measure) and was overcome. Includes allergic reactions to substances inhaled.	Falls or other types which are not the result of hazardous atmospheric conditions, eg, due to surface condition of CS, are covered under other Accident Types such as Ref. No. 8.

(*Note: all cases involving mining, tunneling are excluded.)

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
		Includes falls and other accident types even if the employee was outside the CS before he fell, if, and only if, they were the result of being overcome by atmospheric substances. Examples: employee was sitting on top of silo and was overcome by gas from fermenting corn and fell into silo; employee fell from ladder, when he was overcome by gas in CS; employee drowned when he was overcome by gas and fell into 12" deep water in CS.	
2	Explosion or Fire in CS	Only includes cases in which one or more victims were in the CS at the time. May be able to identify a spark - generating activity that occurred in CS, eg, - dip testing tank - welding - electrical tools - light bulbs - matches Usually the result of a combination of combustible gases in CS and spark from activity of employee in CS.	Cases in which a CS exploded but no victim was inside. Cases in which the CS exploded for "no apparent reason" or a reason not connected with the activities of those in the CS.

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
3	Explosion or Fire at Point-of-Entry of CS	Cases in which an employee was welding, using a power tool, or some other spark generating activity at the entry point to the CS.	Cases in which a CS exploded for "no apparent reason" or for a reason unconnected with the activity of the employee near the CS, eg, "just walking by and it blew up."
		Driving an automobile near to a CS containing combustible materials.	Cases in which the employee was welding (or performing some other spark-generating activity) on a CS which is too small for, and would almost certainly never be used to contain an employee, eg, 55 gal oil drums. Welding drums containing flammable liquids or left over vapors is an extremely common cause of fatalities, and has causal factors similar to CS-related cases were not typical of the problem NIOSH is addressing.
	Electrocution or Electrical Shock	Must appear to be result, at least in part, of the CS.	Cases in which an electrically "hot" source just happened to be in a CS eg, "I picked up a cable with a frayed wire".
		Frequently the result of the conductive walls of the CS.	

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
5	Caught In/ Crushing of CS	Cases in which an employee entered a machine and failed to "lock-out". The machine is activated and the employee is crushed inside the machine. The victim must be inside a machine which it was intended that he should enter and he must have entered deliberately. Elevator shafts, or cases in which the employee was on top of an elevator and crushed in the "CS" when it was elevated. Examples of such machines include rock crushers.	Cases in which the machine is too small for the employee to ever place his entire body inside eg, caught in conveyor gear's. Cases in which the employee was under (not in) a machine or machine part. In particular, being trapped under a vehicle eg, when the jack slips or under a falling bed of a dump truck are not included. Cases in which the employee is drawn into the machine. Elevator injuries if person is inside the elevator. Falls into machines.
6	Trapped in Unstable Materials in CS	"Quicksand" effect of standing in silos containing fine grain or beans. Employee must have been in the CS before the surface gave way eg, unjamming blockage or intentionally stepped into CS with the unstable surface material.	Falls into CS containing such the result of atmospheric conditions (Ref. No. 1).

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
7	Struck by Falling Objects in CS	Employee is struck by objects falling from walls of CS or through point of entry of CS. Related in that employee is unable to maneuver to safety in a CS. Includes being suffocated when a CS is accidentally filled while the employee is in it.	(Eye injuries are covered in Ref. No. 11.) Does not include cave-ins of trenches as these have not been considered to be CS's.
8	Falls (while in CS)	Only to employees in CS due to surface condition eg, wet, oil; configuration eg, a rolling barrel; or other characteristics of the CS. Falls through holes in or breaking part of CS, eg, employee goes through weak part of ventilation duct as he crawls through it. Falls over objects or tools, eg, holes, on floor of CS when it is not possible to locate elsewhere. Falls due to poor lighting in CS. Falls due to uneven surface of CS.	Falls into a CS eg, uncovered manhole. Atmospheric condition of CS Falls in CS where no characteristic of the CS was involved. (Falls while leaving or entering the CS are covered in Ref. No. 9.)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
9	Ingress/Egress	Strains, bodily reactions, abrasions, or falls as the result of entering or leaving a cramped, sharp-edged, high-level, or otherwise hazardous point-of-entry to a CS.	(Must be a bonafide CS, eg, ingress/egress of vehicle cabs, though subject to similar hazards, are not included because they are not a CS.)
10	Insufficient Maneuver	Strains, bodily reactions, abrasions, contact with caustic substances, etc. when they are in part the result of attempting to maneuver in a CS. Includes striking self or being struck by fellow employee as the result of a CS. Low head room eg, striking head.	Cases of insufficient space when the employee is working under a machine (even though cramped), because these are not considered a CS.
11	Eye Injury in CS	From dust falling from walls of CS, generated by activity in CS, or from materials in CS. Welding arc when unable to use face shield because of CS.	
12	Contact with Temperature	Burns or scalds from hot steam discharged into CS. Heat exhaustion or frost bite from temperature of CS.	

Safety Sciences, San Diego, California - 1977 [1]

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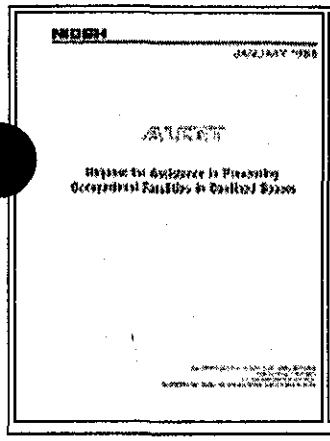

Request for Assistance in...

Preventing Occupational Fatalities in Confined Spaces

NIOSH ALERT:January 1986
DHHS (NIOSH) Publication No. 86-110

REQUEST FOR ASSISTANCE IN PREVENTING OCCUPATIONAL FATALITIES IN CONFINED SPACES

SUMMARY

This Alert requests the assistance of managers, supervisors, and workers in the prevention of deaths that occur in confined spaces. Confined spaces may be encountered in virtually any occupation; therefore, their recognition is the first step in preventing fatalities. Since deaths in confined spaces often occur because the atmosphere is oxygen deficient or toxic, confined spaces should be tested prior to entry and continually monitored. More than 60% of confined space fatalities occur among would-be rescuers; therefore, a well-designed and properly executed rescue plan is a must. This Alert describes 16 deaths that occurred in a variety of confined spaces. Had these spaces been properly evaluated prior to entry and continuously monitored while the work was being performed and had appropriate rescue procedures been in effect, none of the 16 deaths would have occurred. There are no specific OSHA rules that apply to all confined spaces. Recommendations for Recognition, Testing, Evaluation, and Monitoring, and Rescue of Workers are presented. Other National Institute for Occupational Safety and Health (NIOSH) publications on this subject as well as a source for additional information and assistance are also presented.

January 1986

BACKGROUND

The deaths of workers in confined spaces constitute a recurring occupational tragedy; approximately 60% of these fatalities have involved would-be rescuers. If you are required to work in a:

SEPTIC TANK	SILO	REACTION VESSEL
SEWAGE DIGESTER	VAT	BOILER
PUMPING/LIFT STATION	DUCT	PIPELINE
SEWAGE DISTRIBUTION or HOLDING TANK	UTILITY VAULT	PIT

similar type of structure or enclosure, you are working in a CONFINED SPACE. The Occupational Safety and Health Administration (OSHA) defines a confined space in 29 CFR 1926.21 as "any space having a limited means of egress, which is subject to the accumulation of toxic or flammable contaminants or has an oxygen deficient atmosphere." The NIOSH ***Criteria for a Recommended Standard .... Working in Confined Spaces*** dated December, 1979, defines a confined space as:

...a space which by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which is not intended for continuous employee occupancy. Confined spaces include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.

CASE REPORTS OF FATAL INCIDENTS

Case #1 - RECOGNITION AND RESCUE (FATALITIES = 1 WORKER + 1 RESCUER)

On December 29, 1983, a 54-year-old worker died inside a floating cover of a sewage digester while attempting to restart a propane heater that was being used to warm the outside of the sewage digester cover prior to painting it Workers had wired the safety valve open so that the flow of propane would be constant, even if the flame went out. The heater was located near an opening in the cover of the digester. When the worker attempted to restart the heater, an explosion occurred that vented through the opening. The worker crawled away from the heater into an area that was oxygen deficient and died. A co-worker attempted a rescue and also died.

Case #2 - RECOGNITION AND RESCUE (FATALITIES = 1 WORKER + 1 RESCUER)

On March 8, 1984, a 20-year-old construction worker died while attempting to refuel a gasoline engine powered pump used to remove waste water from a 66 inch diameter sewer line that was under construction. The pump was approximately 3,000 feet from where the worker had entered the line. The worker was overcome by carbon monoxide. A co-worker, who had also entered the sewer line, escaped. A 28-year-old state inspector entered from another point along the sewer line and di in a rescue attempt. Both deaths were due to carbon monoxide intoxication. In addition to the fatalities, 30 firefighters and 8 construction workers were treated for carbon monoxide exposure.

Case #3 - RECOGNITION AND RESCUE (FATALITIES = 2 RESCUERS)

On October 4, 1984, two workers (26 and 27 years old) were overcome by gas vapors and drowned after rescuing a third worker from a fracturing tank at a natural gas well. The tank contained a mixture of mud, water, and natural gas. The first worker had been attempting to move a hose from the tank to another tank. The hose was secured by a chain and when the worker moved the hose, the chain fell into the tank. The worker entered the tank to retrieve the chain and was overcome.

Case #4 - RECOGNITION AND RESCUE (FATALITIES = 1 WORKER + 1 RESCUER)

On December 5, 1984, a 22-year-old worker died inside a toluene storage tank that was 10 feet in diameter and 20 feet high while attempting to clean the tank. The worker entered the tank through the 16 inch diameter top opening using a 1/2 inch rope for descent. Although a self-contained breathing apparatus was present, the worker was not wearing it when he entered the tank. The worker was overcome and collapsed onto the floor the tank. In an attempt to rescue the worker, fire department personnel began cutting an opening into the side of the tank. The tank exploded, killing a 32-year-old firefighter and injuring 15 others.

Case #5 - RECOGNITION AND RESCUE (FATALITIES = 1 WORKER + 1 RESCUER)

On May 13, 1985, a 21-year-old worker died inside a waste water holding tank that was four feet in diameter and eight feet deep while attempting to clean and repair a drain line. Sulfuric acid was used

to unclog a floor drain leading into the holding tank. The worker collapsed and fell face down into six inches of water in the bottom of the tank. A second 21-year-old worker attempted a rescue and was also overcome and collapsed. The first worker was pronounced dead at the scene and the second worker died two weeks later. Cause of death was attributed to asphyxiation by methane gas. Sulfuric acid vapors may have also contributed to the cause of death.

Case #6 - RECOGNITION AND RESCUE (FATALITY = 1 RESCUER)

On June 7, 1985, a 43-year-old father died while attempting to rescue his 28-year-old son from a tank used to store spent acids from a metal pickling process. The tank was out of service so that sludge could be removed from the bottom. The son collapsed in the tank. The father attempted a rescue and also collapsed. The two were removed from the tank; the son was revived, but the father died. The cause of death is unknown.

Case #7 - RECOGNITION (FATALITY = 1 WORKER)

On July 2, 1985, a crew foreman became ill and was hospitalized after using an epoxy coating, which contained 2-nitropropane and coal tar pitch, to coat a valve on an underground waterline. The valve was located in an enclosed service vault (12' x 15' x 15'). The worker was released from the hospital on July 3, 1985, but was readmitted on July 6, 1985; he lapsed into a coma and died on July 12, 1985, as a result of acute liver failure induced by inhalation of 2-nitropropane and coal tar pitch vapors. A co-worker was also hospitalized, but did not die.

Case #8 - RECOGNITION AND RESCUE (FATALITIES = 1 WORKER + 3 RESCUERS)

On July 5, 1985, a 27-year-old sewer worker entered an underground pumping station (8' x 8' x 7') via a fixed ladder inside a three foot diameter shaft. Because the work crew was unaware of procedures to isolate the work area and ensure that the pump had been bypassed, the transfer line was still under pressure. Therefore, when the workers removed the bolts from an inspection plate that covered a check valve, the force of the waste water blew the inspection plate off, allowing sewage to flood the chamber, and trapping one of the workers. A co-worker, a supervisor, and a policeman attempted a rescue and died. The first two deaths appeared to be due to drowning and the latter two appeared to be due to asphyxiation as a result of inhalation of "sewer gas."

REGULATORY STATUS

As stated in the Regulatory Program of the United States Government (Confined Spaces [29 CFR 1910], page 282 dated August, 1985), "there are no specific OSHA rules directed toward all confined-space work, forcing OSHA compliance personnel to cite other marginally applicable standards or section 5(a)(1) in cases involving confined spaces. For this reason, OSHA field personnel have frequently and strongly recommended the promulgation of a specific standard on confined spaces." In the document ***Criteria for a Recommended Standard .... Working in Confined Spaces***, the National Institute for Occupational Safety and Health (NIOSH) has provided comprehensive recommendations for assuring the safety and well-being of persons required to work in confined spaces including a proposed classification system and checklist that may be applied to different types of confined spaces.

CONCLUSIONS

The case studies described above are summarized in Table 1:

CASE	DATE	TYPE OF SPACE	TYPE OF HAZARD	WORKER	RESCUER	TOTAL	COMMENT

#1	12/29/83	Sewage digester	Oxygen deficiency	1	1	2	---
#2	3/8/84	Sewer line construction	Toxic atmosphere; physical hazard,	1	1	2	38 others in
#3	10/4/84	Fracturing tank	Oxygen deficiency	0	2	2	2 rescuers d
#4	12/5/84	Toluene storage tank	Toxic atmosphere; explosion; limited entry and exit	1	1	2	15 others in
#5	5/13/85	Waste water tank physical hazard	Toxic atmosphere;	1	1	2	Rescuer died later
#6	6/7/85	"Spent" acid storage tank	Toxic atmosphere	0	1	1	Rescuer was worker
#7	7/2/85	Underground waterline, valve area	Toxic atmosphere	1	0	1	Worker died liver fai another w but recov
#8	7/2/85	Sewage pumping station	Physical hazard; toxic atmosphere	1	3	4	2 died of dr 2 of asphy
			TOTALS	6	10	16	53 OTHERS IN

Based on the information derived from these case studies, NIOSH concludes that these fatalities occurred as a result of encountering one or more of the following potential hazards:

- lack of natural ventilation,
- oxygen deficient atmosphere,
- flammable/explosive atmosphere,
- unexpected release of hazardous energy,
- limited entry and exit,
- dangerous concentrations of air contaminants,
- physical barriers or limitations to movement, or
- instability of stored product.

In each of these cases there was a lack of RECOGNITION and TESTING, EVALUATION, and MONITORING prior to entry nor had a well-planned RESCUE been attempted.

These incident reports suggest that RECOGNITION of what is a confined space in conjunction with the proper TESTING, EVALUATION, and MONITORING of the atmosphere and development of appropriate RESCUE procedures could prevent such deaths. These three steps are discussed below.

NIOSH investigations indicate that workers usually do not RECOGNIZE that they are working in a confined space and that they may encounter unforeseen hazards. TESTING and EVALUATION of the atmosphere are typically not initiated prior to entry and MONITORING is not performed during the confined space work procedures. RESCUE is seldom planned and usually consists of spontaneous reaction in an emergency situation.

RECOMMENDATIONS

In light of findings to date regarding occupational deaths in confined spaces, NIOSH recommends that managers, supervisors, and workers be made familiar with the following three steps:

1. RECOGNITION

Worker training is essential to the RECOGNITION of what constitutes a confined space and the hazards that may be encountered in them. This training should stress that death to the worker is the likely outcome if proper precautions are not taken before entry is made.

2. TESTING, EVALUATION, AND MONITORING

All confined spaces should be TESTED by a qualified person before entry to determine whether the confined space atmosphere is safe for entry. Tests should be made for oxygen level, flammability, and known or suspected toxic substances. EVALUATION of the confined space should consider the following:

- methods for isolating the space by mechanical or electrical means (i.e., double block and bleed, lockout, etc.),
- the institution of lockout-tagout procedures,
- ventilation of the space,
- cleaning and/or purging,
- work procedures, including use of safety lines attached to the person working in the confined space and its use by a standby person if trouble develops,
- personal protective equipment required (clothing, respirator, boots, etc.),
- special tools required, and
- communications system to be used.

The confined space should be continuously MONITORED to determine whether the sphere has changed due to the work being performed.

3. RESCUE

RESCUE procedures should be established before entry and should be specific for each type of confined space. A standby person should be assigned for each entry where warranted. The standby person should be equipped with rescue equipment including a safety line attached to the worker in the confined space, self-contained breathing apparatus, protective clothing, boots, etc. The standby person should use this attached safety line to help rescue the worker. The rescue procedures should be practiced frequently enough to provide a level of proficiency that eliminates life-threatening rescue attempts and ensures an efficient and calm response to any emergency.

OTHER HELPFUL PUBLICATIONS BY NIOSH

NIOSH has published the following documents which contain further information:

Criteria for a Recommended Standard .... Working in Confined Spaces, DHEW Publication No. 80-106.

Guidelines for Controlling Hazardous Energy During Maintenance and Servicing, DHHS Publication No. 83-125.

We ask that editors of appropriate trade journals and safety and health officials (i.e., inspectors, managers, and hygienists, especially those associated with work in confined spaces) bring these recommendations to the attention of workers, supervisors, managers, and owners.

Requests for additional information on control practices or questions related to this announcement should be directed to Director, Division of Safety Research, National Institute for Occupational Safety and Health, 1095 Willowdale Road, Morgantown, West Virginia 26505,Telephone, (304) 285-5894; or call 1-800-35-NIOSH (1-800-356-4674).

We greatly appreciate your assistance.

J. Donald Millar, M.D., D.T.P.H (Lond.)
Assistant Surgeon General
Director, National Institute for
Occupational Safety and Health
Centers for Disease Control

Confined Space Alert--DHHS (NIOSH) Publication No. 86-110

Go back to the NIOSH home page or to the CDC home page.

This document was last updated on 7/11/96.

Safety Requirements for Confined Spaces

ANSI/ASSE Z117.1-2003

AMERICAN SOCIETY OF SAFETY ENGINEERS

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ANSI®
Z117.1-2003

American National Standard Safety Requirements for Confined Spaces

Secretariat

American Society of Safety Engineers
1800 East Oakton Street
Des Plaines, Illinois 60018-2187

Approved February 20, 2003

ANSI Board of Standards Review

American National Standard

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Foreword

(This Foreword is not a part of American National Standard Z117.1-2003)

This standard was developed by an American National Standards Committee, national in scope, functioning under the procedures of the American National Standards Institute with the American Society of Safety Engineers (ASSE) as Secretariat. This standard establishes minimum safety requirements for confined spaces.

It is intended that the procedures and performance requirements detailed herein will be adopted by every employer whose operations fall within the scope and purpose of the standard.

Neither the standards committee, nor the secretariat, feel that this standard is perfect or in its ultimate form. It is recognized that new developments are to be expected, and that revisions of the standard will be necessary as the art progresses and further experience is gained. It is felt, however, that uniform requirements are very much needed and that the standard in its present form provides for the minimum performance requirements necessary in developing and implementing a comprehensive confined space program for the protection of personnel.

In 1993 OSHA estimated that 238,000 establishments had permit required confined spaces. These establishments employed approximately 1.6 million workers, including contractors, who entered 4.8 million permit-required confined spaces annually. OSHA further estimated that 63 fatalities and 13,000 lost workday cases and non-lost workday cases involving confined spaces entry occurred annually.

OSHA and NIOSH data during the period 1980-1993 indicates atmospheric conditions were the leading cause of death associated with confined space entry. The data indicates that oxygen deficiency, hydrogen sulfide, methane, and inert gases ranked as the leading specific atmospheric hazardous conditions. Engulfment was found to be second in terms of occurrence. Mechanical asphyxiation from loose materials such as grain, agricultural products, sand, cement, and gravel was dominant. Evidence suggests that the cause of death associated with confined space entry has not changed appreciably during recent years.

The Z117 Committee acknowledges the critical role of design in influencing the safe entry of confined spaces. Design deficiencies often increase the risk for entrants: examples are (1) means of entry (portals, hatchways, etc.) which are too small, improperly located, or that complicate/inhibit escape; (2) spaces which are convoluted, unnecessarily obstructed, or hazardously configured; (3) internal clearances which are too tight for safe passage; (4) space penetration distances which are excessive without alternative means of access or escape; (5) absence of appropriate devices to isolate all energy sources from the space; (6) no provision for vessel mechanisms/devices to prevent loose materials from bridging, compacting, etc. (7) lack of features that would enhance space ventilation effectiveness; (8) structural weaknesses in walls, floors, ceilings, or pipes containing gases, liquids, or steam, or which increase hazard risk to entrants while working or coming in contact with stated structures in confined spaces; (9) absence of anchor points for retrieval devices.

The standard does not attempt to address these issues. It is believed they are best dealt with by the purchaser, employer, or owner during a project's design, acquisition, or construction. However, it is recommended that designers, manufacturers, and users make confined space design issues a priority when new or modified machinery, equipment, processes or facilities are contemplated.

For existing confined spaces, which have recognized design deficiencies, it should be the responsibility of those authorizing entry to either:

- modify or correct the deficiencies when possible, or
- employ alternate means to accomplish the work without exposing personnel, or
- develop and implement specific safe entry procedures for each confined space, or
- dismantle, open, remove, etc. the equipment/process rather than enter if the risk is deemed

unacceptable.

Suggestions for improvement of this standard will be welcome. They should be sent to the American Society Safety Engineers, 1800 East Oakton Street, Des Plaines, Illinois 60018-2187.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Confined Spaces Z117. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved that standard, the Z117 Committee had the following members:

Edward V. Grund, Chairman
Terry W. Krug, Vice-Chairman
Timothy R. Fisher, Secretary
Patrick J. Arkins, Assistant Secretary

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Contents

Explanation of Standard

American National Standard Z117.1-2003 uses a two-column format to provide both specific requirements and supporting information.

The left column, designated "Standard Requirements," is confined solely to these requirements and is printed in bold type. The right column, designated "Explanatory Information," contains only information that is intended to clarify the standard. This column is not a part of the standard.

Operating rules (safe practices) are not included in either column, unless they are of such a nature as to be vital safety requirements, equal in weight to other requirements, or guides to assist in compliance with the standard.

The information and materials contained in this publication have been developed from sources believed to be reliable. However, the American Society of Safety Engineers (ASSE) as secretariat of the ANSI accredited Z117 Committee or individual committee members accept no legal responsibility for the correctness or completeness of this material or its application to specific factual situations. By publication of this standard, ASSE or the Z117 Committee does not ensure that adherence to these recommendations will protect the safety or health of any persons, or preserve property.

American National Standard Safety Requirements for Confined Spaces

STANDARD REQUIREMENTS	EXPLANATORY INFORMATION *(Not part of American National Standard Z117.1-2003)*
1. *Scope, Purpose, and Application*	
1.1 *Scope.* This standard provides minimum safety requirements to be followed while entering, exiting and working in confined spaces at normal atmospheric pressure.	E1.1 The scope of this standard does not address confined space design issues. Please see the Foreword section of this standard for additional general information addressing confined space design.
Exception. This standard does not pertain to underground mining, tunneling, caisson work, intentionally inert confined spaces, or other similar tasks that have established national consensus standards.	
1.2 *Purpose.* The purpose of this standard is to establish minimum requirements and procedures for the safety and health of employees who work in, and in connection with, confined spaces.	E1.2 This standard is a performance standard and, as such, is not intended to replace existing specific standards and procedures, but rather to support those that meet the performance objectives defined in this standard.
1.3 *Application.* This standard is designed for voluntary application immediately upon approval as an American National Standard.	
2. *Definitions*	
ATTENDANT. A person who is assigned to monitor a confined space process or operation and provide support or react as required to provide for the safety of the entrants and entry team.	
BIOLOGICAL HAZARDS. Microbial agents presenting a risk or potential risk to the well-being of humans through inhalation, ingestion, skin absorption, or injection.	Explanation: Microorganisms may cause toxic release or an oxygen deficient atmosphere. Bio hazards may include, but are not limited to: Infectious or parasitic agents; microorganisms such as some fungi, mold, yeasts and algae; plants and plant products, and animals and animal products, which cause occupational disease.
BLINDING/BLANKING. Inserting a solid barrier across the open end of a pipe, or in between two flanges, leading into or out of the confined space, and securing the barrier in such a way to prevent leakage of material.	Explanation: A blank is designed as a flat plate between two flanges typically inside the flange bolt pattern (ASME B31.3 Paragraph 304.5.3). The blank must be sized for full design pressure (maximum non-shock pressure rating) of the line. A blind is designed as a bolted flat plate, which can be used to terminate a pipe line (ASME B3 1.3 Paragraph 304.5.2b).

When a blind is required, use the geometry specified in ASME/ANSI B16.5.

CONFINED SPACE. An enclosed area that is large enough and so configured that an employee can bodily enter and has the following characteristics:

- **its primary function is something other than human occupancy.**
  and
- **has restricted entry and exit. (Restricted entry and exit is a physical configuration, which requires the use of the hands or contortion of the body to enter into or exit from a confined space.)**

Explanation: Examples of confined spaces include but are not limited to tanks, silos, vessels, pits, sewers, pipelines, boilers, septic tanks, utility vaults, tank cars and other mobile containers.

Temporary structures may meet the criteria of this definition.

Tanks and other structures being constructed may or may not be considered confined spaces until completely closed.

DOUBLE BLOCK AND BLEED. A method used to isolate a confined space from a line, duct or pipe by physically closing two main valves on a piping system, and opening a "vented-to-atmosphere" valve between them.

Explanation: Bleed means the contents will flow from the bleed point in the event of valve failure or leakage. The bleed point should be appropriately sized to accomplish its relief function and prevent any flow into the confined space.

EMERGENCY. Any occurrence inside or outside of the confined space that could endanger the entry team.

ENGULFMENT. The surrounding and effective capture of a person by a liquid or flowable solid substance.

ENTRANT. A person who enters a confined space to perform an assigned task.

ENTRY. Ingress by persons into a confined space, which occurs upon breaking the plane of the confined space portal with any part of the body. Entry includes all periods of time in which the confined space is occupied.

ENTRY SUPERVISOR/LEADER. An individual who has been assigned the responsibility for directing all aspects of the confined space entry.

EVACUATION. An unaided emergency exit out of a confined space. This action may result from the entrant's own decision or by a command from outside the space.

This is referred to in OSHA Regulation 29 CFR 1910.146 as self- rescue.

HAZARD. A condition or changing set of circumstances that presents a potential for injury, illness, or property damage. The potential or inherent characteristics of an activity, condition, or circumstance, which can produce adverse or harmful consequences.

Examples are materials that cause oxygen deficiency/ enrichment flammability, toxicity, corrosivity, stored product, chemical and mechanical energy.

HAZARDOUS ATMOSPHERE. An atmosphere that may be, or is injurious to occupants by reason of: oxygen deficiency or enrichment; flammability or explosivity; or toxicity.

HORIZONTAL RESCUE. Methodology to move the entrant to safety while the entrant's weight is supported by the surface of the space's floor or other horizontal level within the space.

HOT WORK. Work within a confined space that produces arcs, sparks, flames, heat, or other sources of ignition.

ISOLATION. A process of physically interrupting, or disconnecting, or both, pipes, lines and energy sources from the confined space.

LEL/LFL and UEL/UFL. Abbreviation for "lower explosive limit"/"lower flammable limit" and "upper explosive limit"/"upper flammable limit".

Explanation: NFPA 325-1994 defines these as follows:
In the cases of gases or vapors which form flammable mixtures with air or oxygen, there is a minimum concentration of vapor-in-air or vapor-in-oxygen below which propagation of flame does not occur on contact with a source of ignition. There is also a maximum proportion of vapor or gas in air above which flame propagation does not occur. These boundary-line mixtures of vapor or gas with air, which if ignited will just propagate flame are known as the 'lower and upper flammable or explosive limits', and are usually expressed in terms of percentage by volume of gas or vapor in air. No attempt is made to differentiate between the terms 'flammable' and 'explosive' as applied to the lower and upper limits of flammability.

LOCKOUT/TAGOUT. The placement of a lock/tag on the energy isolating device in accordance with an established procedure, indicating that energy isolating device shall not be operated until removal of the lock/tag in accordance with an established procedure. (The term "lockout/tagout" allows the use of a lockout device, a tag, or a combination of both.)

NON-PERMIT CONFINED SPACE (NPCS). A space, which, by configuration, meets the definition of a confined space but which after evaluation is unlikely to have potential hazards or has the hazards eliminated by engineering controls.

OXYGEN DEFICIENT ATMOSPHERE. An atmosphere containing less than 19.5% oxygen by volume.

OXYGEN ENRICHED ATMOSPHERE. An atmosphere containing more than 23.5% oxygen by volume.

PEL. Abbreviation for "Permissible Exposure Limit". PELs are the allowable air contaminant level established by the U.S. Department of Labor, Occupational Safety and Health Administration.

29CFR 1910, Subpart Z, the Occupational Safety and Health Administration "Toxic and Hazardous Substances". (Note: Care should be exercised when using dated PEL criteria.)

PERMIT REQUIRED CONFINED SPACE (PRCS). A confined space, which after evaluation, is found to

contain actual or potential hazards. Because of the hazards, the confined space requires written authorization for entry.

PERMIT SYSTEM. A written procedure for preparing and issuing permits for entry and for returning the permit required confined space (PRCS) to service following termination of entry.

QUALIFIED PERSON. A person who by reason of training, education and experience is knowledgeable in the operation to be performed and is competent to judge the hazards involved and specify controls and/or protective measures.

RESCUE. Aided assistance in exiting the confined space requiring entry by the rescuer(s).

RETRIEVAL. Aided assistance in exiting the confined space not requiring entry.

SHALL. Denotes a mandatory requirement.

SHOULD. A recommendation that is a sound safety and health practice; it does not denote a mandatory requirement.

TLV®. Abbreviation for Threshold Limit Value.

Explanation: "Threshold Limit Values" TLVs® are the recommended worker exposure levels of chemical and physical agents recommended by the ACGIH (American Conference of Governmental Industrial Hygienists). This is a registered trademark of the American Conference of Governmental Industrial Hygienists.

TOXIC ATMOSPHERE. An atmosphere containing a concentration of a substance above the published or otherwise known safe levels.

Explanation: Sources of published or otherwise presumed known acceptable levels of air contaminants include, but are not limited to the most current editions of:

The American Conference of Governmental Industrial Hygienists "Threshold Limit Values and Biological Indices".

In-House standards and vendor material safety data sheets (MSDS).

VERTICAL RESCUE. Methodology to move the entrant to safety while all or a portion of the entrant's weight is supported by life-safety rope or wire. This methodology would include Diagonal Rescue where a portion of the entrant's weight is supported by a surface within the space.

3. *Identification and Evaluation*

General Requirements

3.1 *Confined Space Survey.* A qualified person shall conduct an initial survey of the premises or operations, or both to identify confined spaces as defined by this standard. A process shall be established to identify the addition or deletion of confined spaces to keep the documented inventory current.

E3.1 The purpose of the survey is to develop an inventory of those locations or equipment, or both, which meet the definition of a confined space so that personnel may be made aware of them and appropriate procedures developed for each prior to entry.

3.2 *Hazard Identification.* Confined spaces shall be considered hazardous until determined to be otherwise. Hazards shall be identified for each confined space. The hazard identification process shall include, but not be limited to, a review of the following:

E3.2 Confined spaces can become unsafe as a result of: 1) possible atmospheric contamination by toxic or flammable vapors, or oxygen deficiency or excess; 2) possible physical hazards; 3) the possibility of liquids, gases, or solids being introduced to the space during occupancy; 4) the isolation of occupants from rescue personnel; 5) presence of radiation sources.

3.2.1 The past and current uses of the confined space which may adversely affect the atmosphere of the confined space;

E.3.2.1: Review MSDS(s) to determine compatibility of current and previous contents. Be aware of protective coatings, which could trap materials or residue that may decompose or react with cleaning agents or heat (from welding or burning); and/or exhaust gases from engine powered equipment in or positioned outside the confined space.

3.2.2 The physical characteristics, configuration, and location of the confined space;

E3.2.2 The means of entry and exit, and the hazards posed by adjacent spaces and operations should be reviewed.

3.2.3 Existing or potential atmospheric hazards, such as:

1) Oxygen deficient or enriched atmosphere
2) Flammable/explosive atmosphere
3) Toxic atmosphere;

E3.2.3 The current edition of the ACGIH Threshold Limit Values, 29CFR1910, Subpart Z, and Material Safety Data Sheets are examples of reference sources, which should be consulted to determine the exposure limits for toxic materials.

3.2.4 Biological hazards;

3.2.5 Mechanical hazards.

3.2.6 Physical hazards.

E3.2.6 Electrical, thermal, radiological, noise, or engulfment

3.3 *Hazard Evaluation.* Hazards identified shall be evaluated by a qualified person. Each hazard shall be examined with respect to:

3.3.1 Scope of hazard exposure;

E3.3.1 Consideration should be given to how many, or which employees, or both, are exposed or may be affected.

3.3.2 Magnitude of the hazard;

E3.3.2 Consideration should be given to how much energy may be released; how toxic are the chemicals; quantity of materials which could be inadvertently introduced, etc.

3.3.3 Likelihood of hazard occurrence:

E3.3.3 Consideration should be given to the probability for the hazard to occur.

3.3.4 Consequences of the hazard occurrence;

E3.3.4 Consideration should be given to the most likely outcome if the hazard occurs, i.e. space explosion, death by asphyxiation, etc.

3.3.5 Potential for changing conditions or activities;

E.3.3.5: Examples of changes in conditions / activities are; introduction of hot work or cleaning agents into the confined space that were not previously identified. The filling / emptying of an adjacent compartment / tank is an example of changes in adjacent spaces. Weather changes, such as thunder storms, (drop in barometric pressure, lightening etc.) heat of the day increasing vaporization and affecting personnel (heat exhaustions) are examples of changes in the environment which can cause problems in confined spaces. The hazard introduced by portable hand or power tools should also be considered. Introduction of exhaust contaminants from internal combustion engines in or near the space.

3.3.6 Strategies for controlling the hazards;

E.3.3.6 Hazards should be eliminated or controlled to the extent that an acceptable level of risk is attained prior to conducting confined space entries. The following hierarchy of control should be followed:

- Eliminate the hazard;
- Substitute (material procedure, etc.) with a less hazardous replacement
- Isolate the hazard;
- Use engineering controls;
- Use administrative controls;
- Use PPE

3.3.7 Impact on the need for emergency response.

E3.3.7 Physical conditions that could hinder emergency rescue may include: manway or manhole size, scaffolding or pipe structures, or other obstructions. These special needs should be addressed in assessment for emergency response.

3.4 *Confined Space Classification.* Based on the evaluation of the hazards, a qualified person shall classify the confined space as either a permit-required confined space (PRCS) or non-permit confined space (NPCS). All confined spaces shall be treated as permit spaces until determined to be otherwise.

3.5 *Hazard Re-evaluation.* A qualified person(s) shall determine the need for periodic identification and reevaluation of the hazards based on possible changes in activities in the space, or other physical or environmental conditions, or both, which could adversely affect the space. When the need is determined, a qualified person(s) shall conduct the identification and reevaluation process.

3.6 *Written Program.* If the employer determines that employees will enter confined spaces, the employer shall develop and implement a written confined space entry program. The program shall contain a requirement for a periodic written performance assessment of

E3.6 The written entry program should include how the key items of this standard will be implemented and who is responsible for their execution. Since employers are ultimately responsible for implementation of this standard, management should use the method identified for correcting

the requirements of this standard. An established method, with action steps and assigned responsibility, shall be specified for correcting deficiencies identified by the performance assessment.

deficiencies identified during the performance assessments as a fundamental tool for enforcing the requirements of this standard. Frequency of performance assessment should be governed by the identified need for improvement.

3.6.1 The written program shall include a requirement to develop specific entry procedures for permittable spaces identified during the survey. Procedures shall identify known hazards as well as the actions required to eliminate or control those hazards. Where spaces are identical with respect to hazards and required control actions a single procedure to cover these like spaces is acceptable.

E3.6.1 Procedures that are intended to assist in the evaluation of the space are not a substitute for pre-entry evaluation.

4. ***Non Permit Confined Spaces (NPCS)***

4.1 ***Controls.*** **The employer shall specify what conditions and precautions must be in place to allow for safe entry and what would constitute a change in conditions, which would require a re-evaluation of the confined space. Sections 7 through 17 of this standard shall be considered for NPCS entries to determine their relevance for safe entry.**

4.2 ***Training.*** **Training shall be conducted as needed to maintain competence in entry procedures and precautions.**

E4.2 For more information about general training issues please refer to ANSI Z490.1-2001, Accepted Practices in Safety, Health, and Environmental Training.

4.3 ***Re-evaluation.*** **NPCS's shall be periodically reevaluated to assure proper classification.**

4.3.1 Any change of conditions in the space which introduces new hazards to the space, shall require an immediate re-evaluation of the space before entry.

E4.3.1 Any change in conditions such as, but not limited to, atmospheric conditions while in the space may trigger evacuation or removal of personnel and re-evaluation of the space.

4.4 ***Atmospheric Testing.*** **A qualified person shall determine whether atmospheric testing is required. If testing indicates atmospheric levels are not within acceptable limits the entry shall not proceed.**

E4.4 If atmospheric test results are not within acceptable limits, this should indicate that the engineering controls are not adequate or the potential for generation of hazards is not as minimal as was initially determined. Consequently, the confined space would no longer be an NPCS.

5. ***Permit Required Confined Spaces (PRCS)***

E5. This section provides the elements of a permit system.

5.1 ***Entry Permits.*** **A permit shall be established for all PRCS entries. This document shall include:**

E5.1 The intent of the permit system is to provide a systematic review for hazards, communicate this information to all those involved and provide an approval process for confined space entry.

5.1.1 The date of entry, the location of entry, the names or identification of entrants and type of work which will be conducted in the confined space;

E5.1.1 Under certain conditions, it may be necessary to document the entry and exiting of personnel and/or termination of entry.

5.1.2 The hazards to be controlled or eliminated prior to proceeding with the entry;

5.1.3 Safety equipment required to perform the job;

5.1.4 Safety precautions required to perform the job;

5.1.5 The type of atmospheric tests required and the results of those tests;

5.1.6 The type of equipment which will be necessary for a rescue and how aid will be summoned in the event of an emergency;

5.1.7 A duration for the permit;

E5.1.7 The duration of the permit should not exceed the time needed to complete the assigned work as specified in Requirement

5.1.8 Space for approval authority.

5.2 *Permit Implementation.* Before each entry, an entry permit as defined above will be completed and signed by a qualified person and the contents communicated to the entrants, or posted, or both.

5.3 *Duration of Permits.* For a permit to remain in effect, the following must be done before each re-entry into the confined space:

5.3.1 Atmospheric tests results shall be within acceptable limits per Section 6.0 of this standard. If atmospheric test results are not within acceptable limits, precautions to protect entrants against the hazards shall be addressed on the permit.

5.3.2 A qualified person shall verify that all precautions and other measures called for on the permit are still in effect;

5.3.3 Only operations or work originally approved on the permit shall be conducted in the confined space.

5.4 *Revoking Permits.* When conditions or work activity are outside the limits than those specified on the Permit, or could introduce a new hazard to the confined space, then the permit shall be immediately revoked.

5.5 *Changing Work Conditions.* A new permit shall be issued or the original permit re-issued whenever changing work conditions or work activity introduce new hazards into the confined space.

E5.5 An example of this would be the decision to weld within a confined space after approved work had already begun. Consequently a hot work/welding permit must be issued with hot work considered as part of the evaluation for precautions on the permit.

6. *Atmospheric Testing*

6.1 *Requirements.* Before entry into a confined space,

E6. 1 This will generally include testing for oxygen, com-

necessary testing shall be conducted for hazardous atmospheres by a qualified person. If there is no potential for a hazardous atmosphere, the atmospheric testing may be waived. A qualified person shall possess the knowledge and skills to understand the test instrument's use, calibration procedures, limitations, and have the ability to interpret results.

bustible and toxic atmospheres. It is recommended on a vertical entry that remote probes be used to test at various levels of the confined space. Note: Atmospheric tests will normally be conducted using direct reading real-time equipment. The user should ensure that the electronic test instrument indicates the appropriate response in clean air, and the order of the testing should be as follows unless all are conducted simultaneously:

a) Oxygen
b) Flammability/combustibility
c) Toxicity

6.1.1 Testing equipment and accessories used in hazardous classified areas shall be listed, approved, or certified for use in such areas. This listing, approval, or certification shall be from nationally recognized testing laboratories.

6.1.2 Initial testing of atmospheric conditions shall be done with the ventilation systems shut down.

E6.1.2 Testing with the ventilation off would closely represent the ambient atmosphere inside a confined space in the event of a ventilation system failure.

6.1.3 Further testing shall be conducted with ventilation systems turned on to ensure that the contaminants are removed and that the ventilation system is not a source of contamination.

E6.1.3 Testing with the ventilation on can reveal problems such as the suction of engine exhaust gases into the confined space or where pneumatically powered blowers or tools may bring contaminated air or other gases into the confined space.

6.1.4 If the confined space is vacated for any significant period of time, the atmosphere of the confined space shall be retested before re-entry is permitted.

E6.1.4 Defining when re-testing may be needed should be determined by a qualified person as part of the permit system.

6.1.5 Atmospheric testing may be waived for non-permit confined spaces where it has been established through a formal hazard identification and evaluation study that no atmospheric hazards exist.

E6.1.5 A documented hazard identification and evaluation study meeting the requirements contained in Section 3.2 Hazard Identification and Section 3.3 Hazard Evaluation could be used to establish there are no atmospheric hazards resulting from conditions or work activities performed inside the space.

6.1.6 Instrument reliability verification: Calibration of direct reading portable atmospheric testing instruments shall be conducted according to the manufacturers recommendations, or more often if necessary because of the instruments usage to ensure accuracy is maintained. At a minimum, a function check (e.g.: bump test) shall be done prior to each days use.

E6.1.6 Various types of instrument verification methods include the following:

a) Function check (bump test) – this involves the passing of a challenge gas source across the sensor to produce a response so the user knows all sensors are functioning. This is conducted as often as necessary throughout the testing period. If the instrument has comparable sensor self-testing features it meets the requirements of section 6.1.6 as a function check (bump test).

b) Point Source Calibration (calibration check) – A means of verifying calibration by using a known traceable concentration of a test gas to demonstrate that an instrument response to the test gas is within the instru-

ment manufacturers' allowable limits.

c) Full Span Calibration – (3 or more points) – This involves testing the sensor with different concentrations of gas and comparing the results to established response curves, which is usually done by the instrument manufacturer.

Note: Use of very toxic calibration gases such as, CL2 or NO2 should be used in a well ventilated area

d) For detector tube systems a verification of volume capacity, leakage, and tube shelf life date is recommended per manufacturers instruction.

6.1.6.1 An instrument maintenance record shall be maintained.

E6.1.6.1 The record should include date of purchase, sensor change schedule, maintenance/repair, history, data logging, and battery life.

6.2 *Testing Considerations.* Testing of confined spaces shall be conducted in a manner that represents the atmosphere throughout the confined space.

E6.2 Atmospheric testing for the confined space should be based on the configuration and design of the space, and physical, and chemical characteristics of suspected contaminants that may be encountered. Continuous monitoring should be considered in situations when a worker is present in a space where atmospheric conditions have the potential to change. Examples include broken or leaking pipe or vessels, disturbance of existing materials, the potential for adjacent work activities that can create a hazardous environment or any space that is not capable of being isolated.

6.2.1 Where personnel must enter the confined space to complete atmospheric testing, the space shall be treated as PRCS.

E6.2.1 Proper engineering controls, work practices, and personal protective equipment (PPE) may be needed to address the conditions that may be encountered during testing.

6.3 *Acceptable Limits.*

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

6.3.1.1 Oxygen - 19.5% to 23.5%;

E6.3.1.1 Any variation from normal atmospheric oxygen conditions inside the confined space as compared to outside the confined space should be investigated.

6.3.1.2 Flammability less than or equal to 10% of the Lower Explosive Limit (LEL) or Lower Flammable Limit (LFL);

E6.3.1.2 Any level above zero should be investigated.

6.3.1.3 Toxicity - less than recognized exposure limits.

E6.3.1.3 Any level above zero should be investigated. To determine excessive toxic levels, standards such as the most current American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values document should be referenced, Material Safety Data Sheets (MSDS), 29CFR1910, Subpart Z, or other pertinent information which may apply to the toxic material. Consideration should

be given to the use of continuous monitoring equipment. Applicable exposure limits should not be exceeded even instantaneously.

6.3.2 Whenever testing of the atmosphere indicates that levels of oxygen, flammability, or toxicity are not within acceptable limits, entry shall be prohibited until appropriate controls are implemented or appropriate personal protective equipment is provided.

E6.3.2 The recommended method of entering confined spaces requires that an unacceptable atmosphere be corrected and controlled prior to entry. In some situations, this is not possible or practical and the entrants must be protected by the use of personal protective equipment that is appropriate for the actual conditions. These atmospheric conditions need to be considered when developing the specific work plan and rescue procedures. Entry under these conditions must be part of the entry permit or a new permit issued.

6.3.2.1 If the source of the contaminant cannot be determined, precautions shall be adequate to deal with the worst possible condition, which the contaminant could present in the confined space.

6.3.2.2 If there is the possibility that the confined space atmosphere can become unacceptable while the work is in progress, procedures and equipment shall be provided to allow the employee to safely exit the confined space.

7. *Entry Team*

7.1 *Attendant.*

7.1.1 *Location.* The attendant shall be stationed immediately outside the point of entry/exit of the confined space to observe the permit required confined space (PRCS) and be able to communicate with the occupants throughout the entry.

E7.1.1 This may be supplemented visually or verbally through remote means such as radio, hardwire, video, camera, etc... Communication equipment should be safe for the intended use.

7.1.2 *Personnel Requirements.* The number of attendants needed shall be determined by a qualified person who shall consider the manpower necessary to carry out the duties.

E7.1.2 The number of attendants should be determined by considering the manpower it will take to carry out duties assigned to the attendant for the entry(ies). If several entry points are within a few feet of each other, one attendant may be able to monitor more than one entry directly, or more than one entry may be monitored using remote technology, such as multiple radios and/or video monitors. This would be dependent upon the attendant's ability to communicate with the entrants and summon aid in the event of an emergency.

7.1.3 *Duties.* Attendants shall have the following duties:

7.1.3.1 Provide standby assistance to entrants entering the confined space.

E7.1.3.1 "Standby Assistance" may include checking breathing air cylinders, or any ancillary duties that do not require the attendant to enter the confined space or leave his/her position, or distract them from monitoring the entrant(s) in the space(s).

7.1.3.2 Direct entrants to exit the confined space when any irregularities are observed.

E7.1.3.2 Irregularities include: (A) Whenever unanticipated hazards or other conditions or operation not allowed by the permit arise; (B) Whenever entrants exhibit symptoms of exposure to contaminants potentially in the space; (C)

Whenever surrounding operations or conditions create hazards for entrants, including entry of the space by unauthorized personnel.

7.1.3.3 Initiate evacuation and emergency procedures.

E7.1.3.3 Attendants should summon the rescue team as soon as the attendant recognizes there may be a problem.

7.1.3.4 Monitor for any conditions or changes that could adversely affect the entry.

7.1.3.5 Remain at the entry point unless relieved by another attendant or until the entry is completed or terminated.

7.2 ***Entrant.***

7.2.1 Duties

7.2.1.1 An entrant shall:

1) **Recognize potential hazards that may be encountered during the entry and proper use and limitations of equipment for control of these hazards. Inspect for hazards not identified by atmospheric monitoring during entry activities.**
2) **Respond to emergencies, which includes method(s) for self-rescue.**

Explanation: Hazards that may not be detectable include structural weakness, biological agents, dangerous insects/animals, engulfment potential, and low volatility hydrocarbons, (e.g. diesel fuels), or any materials for which direct reading instrumentation is not available.

3) **Recognize symptoms and warning signs of exposure to potential hazards or prohibited conditions.**

4) **Notify the attendant of any emergency or unacceptable condition in the confined space.**

5) **Exit the confined space immediately if symptoms, warning signs, or unacceptable conditions occur or if directed by the attendant or entry supervisory leader.**

6) **Inspect for hazards during entry activities.**

7.3 ***Attendant(s)/Entrant(s) Communication.*** **Attendant(s) and Entrant(s) shall be able to maintain two-way communication.**

E7.3 Communication methods should be selected according to hazards and potential for injury or harm to personnel entering the space. Signaling, visual contact and verbal radio communication are examples of available methods.

7.4 ***Entry Supervisor/Leader.***

7.4.1 Duties

7.4.1.1 The Entry Supervisor/Leader shall:

1) **Know the requirements of the confined space entry program, including proper execution of duties of entrants, attendants and rescue per-**

sonnel.

2) **Verify that all required actions have been taken prior to endorsing the permit and allowing entry to begin, and ensure that acceptable conditions are maintained for the duration of the entry.**

3) **Verify that rescue services are available prior to and throughout the entry and that the means for summoning them are operable.**

4) **Communicate the status and requirements of the entry to other Entry Supervisor/Leader(s) whenever the Entry Supervisor/Leader is changed.**

5) **Terminate entry, assure removal of personnel and equipment, and revoke or cancel the permit when required.**

E7.4.1.1.(Note-#2) An initial external visual inspection should be conducted where possible, prior to entry to look for hazards not identified by the atmospheric monitoring.

8. *Isolation and Lockout/Tagout*

8.1 *General.* All energy sources which are potentially hazardous to confined space entrants shall be secured, relieved, disconnected and/or restrained before personnel are permitted to enter the confined space.

E8.1 The objective is the control of any situation where unexpected energization, start-up or release of stored energy would cause injury to workers. Energy sources may include: electrical, mechanical, hydraulic, pneumatic (air), chemical, thermal, radioactive and the effects of gravity.

8.2 *Isolation.* Methods and means shall be selected and used to prevent flammable, toxic, irritating, or oxygen displacing gases and vapors from entering the space. All hazardous material, high pressure, high temperature and other piping that could be reasonably expected to introduce a hazard shall be isolated by utilizing blinding, disconnection, removal, or double block and bleed as needed to prevent entry of material(s) and hazardous contaminant(s).

E8.2 Before the method(s) of isolation is selected, a qualified person should consider the hazards that may exist or develop to include temperature, pressure, flammability, reactivity, corrosiveness or toxicity of material in the piping and reactions that could occur with cleaning or purging agents, as well as any physical hazards.

A confined space shall be isolated to prevent entry of material(s) and hazardous contaminants using one or more of the following methods:

- **Inserting a blank sized for the proper pressure in piping nearest to the confined space.**
- **Depressurizing and disconnecting contaminant supply line(s) and providing a blank or blind on piping leading into the confined space.**
- **Misaligning pipe(s) at connections closest to the confined space and capping, blinding, and plugging ends.**
- **Utilizing two (2) blocking valves with an open vent or bleed valve between the blocking valves. If the**

bleed valve is not the same diameter as the line, then the bleed point should be monitored periodically during the work shift.

8.2.1 Pipelines or similar conveyances between the confined space and point(s) of isolation shall be drained, cleaned, or flushed of hazardous material and known hazardous contaminants as necessary.

E8.2.1 Pipelines between the confined space and the first valve, blank or associated equipment may contain material or hazardous contaminants. A qualified person should ensure that such piping has been flushed, cleaned or purged. If this is not possible, i.e., a clogged line, special precautions and procedures necessary to protect occupants and control the hazards should be in place.

8.2.2 Precautions shall be taken to ensure that whenever drains, vents or piping are left open that reversal of flows, or air contamination from adjacent processing, or chemical handling, cannot enter the confined space.

E8.2.2 A qualified person should assess the impact of other equipment in isolating a confined space. Inter-connected equipment, vessels or machinery may affect the isolation method(s) chosen.

8.2.3 In confined spaces where complete isolation is not possible, provisions shall be made for as rigorous of isolation as practical and an evaluation conducted according to Section 3. If an atmospheric hazard potential exists, continuous monitoring shall be conducted during the entry.

E8.2.3 A decision to enter these or other similar spaces should be based upon assessing the potential for hazardous contaminants being present and either devising a plan for protecting personnel entering the space or suspending entry until adequate hazard control and protection of occupants can be assured. Use of methods such as ventilation or PPE should be considered.

8.2.4 Special precautions shall be taken when entering double walled, jacketed, or internally insulated confined spaces that may discharge hazardous material through the vessel's internal wall.

E8.2.4 Distillation vessels, boilers , cargo tanks, adjoining voids on ships and barges, and similar type equipment may contain cracks or leaks that may produce a hazardous environment inside the confined space.

8.3 *Lockout/Tagout.* Equipment or process shall be locked or tagged or both per ANSI Z244.1-1982 (R-1993) Lockout/Tagout of Energy Sources.

8.3.1 Where there is a need to test, position or activate equipment by temporarily removing the lock or tag or both, a procedure shall be developed and implemented to control hazards to the occupants.

E8.3. 1 Equipment start-up may pose entanglement, entrapment or engulfment hazards to occupants inside the space. A qualified person should access the hazard of temporarily removing the locks/tags.

8.3.2 Any removal of locks, tags, or other protective measures shall be done in accordance with ANSI Z244.1-1982 (R1993) Lockout/Tagout of Energy Sources.

8.3.3 Lockout, or tagout, or both, of equipment, systems and processes shall be verified prior to permitting entry into the confined space.

E8.3.3 Confirming adequate lockout, or tagout, or both, of potentially hazardous stored or residual energy should be included as part of confined space entry permit review.

9. *Ventilation*

9.1 *Requirements.* When ventilation is used to control atmospheric contaminants in the confined space, the space should be ventilated until the atmosphere is within the acceptable limits. Atmospheric testing shall

E9.1 Consideration should be given to the volume of the space to be ventilated, the output capacity of the ventilating device, and the distribution of air within the confined space. In addition, the air movers should meet the specifications as

be done in accordance with Section 6.

outlined in ANSI/NFPA 91-1999 and ANSI Z9.2-1979 (R1991).

Ventilation normally consists of a pre-entry purge of several air changes, then continuous introduction of fresh air during occupancy.

Natural ventilation may be acceptable if it can achieve the same results as the mechanical ventilation. Consideration should be given to bonding and using intrinsically safe air movers when moving flammable atmospheres. Ventilation may not be appropriate under conditions such as the presence of friable or loose asbestos; significant bird/rodent droppings presenting a biological risk; gas, vapor, dust concentrations above UEL, etc.

9.1.1 Blowers or other means of introducing air into the space shall be placed in such a manner to minimize the possibility of introducing air contaminants, which may create unacceptable limits (e.g., carbon monoxide).

9.1.2 Ventilation shall be maintained during the entry if there is a potential for the atmospheric conditions in the confined space to become unacceptable.

9.1.3 When ventilation is not possible or feasible for complete elimination of atmospheric hazards, other protective measures or methods to control air contaminants and protect entrants shall be determined by the qualified person prior to authorizing entry.

10. ***Cleaning/Decontamination***

10.1 Confined spaces shall be cleaned and decontaminated of hazardous materials as the preferred method of eliminating or reducing exposure. Cleaning and decontamination shall be done to the extent feasible before entry.

E10. 1 In some instances, the purpose of the entry is to clean the confined space. In these cases, the confined space should be cleaned and decontaminated as much as possible before personnel enter. Proper PPE and other precautions should be used to address any hazards, which will remain after the pre-entry cleaning. Prior to commencing cleaning and decontamination, care should be exercised in the selection of cleaning compounds to ensure their compatibility with the environment in which they will be used.

10.2 Entry team members and equipment shall be decontaminated and cleaned as necessary during or after the confined space activity.

11. ***Personal Protective Equipment (PPE)***

11.1 ***General.*** **A qualified person shall determine personal protective equipment needed by all personnel entering the confined space including rescue teams.**

E11.1 A hazard evaluation should be done to determine what PPE should be used. Combinations of equipment such as respirators, full suits, etc., may be needed. A guide can be found in Appendix B, General Description and Discussion

of the levels of Protection and Protective Gear, of the OSHA Regulation 29CFR 1910.120. The stress placed on the entrant by PPE, such as heat and loss of mobility, should be carefully evaluated.

11.2 *Selection.* Employees shall wear personal protective equipment selected in accordance with the requirements of the job to be performed. PPE shall meet the specifications of applicable standards and regulations. PPE that will not exacerbate present hazards or create additional hazards shall be selected.

E11.2 Head Protection. Consideration should be given to: 1) falling objects, both from within the confined space and also through the entryway, and 2) structures and equipment that present hazards to the head. (Ref. ANSI Z89.1-1997).

Fall arresting systems should be used by personnel entering vertical confined spaces and personnel exposed to falling into the space as determined by a qualified person.
Fall arrest systems should conform to ANSI Z359. 1-1992 (R-1999).

Eye and Face Protection. Consideration should be given to irritant dusts, vapors, mists, abrasive particles and flying objects. Safety glasses, impact goggles, chemical goggles, or face shields appropriate to the conditions in the confined space and the work to be performed should be provided as needed.
(Ref. ANSI Z87. 1-1989 (R-1998).

Hand Protection. Consideration should be given to mechanical protection (sharp edges, abrasions, and punctures), chemical protection (acid solvents), physical protection (heat, cold), electrical protection and handling of slippery tools and materials.

Foot Protection. Consideration should be given to physical hazards (falling objects, rolling equipment), chemical hazards (acids, solvents), slip resistance, electrical conductivity, and generation of sparks. (Ref. ANSI Z41 -1991).

Protective Clothing. Consideration should be given to temperature, moisture, chemical resistance, vapor, and liquid permeability, flame retardancy, static resistance and likelihood of contamination of clothing with toxic materials. Protective clothing should be cleaned and decontaminated, or disposed of, after each use in accordance with the manufacturer's instructions.

Respiratory Protection. Respirators should be selected and used in conjunction with an organized respiratory protection program. Breathing equipment used should be NIOSH approved. When conditions warrant, consideration should be given to conformity with NFPA 1981. Users should follow manufacturer's instructions.
(Ref. ANSI Z88.2-1992 and 29CFR 1910.134).

Hearing Protection. If hearing protection is required, consideration should be given to how it will affect communications between the personnel in the confined space and the attendant.
(Ref. 29CFR 1910.95).

11.3 *Inspection.* PPE shall be inspected prior to each use.

12. *Auxiliary equipment*

12.1 *Entry and Exit.* Each entry and exit point shall be evaluated to determine the most effective methods and equipment to be utilized to enable employees to safely enter and exit the confined space. Safe entry and exit means shall be provided for confined spaces.

E12.1: This may involve the use of ladders. However, if use of a ladder is impractical, another means of lowering and raising employees should be selected, i.e., bosun chairs, winch/hoist devices, etc. Access winches/hoists, bosun chairs, harness components, scaffolds, etc., should be compatible with the intended use according to the manufacturer's instructions and suitable for confined space applications.

12.2 *Retrieval Equipment.* Appropriate retrieval equipment or methods shall be used whenever a person enters a PRCS. Exception: If the retrieval equipment increases the overall risks of entry or does not contribute to the rescue, its use may be waived.

E12.2 In general, mechanical lifting devices should have a mechanical advantage adequate to safely rescue personnel. A manually operated device should be used. If a powered (electric, pneumatic, hydraulic) lifting device is used, then it should be equipped with a slip clutch or similar device to stop motion against a preset resistance and a back-up manual mode of operation. Mechanical lifting devices should have a mechanical advantage of at least four to one and the capacity to lift entrants including any attached tools and equipment.

12.3 *Fall Protection.* Where a potential exists for persons or objects falling into a confined space, warning systems or barricades shall be employed at the entrance.

E12.3 While protection is desired to prevent attendants or others from falling into a confined space, such protection should not interfere with ventilation or egress from the confined space.

12.4 Electrical Equipment. Electrical equipment used in hazardous locations shall meet the appropriate requirements of Article 500 of the National Electrical Code (NFPA-70).

E12.4 Tools, lighting, communications and test equipment which will be used in hazardous or classified locations should be listed, labeled or otherwise determined to be safe for the class and use by an Accredited nationally recognized tsting laboratory acceptable to the Occupational Safety and Health Administration or other authority having jurisdiction.

12.4.1 Where there is potential for electrical shock, appropriate electrical equipment or systems shall be used.

E12.4.1 This would include protection such as ground fault circuit interrupters (GFCI), assured grounding systems, double insulated tools, and/or low voltage systems.

13. *Warning Signs and Symbols*

13.1 *Identification.* All permit required confined spaces that can be entered without the use of tools, special equipment, or key(s) shall have a sign identifying it as a permit required confined space.

E13.1 Permit required confined spaces such as vessels, tanks, silos, ovens, reactors, etc. may be identified by signage in order to supplement the training of personnel regarding confined space identification and hazards.

13.1.1 Signs shall be maintained in a legible condition.

13.1.2 The sign shall read "Danger-Permit Required Confined Space".

14. *Emergency Response*

14.1 *Emergency Response Plan.* A plan of action shall be written with provisions to conduct a timely rescue for entrants in a confined space should an emergency arise. Included in these provisions shall be:

E14.1 These rescue provisions will normally be present in the form of emergency response procedures.

1. Evacuation when certain hazards are identified during an entry;

2. Retrieval by trained crew members using non-entry methods;

3. Rescue entry by trained emergency response personnel familiar with confined space hazards as well as rescue procedures and equipment.

14.1.1 Determination of what methods of rescue must be implemented to retrieve entrants;

14.1.1.1 Horizontal Rescue

E14.1.1.1 A review should be conducted of all the different types of confined spaces which will be entered and what steps/equipment it will take to get someone out. Consideration should be given to the size and configuration of the confined space, whether the space would require a vertical or horizontal rescue, anchor placement, hazards likely to be encountered, and the body size of entering personnel.

14.1.1.2 Vertical Rescue: This rescue methodology shall include the use of fall protection for the entrant as well as suspended rescuers.

E14.1.1.2 Consideration should be given to prevent abrasive injury to the entrant from the supporting surface he/she is being moved upon. Additionally, entanglement and obstruction hazards must be negotiated safely. To avoid further injury, a constant watch should be utilized anytime a entrant is being physically moved.

14.1.2 Determine the type and availability of appropriate equipment needed to rescue or retrieve entrants:

14.1.3 Designation of trained rescue personnel that are available where PRCS entries are conducted;

14.1.4 An effective means to summon rescuers in a timely manner;

14.1.5 Training and drilling attendant(s) and rescue personnel in preplanning, rescue and emergency procedures according to section 15 of this standard.

14.2 Atmospheric Monitoring shall be conducted to ensure the safety of the rescue personnel.

14.3 Respiratory Protection Equipment: All rescue personnel shall use self-contained breathing apparatus

(SCBA) or Combination Type C Airline/SCBA breathing equipment when potential atmospheric hazards exist. Users shall follow manufacturer's instructions.

14.4 Rescue Equipment Inspection: All rescue equipment shall be inspected, by a qualified person, periodically and prior to use, to ensure that it is operable.

15. ***Training***

15.1 ***General Requirements.*** **Personnel responsible for supervising, planning, entering or participating in confined space entry and rescue shall be adequately trained in their functional duties prior to any confined space entry. Training shall include:**

E15.1 Training, whether basic or advanced, formal or informal, should be commensurate with the complexity of the confined space entry requirements. For general requirements regarding training, refer to Z490.1-2001 Accepted Practices in Safety, Health, and Environmental Training.

15.1.1 An explanation of the general hazards associated with confined spaces;

15.1.2 A discussion of specific confined space hazards associated with the facility, location or operation;

15.1.3 The hazard for which the PPE was selected, and the proper use, inspection, care and maintenance, and limitations of PPE and other safety equipment;

15.1.4 An explanation of the permit system and other procedural requirements for conducting a confined space entry;

15.1.5 How to respond to emergencies;

E15.1.5 Consideration should be given to rescue strategies and techniques. Additionally, crisis decision making including a scene evaluation and risk vs. reward (some rescues should not be attempted) should be taught and practiced. Rescue team access and patient extraction should include packaging which considers type and degree of injury and/or nature of incapacity. The entry team should be taught an incident management system stressing team member task assignments.

15.1.6 Duties and responsibilities as a member of the confined space entry team;

15.1.7 A description of how to recognize probable air contaminant overexposure symptoms to themselves and co-workers, and method(s) for alerting attendants.

15.2 ***Training for Atmospheric Monitoring Personnel*** **Training shall include training in the proper use of atmospheric monitoring instruments. This shall include field calibration, basic knowledge of the work being performed, the anticipated hazardous contami-**

E15.2 It is important for individuals conducting atmospheric tests to possess adequate knowledge of the proper operation of monitoring equipment as well as its limitations associated with anticipated conditions (such as inaccurate measurement readings for flammable gas when the oxygen level

nants, and any process which could significantly alter original conditions inside or outside the confined space.

is below 16% for certain equipment). Similarly, these individuals should have information about the related process to anticipate potential atmospheric contaminants, such as a nearby reactor containing a highly toxic substance which could endanger the entry team in the event of a leak or release.

15.3 *Training for Attendants.* Training shall include the following:

15.3.1 Duties, responsibilities and procedures for both routine and emergency operations;

15.3.2 Hazards that may be encountered by entrants and the signs and symptoms of over exposure;

15.3.3 Procedures for summoning rescue or other emergency services;

15.3.4 The proper use of equipment used for communicating with entry and emergency/rescue personnel;

E15.3.4 Entry by an attendant for rescue may only be accomplished if the attendant has been trained in rescue procedures, is properly equipped, and only if the attendant is relieved by another trained attendant.

15.3.5 Performance of non-entry retrievals;

E15.3.5 Attendants should understand that not all retrievals should be attempted or are possible. Line entanglement is common and entrants that sustained a traumatic injury should be properly packaged (possibly including spinal immobilization) before being moved.

15.4 *Training for Emergency Response Personnel* shall include:

E15.4 Guidance as to qualifications and training requirements for rescue providers may be found in NFPA 1670 "Standard on Operations and Training for Technical Rescue Incidents" and NFPA 1006 "Standard for Rescue Technician Professional Qualifications".

15.4.1 The rescue plan and procedures developed for each type of confined space they are anticipated to encounter;

E15.4.1 Emergency response personnel should simulate actual rescue conditions by conducting practice drills.

Typical potential rescue problems which should be addressed are egress restrictions, ability to lift without injury, problems in using rescue equipment, and fall hazards.

Such training should not be limited to internal emergency response personnel. When possible, outside response agencies should receive the same type of training to ensure their effectiveness in a rescue situation.

15.4.2 Use of emergency rescue equipment;

E15.4.2 Individuals involved in rescues should receive training in the use of rescue equipment including medical equipment they would be expected to use or operate during an emergency rescue.

15.4.3 First Responder/Emergency Response training Level or equivalent with confined space specific

E15.4.3 Persons performing Cardio Pulminary Resucitation, Automated External Defibrillator, and/or first aid or both,

training.

should possess current certification,

15.4.4 Work location and confined space configuration to minimize response time.

E15.4.4 Rescuers should be able to effectively locate the emergency site without undue delay. Consideration should be given to notifying on-site Emergency Rescue Personnel of the location of entries into PRCS's prior to entry.

15.5 ***Verification of Training***

15.5.1 Periodic assessment of the effectiveness of employee training shall be conducted by a qualified person.

E15.5.1 Training effectiveness may be evaluated by several techniques. Written, as well as practical testing is recommended. Personnel should be questioned or asked to demonstrate their practical knowledge of confined space hazards that are in their work areas, to identify locations of confined spaces, their role is exercising proper permit procedures, use and donning of personal protective equipment, such as respirators, and their role in response to emergency situations.

15.5.2 Training sessions shall be repeated as often as necessary to maintain an acceptable level of personnel competence.

E15.5.2 Personnel who are routinely entering the same confined space on a daily basis will require less refresher training than employees who only occasionally enter a confined space. Periodic skill evaluation will determine the frequency of refresher training.

15.5.3 Written records of training shall be maintained and include as a minimum:

a. employee name;
b. trainer's name;
c. date(s) of training;
d. training duration
e. training content.

E15.5.3 Documentation should be maintained in a central location and periodically reviewed to ensure proper follow-up for refresher training.

16. ***Medical Suitability.*** **The physical and psychological suitability of persons to adequately perform required duties of confined space work shall be considered as needed prior to working in confined spaces.**

E16. Work in confined spaces may involve a variety of stressors which should be evaluated by a physician or other licensed Health Care Professional (HCP) against an essential job function based job description specific to the confined space, as appropriate.

Examples include, but are not limited to, thermal extremes (hot or cold), vertigo, claustrophobia, and physical and psychological stressors associated with specific confined space environments.

Observation during field activities associated with confined space work or training may be useful in assessing candidates' physical or psychological medical suitability for this type work.

The confined space employer should make the final decision regarding medical suitability after reviewing recommendations and input.

17. ***Contractors***

17.1 ***Hazard Appraisal.*** **When an employer arranges to**

E17.1 Employers should evaluate potential contractors to

have employees of another employer (contractor) perform work that involves confined space entry, the employer shall inform the contractor about the confined space including:

- **the classification of the space (e.g., permit or non-permit);**
- **hazards and operations within or near the space;**
- **the employer's experience with the space;**
- **any precautions or procedures that the host employer had implemented for the protection of employees in or near the confined space where contractor personnel will be working.**

ensure they have appropriate qualifications for the full scope of work to be performed, including a confined space safety program meeting this standard.

It should be noted that a variety of employer/contractor interface scenarios are possible. The employer may be on a scene and physically controlling day-to-day contractor operation, the contractor may be working largely independently of employer oversight, or some other interface may be in place. The key factor is to ensure responsibility/authority is clearly delineated in the project contract to avoid confusion and/or omission of elements key to safe confined space entry operations.

17.2 ***Identification of Rescue Responder***

Responder. The employer and contractor shall establish who will serve as the rescue responder in an emergency and what system will be used to notify the responder that an emergency exists.

E17.2 Pre-planning should be conducted between the contractor and the employer to establish who will be responsible to perform rescue and provide medical services in the event of an emergency situation. If the contractor expects to use the employer's rescue capability, this should be agreed upon before the entry and the method of contacting the rescue responder established.

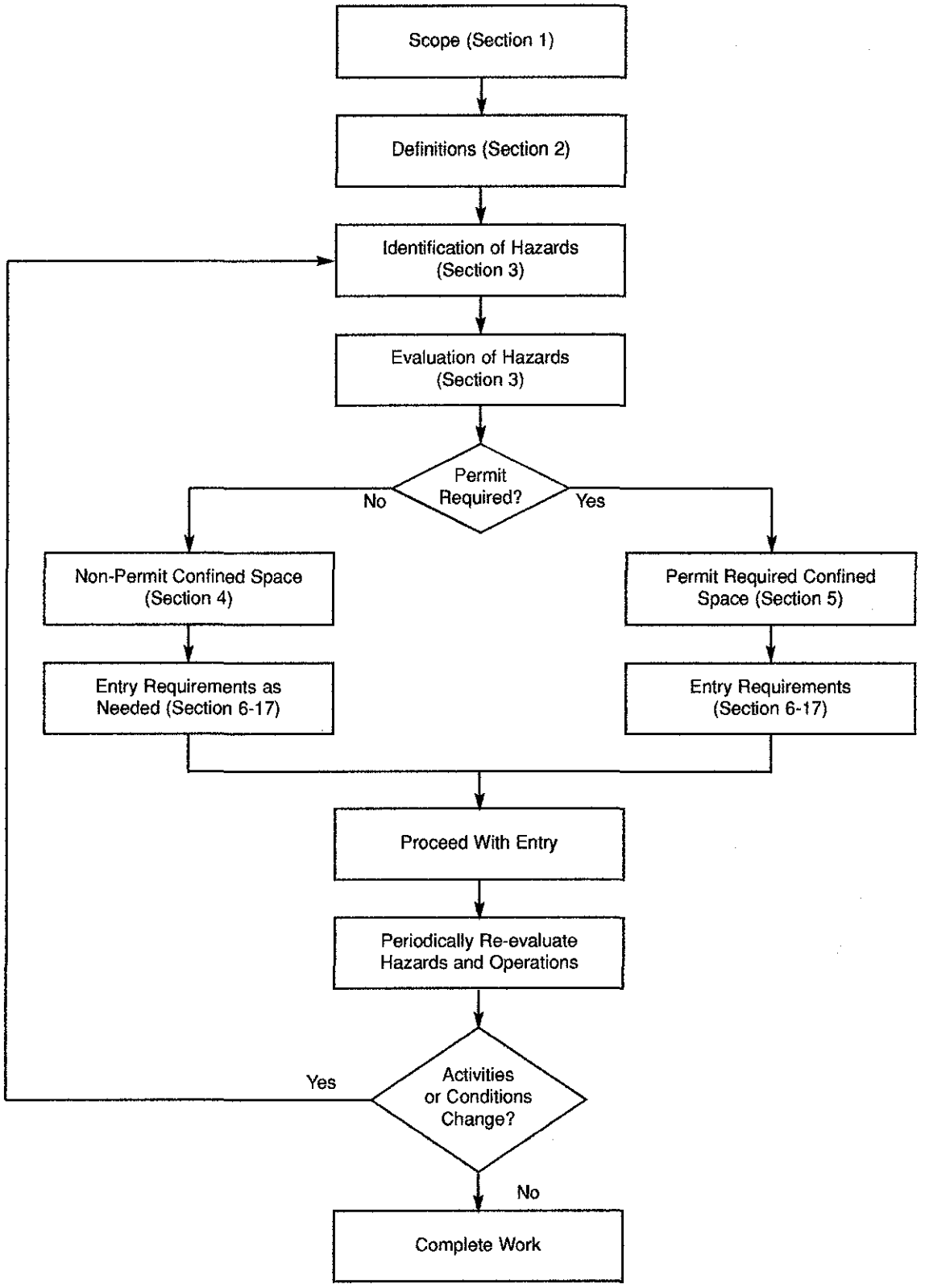
17.3 ***Permit System.*** **Contractors shall ensure a permit confined space program is being followed, meeting the requirements of this standard. If the confined space is a permit space, entry is allowed only through compliance with a permit space program.**

E17.3 Contractors may submit a copy of their permit entry program with the contracting entity, or agree by contract to follow the permit program of the contracting entity. The contractor and host employer may arrange for the contractor employees to adhere to the host employer's permit space program or to follow the contractor's program. If the host employer's program will be used, the contractor must be informed of the program's requirements and be given a copy of the completed permit for retention and review purposes. Likewise, if the contractor's program will be used, the contractor must inform the host employer of the requirements of the contractor's program.

17.4 ***Coordination.*** **When both employer and contractor personnel will be working in or near permit spaces entry, the two parties must coordinate their operations for activities impacting confined space entry.**

17.5 ***Ongoing Dialogue.*** **The contractor must inform the host employer immediately of any hazards encountered or created during the course of entry. A follow-up discussion must be held at the conclusion of the entry operation concerning any additional hazards or problems encountered.**

Appendix A
Logic Diagram for Confined Space Entry



Appendix B - References
Pertinent Standards and Other Reference Materials on the Subject of Confined Spaces.

United States Standards

Occupational Safety and Health Administration

29 CFR 1910.146 Permit-Required Confined Spaces
Numerous U.S. states have their own confined space regulations. Many of these are similar to the federal standard but some have significant differences.
Related OSHA standards
29 CFR 1910.147 Control of Hazardous Energy (lockout/tagout)
29 CFR 1910.252 Welding, Cutting and Brazing
29 CFR 1910.268 Telecommunications
29 CFR 1910.269 Electric Power Generation, Transmission, and Distribution
29 CFR 1910.272 Grain Handling Facilities
29 CFR 1915 Subpart B Confined and Enclosed Spaces and Other Dangerous Atmospheres in Shipyard Employment
29 CFR 1915.76 Access to cargo spaces and confined spaces.
29 CFR 1926.651 Specific Excavation Requirements.
29 CFR 1926.800 Underground Construction

American National Standards Institute

- Accepted Practices for Safety, Health, and Environmental Training, Z490.1-2001
- Blower and Exhaust Systems, ANSI/NFPA 91-1998 Fundamentals Governing the Design and Operation of 2 Local Exhaust Systems, ANSI Z9.2-1979(R1991)
- Flammable and Combustible Liquids Code, ANSI/NFPA 30-2000
- Flammable and Combustible Liquid Tank Vehicles, ANSI/NFPA 385-2000
- National Electrical Code, ANSI/NFPA No.70-2001
- Practices for Respiratory Protection, ANSI Z88.2-1992
- Protective Headwear for Industrial Workers, ANSI Z89. 1-1997
- Safety Requirements for the Lockout/Tagout of Energy Sources, ANSI Z244.1-1982(R-1993)
- Personal Protection – Protective Footwear, ANSI Z41-1999
- Safety in Welding and Cutting, ANSI Z49. 1-1999
- Practice for Occupational and Educational Eye and Face Protection, ANSI Z87. 1-1989 (R-1998)
- Standard for Fire Prevention During Welding, Cutting, and Other Hot Work NFPA 51B-1999
- Safety Requirements for Personal Fall Arrest Systems, ANSI Z359.1 - 1992 (R1999)

American Petroleum Institute

#2217A Guidelines for Work in Inert Confined Spaces in the Petroleum Industry
#2013 Cleaning Mobile Tanks in Flammable or Combustible Liquid Service
#2015 Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks
#2016 Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks
#2026 Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service
#2207 Preparing Tank Bottoms for Hot Work
#1141 Guidelines for Confined Space Entry on Board Tank Ships in the Petroleum Industry

American Society for Testing and Materials

#D4276 Practice for Confined Area Entry
#F1764 Standard Guide for Selection of Hardline Communication Systems for Confined Space Rescue

National Fire Protection Association Standards that reference Z117

NFPA 86 Standard for Ovens and Furnaces
NFPA 86C Standard for Industrial Furnaces Using a Special Processing Atmosphere
NFPA 86D Standard for Industrial Furnaces Using Vacuum as an Atmosphere
NFPA 306 Standard for the Control of Gas Hazards on Vessels

(also refers to API 1141)
NFPA 326 Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair (also refers to API 2015)
NFPA 329 Recommended Practice for Handling Releases of Flammable and Combustible Liquids and Gases
NFPA 385 Standard for Tank Vehicles for Flammable and Combustible Liquids
NFPA 560 Standard for the Storage, Handling, and Use of Ethylene Oxide for Sterilization and Fumigation

Overseas Standards
Australian Standard 2865 Work in Confined Spaces
United Kingdom Health and Safety Executive
Statutory Instrument 1997 No. 1713 The Confined Spaces Regulations 1997
Approved Code of Practice, Regulations and Guidance "Safe work in confined spaces" ISBN 0-7176-1405-0
Irish Health and Safety Authority
#218 Safety, Health and Welfare at Work (Confined Spaces) Regulations

Books and Publications about Confined Space
"Complete Confined Spaces Handbook"
John F. Rekus, © 1994 John Rekus
Lewis Publishers an imprint of CRC Press
ISBN 0-87371-487-3

"Safety and Health in Confined Spaces"
Neil McManus
© 1999 NorthWest Occupational Health and Safety, a division of Training by Design, Inc.
Lewis Publishers an imprint of CRC Press
ISBN 1-56670-326-3

"Confined Space Safety Manual" 2nd edition
R. Craig Schroll
© 1997 FIRECON
ISBN 0-945492-05-7

"Confined Space Entry: Guide to Compliance"
Frank R Spellman
© 1998 CRC Press
ISBN: 1-566767-04-0

"Guidelines for Hot Work in Confined Spaces"
Martin H. Finkel
© 2000 American Society of Safety Engineers
ISBN 1-885581-30-0

"Worker Deaths in Confined Spaces"
National Institute for Occupational Safety and Health
Publication #94-103

"Field Guidelines for Temporary Ventilation of Confined Spaces"
Michael K. Harris, Lindsay E. Booher, and Stephanie Carter
© 1996 American Industrial Hygiene Association
ISBN 0-932627-78-1

"Confined Space Entry an AIHA Protocol Guide"
© 2001 American Industrial Hygiene Association
ISBN 0-93267-08-4

"Confined Space Entry an AIHA Protocol Guide, 1st Edition"
Vernon E. Rose and Terry W. Krug
© 1995 American Industrial Hygiene Association
ISBN 0-932627-67-6

"Confined Space and Structural Rope Rescue"
Michael Roop, Thomas Vines, and Richard Wright
© 1998 Mosby, Inc.
ISBN 0-8151-7383-0

Books on Related Topics
"Air Monitoring Instrumentation"
Carol J. Maslansky and Steven P. Maslansky
© 1993 Van Nostrand Reinhold
ISBN 0-442-00973-9

"Air Monitoring for Toxic Exposures an Integrated Approach"
Shirley A. Ness
© 1991 Van Nostrand Reinhold
ISBN 0-442-20639-9

"Direct-Reading Colorimetric Indicator Tubes Manual" 2nd edition
Edited by Janet B. Perper and Barbara J. Dawson
© 1993 American Industrial Hygiene Association
ISBN 0-932627-53-6

"Air Sampling Instruments for Evaluating Atmospheric Contaminants" 8th edition
© 1995 American Conference of Governmental Industrial Hygienists, Inc.
Technical Editors Beverly S. Cohen and Susanne V. Hering
ISBN 1-882417-08-9

"Manual of Recommended Practice for Combustible Gas Indicators and Portable Direct-Reading Hydrocarbon Detectors"
2nd edition
Edited by C. F. Chelton
© 1993 American Industrial Hygiene Association
ISBN 0-932627-48-X

The Dictionary of Terms Used in the Safety Profession, Fourth Edition,
©American Society of Safety Engineers, Edited by Richard W. Lack, 2001

"The Occupational Environment – Its Evaluation and Control"
Edited by Salvatore R. DiNardi
© 1997 American Industrial Hygiene Association
ISBN 0-932627-82-X
Chapter 9 Direct-Reading Instrumental Methods for Gases, Vapors, and Aerosols
Chapter author Lori A. Todd
Chapter 42 Confined Spaces
Chapter author R. Craig Schroll

"Lockout/Tagout The Process of Controlling Hazardous Energy"
Edward V. Grund
© 1995 National Safety Council
ISBN 0-87912-174-2

"Lockout Tagout A Practical Approach"
Stephen M. Kelley
© 2000 American Society of Safety Engineers
ISBN 1-885581-35-1

National Institute for Occupational Safety and Health (NIOSH) Abstract: Request for Assistance in Preventing Occupational Fatalities in Confined Spaces, January 1986.

National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education and Welfare. Criteria for a recommended standard. Working in Confined Spaces. Publication No.80-106, December 1979.

National Institute of Occupational Safety and Health (NIOSH), U.S. Department of Health and Human Services. Worker Deaths in Confined Spaces a Summary of Surveillance Findings and Investigative Case Reports. Publication No.94-103, 1994.

National Institute of Occupational Safety and Health (NIOSH) - Certified Equipment List U.S. Department of Health and Human Services. Publication No.83-122.

Occupational Safety and Health Administration, (OSHA), U.S. Department of Labor; Federal Code 29CFR 1910, 1915, 1916, 1918, 1926, and 1928, Occupational Safety and Health Standards.

Office of Pipeline Safety, U.S. Department of Transportation Federal Code 49CFR 192.
Selected Occupational Fatalities Related to Fire and/or Explosion in Confined Spaces as Found in Reports of OSHA Fatality/Catastrophe Investigations, U.S. Dept. of Labor, April 1982.

Appendix C - Examples Of Confined Space Surveys and Permits

Committee Note: These examples are included in the appendices to provide readers with an example of some survey and permit forms used in business and industry. It is not meant to constitute in any way that these are the only forms to use, nor does this appendices specify any specific format or model to follow.

The information and materials contained in this appendix have been developed from sources believed to be reliable. However, the American Society of Safety Engineers (ASSE) as secretariat of the ANSI accredited Z117 Committee or individual committee members accept no legal responsibility for the correctness or completeness of this material or its application to specific factual situations. By publication of this appendix material, ASSE or the Z117 Committee does not ensure that adherence to these recommendations will protect the safety or health of any persons, or preserve property.

CONFINED SPACE ENTRY PERMIT

ALL COPIES OF PERMIT WILL REMAIN AT JOB SITE UNTIL JOB IS COMPLETED

1.

LOCATION and **DESCRIPTION** of Confined Space _____ Date _____

PURPOSE of Entry _____ Time _____ M

DEPARTMENT _____ Expiration _____ M

PERSON in Charge of Work _____

2.

SUPERVISOR (S) in Charge of Crews	Type of Crew	Phone

3.

SPECIAL REQUIREMENTS	Yes	No		Yes	No
Lock Out - De-energize			Escape Harness		
Lines Broken - Capped or Blanked			Tripod emergency escape unit		
Purge - Flush and Vent			Lifelines		
Ventilation			Fire Extinguishers		
Secure Area			Lighting		
Breathing Apparatus			Protective Clothing		
Resuscitator - Inhalator			Respirator		

4.

TEST(S) TO BE TAKEN (valid for one 8-hour turn only)	P.E.L.*	YES	NO	DATE M	DATE M	DATE M	DATE M	DATE M	DATE M	DATE M	DATE M
% of Oxygen	-19.5% +21%										
% of L.E.L.*	Any % over 10										
Carbon Monoxide	35 ppm										
Aromatic Hydrocarbon	10 ppm										
Hydrocyanic Acid	4.7 ppm										
Hydrogen Sulfide	10 ppm										
Sulfur Dioxide	2 ppm										
Ammonia	25 ppm										

GAS TESTER Name _____

Note. Continuous/periodic tests shall be established before beginning job. Any questions pertaining to test requirements contact certified division gas tester, Plant Gas Coordinator, or the Industrial Hygienist

5.

INSTRUMENTS USED	Name	Type	Ident. No.

SAFETY STANDBY PERSON(S) Name _____ Ck No.

YES ☐ _____

NO ☐ _____

AMBULANCE

FIRE

Supv. Authorizing all above conditions satisfied _____

*P.E.L. Permissible Entry Level *L.E.L. Lower Explosion Level Orig. to Dept. Copy to Safety

CONFINED SPACES
ENTRY PERMIT

LOCATION OF CONFINED SPACE	DATE/TIME:
PURPOSE OF ENTRY	DURATION:
AUTHORIZED BY	EXPIRES ON:
ATTENDANT(S)	

AUTHORIZED ENTRANTS (LIST ON BACK OF FORM)

•MEASURES FOR ISOLATING & EQUIPMENT•	•YES•	•NO•	•MEASURES FOR ISOLATING & EQUIPMENT•	•YES•	•NO•
Lock Out - De-Energize - Try-Out Equipment			Self-Contained Breathing Apparatus		
Line(s) Broken - Capped - Blanked			Air-Line Respirators w/Emergency-Escape Capability		
Purge - Flush and Vent			Air-Purifying Respirators and Cartridges		
Ventilation			Resuscitator/Inhaler		
Secure Area (Post and Flag)			Communications Equipment		
Full Body Harness w/"D" Ring			Protective Clothing		
Tripod Emergency Escape Unit			Head/Eye/Hearing Protection (circle type(s))		
Lifelines			Hot Work Permit Required		
Fire Extinguishers					
Lighting (Explosion-Proof)					

ATMOSPHERE MONITORING

TEST(S) TO BE TAKEN	YES	NO	Acceptable Entry Conditions (Circle Appropriate Level) TLV*	PEL**	———
Oxygen			19.5-23.5%		
Combustible Gas			Below 10% LEL		
Carbon Monoxide			0-25 PPM	0-50 PPM	
Hydrogen Sulfide			0-10 PPM	0-10 PPM	
Hydrogen Cyanide			0-10 PPM	0-10 PPM	
Sulfur Dioxide			0-2 PPM	0-5 PPM	
Ammonia			0-25 PPM	0-50 PPM	

Test No.	1	2	3	4	5	6	7	8
DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE
	11/4							
	2:05							
	.m.	.m.	.m.	.m.	.m.	.m.	.m.	.m.
SAMPLE								

Individual Conducting Test (name) _____

Any questions pertaining to test requirements, contact _____

•INSTRUMENTS USED•	•NAME•	•TYPE•	•IDENT NO•

•STANDBY PERSONS•

YES ○

NO ○

FOR RESCUE & EMERGENCY SERVICES CALL _____

ENTRY SUPERVISOR AUTHORIZING ALL ABOVE CONDITIONS SATISFIED _____

LEL = Lower Explosive Limit PPM = Parts-Per-Million

*As listed in 1992-93 Threshold Limit Values published by American Conference of Governmental Industrial Hygienists

**Permissible Exposure Limits as listed in OSHA 29 CFR 1910.1000

CONFINED SPACE ENTRY PERMIT

Description of Confined Space: _____

Purpose of Entry: _____

Department/Confined Space/Location: _____

Duration of Permit: _____ Entry Time: _____

Name of Entrant(s) _____

Name of Attendant(s) _____

Management Employee in Charge of Entry _____

Signed: _____

CONFINED SPACE TESTING		**TEST RESULTS**					
	P.E.L.	Time	Value	Time	Value	Time	Value
Oxygen	19.5-23.5%						
Flammability level	< 10%						
		TOXICITY TESTING (IDENTIFY SUBSTANCES & P.E.L.)					
Carbon Monoxide	ppm						
	ppm						
	ppm						
	ppm						
	ppm						
	ppm						
	ppm						
	ppm						

CONTINUOUS TESTING ☐ Yes ☐ No

COMMENTS:

IDENTIFICATION OF TEST INSTRUMENTS

MFG. NAME			
TYPE			
IDENTIFICATION NO.			

Name of Tester: _____

SPECIAL REQUIREMENTS	YES	NO	COMMENT
Lockout/Tagout Equipment Supply Lines - Capped/Blanked			
Purging - Flush and Vent			
Ventilation			
Secure Area			
Breathing Apparatus			
Resuscitator			
Hot Work Permit			
Electronic Communication Devices			
Equipment for Maintaining Contact			
Lifelines			
Escape Harness			
Tripod Emergency Escape Unit			
Fire Extinguishers			
Lighting			
Alarm System			
Respirator			
Personal Protective Equipment (identify)			

_____ _____

_____ _____

Confined Space Entry Permit

Permit Expires (date & time)	Confined Space #
Location	
Description of Space	
Purpose of Entry/Description of Work	

Date of Entry	Time of Entry	Expected Duration
Entrants	Attendants	Contractors

Entry Supervisor (date & time) (print & sign)	
Work Crew Supervisor	Area Supervisor
Person Monitoring Atmosphere	
Hot Work Permit # Attach copy	Type of Hot Work
Safety Approval OPTIONAL (print & sign)	
Industrial Hygiene Approval OPTIONAL (print & sign)	

This Permit Must Be Posted Near the Entry to the Space

Alarm device		Nearest phone
In-plant Rescue Team #		Off-site Rescue Team #
Training Qualifications ☐	Pre-entry Briefing ☐	Rescue Crew Available ☐

Return this permit to Safety Department after work is completed.

Atmospheric Monitoring

Prior to Entry				Retest			
Oxygen 19.5-23.5%	LEL <10%			Oxygen 19.5-23.5%	LEL <10%		
Toxic Contaminants				Toxic Contaminants			
Name	MSDS	PEL	Detected	Name	MSDS	PEL	Detected
	☐				☐		
	☐				☐		
	☐				☐		
Tested by				Tested by			
Instrument(s) used				Instrument(s) used			
Last calibration date				Last calibration date			
Calibrated by				Calibrated by			

Periodic Atmospheric Monitoring

	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time
Oxygen								
%LEL								
#1								
#2								
#3								

Isolation of Space

Electrical	Lockout ☐	Tagout ☐	Disconnect ☐	Grounded ☐			
Piping	Blank ☐	Double block & bleed ☐	Lockout valves ☐	Disconnect ☐	Bleed lines ☐	Purge lines ☐	
Hydraulic	Lockout valves ☐	Disconnect ☐	Lockout pump ☐	Bleed lines ☐	Bleed system ☐		
Pneumatic	Lockout valves ☐	Disconnect ☐	Lockout compressor ☐	Bleed lines ☐	Bleed system ☐		
Mechanical	Disconnect linkage ☐	Block linkage ☐	Block movement ☐				
Fire control system	Lockout control panel ☐	Disconnect agent lines ☐	Blank agent lines ☐				
Duct work	Lockout blowers ☐	Lock dampers closed ☐	Disconnect ducts ☐				

Hazards in Space

Previous contents

Contents category	Flammable ☐	Corrosive ☐	Toxic ☐	Irritant ☐	Oxidizer ☐	Dust ☐
Physical State	Solid ☐	Liquid ☐	Gas ☐			
Tank/Vessel	Pressure released ☐	Drained ☐	Cleaned ☐			

Nature of Work

Welding ☐	Cutting ☐	Grinding ☐	Chipping ☐
Scraping ☐	Painting ☐	Spray application ☐	Spray cleaning ☐

Configuration of and environment in space

Slippery surfaces ☐	Vertical drop ☐	Sharp surfaces ☐	Low overhead ☐
Slope of interior ☐	High temperature ☐	Low temperature ☐	Other

External hazards

Traffic ☐	Machinery ☐	Equipment ☐	Processes ☐	Terrain ☐

Miscellaneous hazards

Noise ☐	Animals ☐	Insects ☐	Disease organisms ☐	Ionizing radiation ☐	Non-ionizing radiation ☐

Other Hazards

Equipment Required

Respiratory Protection	SCBA ☐	ABA ☐	SAR ☐	PAPR ☐
Cartridge Respirator	Full face ☐	Half mask ☐	Cartridge ↓	
Organic Vapor ☐	Acid Gas ☐	Organic vapor/Acid gas ☐	Ammonia ☐	Multigas ☐
N95 ☐	P95 ☐	P100 ☐	Other	

Personal Protective Clothing & Equipment

Hard hat ☐	Safety shoes/boots ☐	Safety glasses ☐	Goggles ☐	Faceshield ☐
Coveralls ☐	Leather gloves ☐	Ear plugs ☐	Ear muffs ☐	Splash suit ☐
Chemical gloves ☐	Chemical boots ☐	Welding hood ☐	Welding gloves ☐	Welding jacket ☐
Lighting	Flashlight ☐	Handlight ☐	Light sticks ☐	Cord light ☐	Portable light ☐
Electric Power	Power connection ☐	Generator ☐	GFCIs ☐	Cords ☐

Ventilation	CFM Required	Ventilator # & CFM rating	Ducts ☐	Elbows ☐	Connectors ☐	Saddle/Tank vent ☐

Entry Equipment

Ladder ☐	Body harness ☐	Personal alert ☐	Emergency signal ☐
Communications ☐	Retrieval device ☐	Tripod ☐	Anchor point ☐

Rescue equipment must be available for rescue crew ☐

Other Equipment

Alternate Procedure Entry - ☐	Reclassified - ☐	Permit canceled (date & time)

Confined Space Survey Form

Date of Survey		Confined Space #		Permit Required?	Yes ☐ No ☐

Location of Space

Description of Space

Possible Atmospheric Hazards: Oxygen; deficiency ☐ enrichment ☐ Flammable ☐ Toxic ☐
Specific hazard for flammable and/or toxic:
Comments:

Possible Content Hazards: Previous contents ☐ Content fill or removal ☐ Shifting contents ☐ Fluid levels ☐ Dust ☐
Comments:

Potential Energy: Electrical ☐ Hydraulic ☐ Pneumatic ☐ Mechanical ☐ Fire control system ☐
Comments:

Environment in the Space
Slippery surfaces ☐ Ambient temperature high or low ☐ Surface temperatures high or low ☐ Noise ☐
Comments:

Configuration of Space
Interior shape & slope ☐ Low overhead clearance ☐ Drop offs ☐ Complex layout ☐ Stability ☐ Structural integrity ☐
Comments:

External Hazards: Traffic ☐ Machinery ☐ Equipment ☐ Processes ☐ Terrain ☐
Comments:

Other Hazards: Animals ☐ Insects ☐ Biological organisms ☐ Non-ionizing radiation ☐ Ionizing radiation ☐
Comments:

Confined Space			Permit Required Confined Space		
Can be bodily entered?	Yes ☐	No ☐	Hazardous Atmosphere?	Yes ☐	No ☐
Limited or restricted entry?	Yes ☐	No ☐	Potential for engulfment?	Yes ☐	No ☐
Not designed for continuous human occupancy?	Yes ☐	No ☐	Internal configuration hazard?	Yes ☐	No ☐
			Other serious safety hazard?	Yes ☐	No ☐

Reasons for entering space & typical activities

Who usually enters space? Maintenance ☐ Production ☐ Contractors ☐ Other

Frequency of entry Select			Number of entry points #		
Eligible for Alternate Procedure?	Yes ☐	No ☐	Eligible for Reclassification?	Yes ☐	No ☐

External connections to space
Comments:

Survey completed by

CONTRACTOR CONFINED SPACE ENTRY

INQUIRY

Job Description: Plant:

Potential Confined Space Hazards:

Special Rules/Requirements:

Emergency Procedures:

	YES	NO
Does Contractor exhibit confined space entry competence, i.e. experience in this type of work, written procedures, testing equipment, etc?		
Is Contractor aware of requirements of applicable state/federal standards?		
Does Contractor confirm that assigned employees are trained in confined space entry procedures? Is Contractor equipped to handle emergencies/rescue?		

Authority	Contractor
Title	Title
Date	Date

(PRINT NAME AND SIGN)

HOT WORK CONTROL PERMIT

(CUTTING - HEATING - WELDING - ETC.)

Date: _____ Time Started: _____ Completed _____

Area: _____
(Building - Floor - Department - Equipment)

Work to be done: _____

_____

To be Supervised by: _____

Fire watch (if required): _____
(Name/Badge No.)

- Safeguards required ----------See Reverse
- Flammable gas indicator test needed ---------- Yes ☐ No ☐

  Result _____
- Confined Space ---------- Yes ☐ No ☐
- Permit expires _____ Date _____ Time _____

Signed: _____
(Individual responsible for issuance of permit)

FINAL FIRE PREVENTION CHECK

Work area and all adjacent areas to which sparks and heat might have spread (including floors above and below and on opposite sides of walls) were inspected 30 minutes after work was completed and the area was found "fire-safe".

Signed: _____
(Permit Issuer)

_____
(Date and Time)

_____
Production Supervisor (Date and Time)

_____
Maintenance Supervisor (Date and Time)

SAFEGUARDS

FIRE EQUIPMENT

- ☐ Sprinkler System in service
- ☐ Fire Extinguisher required. NQ/Type
- ☐ Hose Line (charged)

WITHIN 35 FEET OF WORK

- ☐ Floors swept clean of combustibles
- ☐ Combustible floors wet down or shielded with damp sand, metal or other non-combustible materials
- ☐ Remove combustible material or flammable liquids, if possible
- ☐ Non-removable combustibles and flammable liquids shall be protected with covers, guards or non-combustible shields
- ☐ All wall and floor openings covered
- ☐ Covers suspended beneath work to collect sparks

WORK ON ENCLOSED EQUIPMENT

(Tanks, containers, ducts, dust collectors, etc.)

- ☐ Equipment cleaned of all combustibles
- ☐ Containers purged of flammable vapors/safe atmosphere verified
- ☐ Confined Space Entry Permit Issued

FIREWATCH

- ☐ If required, the firewatch will continue until 30 minutes after the work is completed
- ☐ No firewatch required

I have inspected the work and confirm that the above checked safeguards have been implemented to prevent fire or explosion.

Signed _____

Permit Issuer

Date _____ Time _____

(SAMPLE ONLY)

CONFINED SPACE HAZARD IDENTIFICATION/EVALUATION

FACILITY: Beverage 2-Pc.

CONFINED SPACE: Washer – Wash Tank LOCATION: Front End DATE: November 1992

	IDENTIFIED/POTENTIAL HAZARDS	TESTING	PROTECTIVE EQUIPMENT	SPECIAL REQUIREMENTS
1.	Oxygen Deficiency	MSA Passport – General	None	Prior to Entry
2.	Combustibles	MSA Passport – Natural Gas	None	Prior to Entry
3.	Toxics (Acid/Caustic)	Pump/Tube – Acid Mist – Litmus Paper – Residue	Goggles, gloves, acid gas respirator	Neutralize tank(s)
4.	Electrical Energy	Cycle control circuits to verify isolation	None	Lockout drive motor Disconnect breaker
5.	Chemical Supply	Cycle control circuits to verify isolation	None	Lockout pump motor breaker Close valves and blank lines
6.	Steam Supply	Cycle control circuits to verify isolation	None	Lockout steam line valves
7.	Hot Surfaces/Temperature	Check air/surface temperatures	Protective suit, gloves, and goggles	Cool down cycle and ventilate

CONFINED SPACE HAZARD IDENTIFICATION/EVALUATION

FACILITY: Beverage 2-Pc.

CONFINED SPACE: Washer – Wash Tank   LOCATION: Front End   DATE: November 1992

	IDENTIFIED/POTENTIAL HAZARDS	TESTING	PROTECTIVE EQUIPMENT	SPECIAL REQUIREMENTS
8.	Wet Interior Surfaces	None	Protective clothing, boots, gloves, and goggles	Drain and ventilate
9.	Head Contact (Tight Quarters)	None	Bump Cap	None
10.	Inadequate Lighting	None	Class I Division I Portable Lighting	Ground fault circuit interrupter in line
11.	Power Failure	None	Flash Lights	Portable generator or suspend operations
12.	Electrical Fault – Power Tools	Continuity circuit tester	Double Insulated Tools	G.F.C.I. Portable Station
13.	Welding Hazards	Check welding rod MSDS for metal fume (Ni, Cr, Fe, Mn) generation Chlorinated organics may produce Phosgene gas when heated	Complete welder protective gear; issue Hot Work Permit; respirator – metal fume cartridge or air sup-plied	Provide ventilation at minimum of 1000 CFM/ Welder

RESCUE/RETRIEVAL INCIDENT REPORT

NOTICE: THIS INFORMATION MAY BE PUBLISHED ON ASSE'S WEBSITE, NEWSLETTER, ETC. AS A LEARNING TOOL FOR OTHER RESCUERS.

*RESCUE TEAM:	DATE OF INCIDENT:
*CITY/STATE:	TIME OF INCIDENT:
*NAMES OF RESCUERS:	*TOTAL RESCUE TIME: (TEAM ARRIVAL TO VICTIM EVAL) TYPE OF INCIDENT LOCATION:
SPECIAL CHALLENGES, WEATHER CONDITIONS, ETC.:	POSSIBLE CAUSE OF INCIDENT/INJURY:
REASON FOR VICTIM BEING ON SITE: *(work, inspection, unauthorized, etc.)*	BRIEFLY DESCRIBE PATIENT'S INJURIES:

☐ **CONFINED SPACE** ☐ **ELEVATED** ☐ **BELOW GRADE** ☐ **OTHER:**

RESCUE TECHNIQUES USED:

- ☐ THIRD-MAN PICK-OFF
- ☐ LINE TRANSFER
- ☐ SINGLE-LINE VERTICAL LITTER/SKED LOWER
- ☐ SINGLE-LINE HORZ LITTER/SKED LOWER
- ☐ DOUBLE-LINE LITTER LOWER
- ☐ DOUBLE-LINE LITTER LOWER W/ATTENDANT
- ☐ HARNESS LOWER
- ☐ OTHER:

HORIZONTAL HAULING SYSTEM:

- ☐ Z-rig (3:1)
- ☐ Piggy-back (4:1)
- ☐ Other: _____

SIMPLE M/A HAULING-LOWERING:

- ☐ Z-rig (3:1)
- ☐ Piggy-back (4:1)
- ☐ Other: _____

Other:

- ☐ Compound M/A _____
- ☐ Traverse
- ☐ Other: (list below)

DESCRIBE INCIDENT: (OR ATTACH REPORT, SKETCHES, OR PHOTOS OF INCIDENT)

KEY LESSONS LEARNED FROM THIS INCIDENT...

*REPORTED BY:	*TITLE:
*PHONE:	*E-MAIL:

*OPTION NOTE: PROVIDED INFORMATION WILL NOT BE MADE PUBLIC AT THE REQUEST OF THE REPORTING ENTITY - AS A LEARNING TOOL, ONLY THE VERY BASIC FACTS OF THE INCIDENT WILL BE MADE PUBLIC. INITIAL HERE IF NAMES AND LOCATIONS ARE TO BE WITHELD_____.