Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries

API STANDARD 2217A
FOURTH EDITION, JULY 2009

Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries

Downstream Segment

API STANDARD 2217A
FOURTH EDITION, JULY 2009

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety datasheet.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Foreword

Because inert gas blankets provide protection while introducing significant hazards, many facilities operate on the principle, “If inert entry is not necessary, use another method.” Where inert entry is to be conducted, this standard provides guidelines to aid employers in preparing specific procedures for working safely in inert confined spaces. API 2217A guidance is intended to represent good practice as required by experienced owner facilities and practiced by specialist service companies. This standard recognizes that because of its unique nature, the hazards and requirements for inert entry are generally greater than for “normal” permit-required confined space (PRCS) entry. The emphasis is on safe entry work practices and equipment (such as multiple source respiratory protection) which are not necessarily addressed in regulations. Thus, API 2217A is not a compliance document although a number of OSHA regulatory requirements are incorporated by reference. OSHA regulations are available directly from the internet at www.osha.gov. Facilities outside the United States should review relevant legal requirements in their jurisdiction.

In May 1971, API published Petroleum Safety Datasheet (PSD) 2211, *Precautions While Working in Reactors Having an Inert Atmosphere*. In 1987, API Publication 2217A, *Guidelines for Work in Inert Confined Spaces in the Petroleum Industry*, expanded on the 1971 safety datasheet. A Second Edition appeared in September 1997. The Third Edition, API Standard 2217A, *Guidelines for Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries*, updated prior guidance based on both experience and regulations. That revision included input from both owners and inert entry contract service providers. This Fourth Edition carries forward content from the Third Edition, with increased emphasis on safety for nonentrants, lack of inert gas warning properties and updated references. The essential elements of this publication are based on current industry safe operating practices, consensus standards and regulations. Federal, state, and local regulations or laws may contain additional requirements that must be taken into account.

Several sections of API 2217A draw attention to the insidious nature of inert gas atmospheres. Oxygen-deficient inert atmosphere gases provide no warning of their deadly nature. Those supervising inert entry are charged with providing hazard information and warning to those working near the inert “hot zone.” Special care must be taken to prevent unplanned inert entry and ill-conceived rescue attempts, and administrative safeguards are outlined. Section 8.2 specifically addresses the concern for safety of nonentry personnel which is integrated throughout this standard.

Contents

Page

Tables

Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries

1 Scope and Special Considerations

1.1 Scope

This standard provides guidelines for safely entering and working in and near confined spaces that have inert atmospheres. API 2217A applies to confined spaces that have been intentionally purged with an inert gas until:

— the oxygen level in the vapor space is too low to support combustion, and

— any gases in or flowing out of the confined space are below flammable or reactive levels.

Typical inert entry work in the petroleum and petrochemical industry includes work to service or replace catalyst in reactors.

1.2 Special Considerations

For conformance with this standard the targets set for initiation of inert entry are less than 10 % lower flammable limit (LFL) and no more than 50 % of minimum oxygen level (O_2) for combustion with a maximum of 4 % O_2. If after entry the oxygen level increases to 5 %, the workers shall be removed from the inerted space. Because of these low oxygen levels, special considerations are necessary for entry into confined spaces with inert atmospheres. These require additional safe work practices which supplement (not replace) established regulatory requirements as exemplified in the United States by the OSHA permit-required confined spaces (PRCS) and personal protective equipment (PPE) standards.

Inert confined spaces are, by definition, always PRCS. But, while inert atmospheres in confined spaces are indeed "immediately dangerous to life or health (IDLH)," the hazard is much more severe and immediate than the often used NIOSH "30-minute escape" definition. The sense of smell cannot detect either oxygen or nitrogen, so without instruments there are no warning properties.

Total loss of respiratory protection in an inert atmosphere can cause virtually immediate incapacitation and result in rapid asphyxiation. Unprotected exposure to these hazards results in impairment of the ability to escape unaided (self-rescue) and the risk of death. Because of this severity, stringent requirements are placed on respiratory protection (triple-redundant air supply using equipment approved by NIOSH or equivalent). Special precautions are needed to prevent entry and potential asphyxiation of nonrescue personnel attempting rescue without proper equipment. [1]

The fundamental exposure protection and management concepts presented should be applicable to most situations that involve inert atmospheres in confined spaces in the petroleum and petrochemical industries. The specific work areas of greatest concern are the inert confined space itself and the areas at or near the entrance to, or exhaust from, the inerted space. In the refining and petrochemical industries planned inert entry work activities often relate to catalytic reactor servicing. Where deliberate entry is made into other intentionally inerted confined spaces such as found in tanks, large diameter pipes or in maritime service the same principles should be applicable (with hazard evaluations and adjustments as required for specific conditions and activities).

---

[1] From CSB Bulletin 2003-10-B, *Hazards of Nitrogen Asphyxiation*: "Every year people are killed by breathing 'air' that contains too little oxygen. Because 78 percent of the air we breathe is nitrogen gas, many people assume that nitrogen is not harmful. However, *nitrogen is safe to breathe only when mixed with the appropriate amount of oxygen*. These two gases cannot be detected by the sense of smell. A nitrogen enriched environment, which depletes oxygen, can be detected only with special instruments. If the concentration of nitrogen is too high (and oxygen too low), the body becomes oxygen deprived and asphyxiation occurs."

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. The Bibliography lists other useful sources of relevant information.

API Standard 2220, *Contractor Safety Performance Process*

API Recommended Practice 2221, *Contractor and Owner Safety Program Implementation*

ANSI [2]/AIHA [3] Z88.2, *Practices for Respiratory Protection*

ANSI/ASSE [4] Z117.1, *Safety Requirements for Confined Spaces*

ANSI/ASSE Z244, *Control of Hazardous Energy—Lockout/Tagout and Alternative Methods*

ANSI/ACC [5] Z400.1, *Hazardous Industrial Chemicals—Material Safety Data Sheets—Preparation*

CGA G-7 [6], *Compressed Air for Human Respiration*

CGA Safety Alert SA-16, *Safety Alert—Blended Breathing Air Fatalities*

NFPA 69 [7], *Explosion Prevention Systems*

OSHA 29 *CFR* Part 1910.132 [8], *Personal Protective Equipment*

OSHA 29 *CFR* Part 1910.134, *Respiratory Protection*

OSHA 29 *CFR* Part 1910.146, *Permit-Required Confined Spaces*

OSHA 29 *CFR* Part 1910.147, *Control of Hazardous Energy (Lockout/Tagout)*

OSHA 29 *CFR* Part 1910.1000 (and following) Subpart Z, "Toxic and Hazardous Substances"

OSHA 29 *CFR* Part 1910.1200, *Hazard Communication*

---

2 American National Standards Institute, 25 West 43rd Street, New York, New York 10036, (Tel.) 212-642-4900, www.ansi.org. Most ANSI publications are available from ANSI at http://webstore.ansi.org or the secretariat organization indicated or from www.global.ihs.com.

3 American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, Virginia 22031, (Tel.) 703-849-8888, (Fax) 703-207-3561, www.aiha.org.

4 American Society of Safety Engineers, 1800 East Oakton Street, Des Plaines, Illinois 60018, www.asse.org.

5 American Chemical Council, 1300 Wilson Blvd., Arlington, Virginia 22209, (Tel.) 703-741-5000, (Fax) 703-741-6050, www.americanchemistry.com.

6 Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, Virginia 20151-2923, (Tel.) 703-788-2700, www.cganet.com.

7 National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-7471, www.nfpa.org.

8 U.S Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC 20210, www.osha.gov.

3 Definitions

For the purposes of this publication, the following definitions apply.

3.1
confined space
A space that:

a) is large enough and so configured that an employee can bodily enter and perform assigned work;

b) has limited or restricted means for entry or exit (e.g. tanks, vessels, reactors, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and

c) is not designed for continuous employee occupancy.

3.2
entry supervisor
The person responsible for determining if acceptable entry conditions are present at a confined space where entry is planned, for authorizing entry, overseeing entry operations, and for terminating entry. The duties of entry supervisor may be passed from one individual to another during the course of an entry operation. These responsibilities also may be transferred between the owner and contractors.

3.3
fit testing
The process of evaluating a respirator's sealing characteristics for a specific user and the respirator's performance for the user under controlled conditions. For inert entry, fit testing of respiratory protection equipment shall include the specific equipment which will be used for entry as described in 7.2 n).

3.4
hazard
A situation or inherent chemical or physical property with the potential to do harm (flammability, oxygen deficiency, toxicity, corrosivity, stored electrical, chemical or mechanical energy).

3.5
hazardous atmosphere
An atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self rescue, injury, or acute illness from oxygen deficiency or enrichment; flammability or explosion potential; or toxicity [as set forth in OSHA 29 *CFR* 1910.146(b)].

3.6
hot zone
The area around the entrance to the inerted confined space most likely to be affected by effluent gases; sometimes called the "restricted area."

3.7
immediately dangerous to life or health
IDLH
The traditional NIOSH definition for published IDLH values is the maximum concentration of an air contaminant from which one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects. Total loss of respiratory protection in an inert atmosphere can cause virtually immediate impairment and result in rapid asphyxiation. While inert atmospheres are indeed "IDLH" by NIOSH criteria, the hazard is much more immediate and severe.

3.8
inert entry
Entry into a confined space with an inert atmosphere starts as soon as any part of the entrant's body breaks the plane of an opening into the space and triggers the need for rescue capability. "Entry" includes all subsequent activities in the inert confined space.

3.9
inerting
The process of eliminating the potential for a flammable atmosphere by using an inert gas such as nitrogen or carbon dioxide to displace oxygen required for ignition.

3.10
lower flammable limit
LFL
The minimum concentration of a vapor in air (or other oxidant) below which propagation of flame does not occur on contact with an ignition source. The LFL is usually expressed as a volume percentage of the vapor in air. Sometimes called lower explosive limit (LEL). In popular terms, a mixture containing a percentage of flammable vapor below the LFL is too "lean" to burn.

3.11
material safety datasheet
MSDS
Written or printed material concerning a hazardous chemical and prepared in accordance with OSHA 29 *CFR* 1910.1200, ANSI Z400.1 or comparable international standard. An MSDS provides data on physical properties, safety, fire, and health hazards for a particular chemical, mixture or substance.

3.12
oxygen-deficient atmosphere
An atmosphere in which the oxygen content is below that needed for normal human function without impairment. For inert entry, the typical oxygen content (below 5 % in inert entry situations) is very much less than the oxygen-deficient definition often used (e.g. by OSHA) of "atmosphere containing less than 19.5 percent oxygen by volume" (the OSHA limit is appropriate for areas outside the "hot zone"). Inert entry requires much lower oxygen concentration percentages to provide a working environment minimizing fire hazards by maintaining the oxygen level low enough to prevent combustion.

3.13
permit
An entry permit is a written or printed document provided by the employer or authorizing entity to allow and control entry into a permit space which contains the information specified in 6.2 [and OSHA 29 *CFR* 1910.146(f) or equivalent].

3.14
pyrophoric
A material (e.g. iron sulfide, certain catalysts or certain carbonaceous materials) that, when exposed to air, can spontaneously oxidize and heat, providing a source of ignition if a flammable vapor/air mixture is present.

3.15
risk
The probability and consequences of exposure to a hazard, hazardous environment or situation which could result in harm.

3.16
risk assessment
The identification and analysis, either qualitative or quantitative, of the likelihood and outcome of specific hazard exposure events or scenarios with judgements of probability and consequences.

3.17
risk-based analysis
A review of potential needs based on a risk assessment.

3.18
upper flammable limit
UFL

The maximum concentration of a flammable vapor in air (or other oxidant) above which propagation of flame does not occur on contact with an ignition source. The UFL is usually expressed as a volume percentage of the vapor in air Sometimes called the upper explosive limit (UEL). In popular terms, a mixture containing a percentage of flammable vapor above the UFL is too "rich" to burn.

4 Administrative Controls

4.1 Written Procedures and Guidelines

Each employer whose employees perform confined space work in inert atmospheres shall establish and maintain written procedures and a system of authority and responsibility for controlling work in and near these confined spaces.

As a minimum, the written procedures shall:

a) Be approved by facility management and identify who will authorize inert confined space entry.

b) Require that the entrants, entry supervisor, and rescuers be identified (see 4.2 and 6.2).

c) Provide for a written confined space entry permit specifically addressing inert entry.

d) Require all involved personnel to be trained in the hazards present in confined spaces with inert atmospheres.

e) Require all involved personnel to be trained in the use of proper equipment, procedures, and safeguards for their protection.

f) Establish a procedure to ensure that training for all personnel is current before the start of each job.

g) Establish the requirements for a prejob planning conference that involves representatives of those plant operations affected by the entry to review the written procedures, specific work to be performed, supervisory responsibilities, potential hazards, and safeguards to be followed. Prejob planning shall involve personnel responsible for the overall work on site during the inert entry and those who will be leading the inert entry work. This is often done in "face-to-face" meetings among the people involved.

h) Establish appropriate emergency action plans (see 7.7 and 7.8).

i) Establish criteria to restrict access to the confined space and the surrounding "hot zone" area to prevent unauthorized entry into the confined space or unprotected exposure to effluent.

4.2 Entry Supervisor

Each inert entry shall have an entry supervisor designated by the employer. Before entry begins, the entry supervisor identified on the permit shall sign the entry permit to authorize entry. This safe work practice is also a legal requirement (in the United States). OSHA requires the employer to designate an entry supervisor to supervise work that involves entering PRCS, which includes those with inert atmospheres. The legal requirements are generally consistent with industry practice. In the United States, OSHA 29 *CFR* 1910.146(J) requires the employer to ensure that each entry supervisor:

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

b) Verifies by checking that the appropriate information has been recorded 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 and posting the permit and allowing entry to begin.

c) Terminates the entry and cancels the permit when:

   1) a condition that is not allowed under the entry permit arises in or near the permit space;

   2) the entry operations covered by the entry permit have been completed.

d) Verifies that rescue services are available, that the means for summoning them for timely response are operable, and that potential rescue procedures are planned to assure proper equipment needed for the specific job have been identified, inspected and staged near the entry location.

e) Removes unauthorized individuals who enter or who attempt to enter the permit space during entry operations.

f) Determines, whenever responsibility for a PRCS 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.

g) Verifies that prohibition of access to the inert space is secure when work is not in process or when timely emergency response is not available; and that areas where inert gas is vented are barricaded/cordoned off.

The duties of entry supervisor may be passed from one individual to another during the course of an entry operation. These responsibilities also may be transferred between the owner and contractors. For instance, when the owner meets the conditions of vessel preparation, the entry supervision may be turned over to the contractor selected for the job. The owner certifies that the vessel is approved for turnover to a contractor screened for this specialty work and who represents themselves as having people and equipment to safely perform the task. The transferable role of "entry supervisor" should be defined by agreement to establish which party is responsible for the people who are actually performing the entry work. A means should be established to identify and document the person who is serving as entry supervisor. Personnel involved with the entry should be informed when a different person assumes the entry supervisor role.

4.3 Contractors

If a contractor is utilized to perform work in inert confined spaces, the contractor shall certify to the owner/operator of the facility that the contractor conforms with the written procedures and guidelines specified in Section 4 as well as all regulatory requirements relevant to the work to be performed, and that the personnel to be used have been provided an overview of the job, relevant training and documented experience. See API 2220 and API 2221 for guidance on implementing a contractor safety and health program.

The owner/operator of the facility shall advise contractors of the potential hazards associated with the atmosphere being entered. The owner and the contractor shall agree on whatever special precautions are required.

The owner/operator of the facility shall establish the necessary procedures and system of authority to:

a) control those conditions in and around the inert confined space entry within each party's realm of responsibility;

b) monitor and audit the inert confined space work performed by contractors on a continuing and periodic basis;

c) monitor continuously the conditions (specifically including inert gas flow, oxygen content, flammability, and temperature) in the inert confined space;

d) monitor changes in conditions and establish an action plan (such as withdrawal of workers from the vessel) for implementation when changes in the reactor environment are detected.

If a specialty contractor is actually controlling the entry atmosphere, then they shall provide continuous monitoring and the owner may audit the performance of this responsibility. Where process instrumentation is available, it may provide a means for the owner to conduct supplemental monitoring of conditions (such as temperature) in the inert confined space.

5 Hazards and Risks

5.1 Concept of Hazard vs Risk

Hazards are situations or properties of materials with the inherent ability to cause harm. Oxygen deficiency is an inherent hazard condition of inert atmospheres. Flammability, toxicity, corrosivity, stored chemical or mechanical energy all are hazards associated with various industrial materials or situations.

Risk requires exposure. A hot surface or material can cause thermal skin burns or a corrosive acid can cause chemical skin burns, but these can occur only if there is contact exposure to skin. Oxygen deficiency can cause suffocation only if one is exposed to the inert atmosphere as a source for breathing. There is no risk when there is no potential for exposure.

Determining the level of risk involves estimating the probability and severity of exposure events that could lead to harm, and the resulting consequences. While the preceding examples relate hazards to the risk to people, the same principles are valid for evaluating property risk. For instance, hydrocarbon vapors in a flammable mixture with air can ignite if exposed to a source of ignition, resulting in a fire which could damage property.

To ensure the safety of personnel, the hazards of working in and near inert confined spaces must be recognized and communicated to those potentially at risk. Tool-box meetings, job safety analyses (JSAs) and MSDS reviews are some approaches used. This need gains importance because inert gases have no warning properties. Table 1 lists some of the hazards encountered in inert confined spaces, and the type of exposure events which can result in risk. For inert entry, these hazards always include oxygen deficiency and may include (but are not limited to) the items in Table 1.

Experience and implementation of proper procedures for preparation and conducting work all contribute to risk reduction.

Table 1—Inert Entry Hazards and Potential Risks

Hazard	Exposure Event	Resulting Risk
Oxygen deficiency (always present)	Loss of breathing air	Asphyxiation
Flammable materials	Oxygen intrusion into inert work space Oxygen intrusion into flare lines during purge	Fire or explosion—injury or property damage
Pyrophoric materials	Oxygen intrusion	Introduces ignition source—injury or property damage
Physical hazards	Slip, trip, fall, dropped upon	Physical injury, disconnection/loss of breathing air
	Engulfment	Physical injury, crushing, loss of breathing air
Pressure buildup	Pressure released by movement of material below workers	Physical injury, forceful expulsion of workers from vessel
Toxic substances	Skin or respiratory exposure	Acute or chronic illness
Noise	Excess of acceptable levels	Hearing loss

5.2 Oxygen Deficiency

Oxygen deficiency is the principal hazard present when persons perform inert entry. The confined space to be entered is purged with oxygen-free inert gas to prevent fire and explosion hazards and will typically have an oxygen-deficient atmosphere between 0 % and 4 % for initiation of entry with 5 % maximum. If after entry the oxygen level increases to 5 %, the workers shall immediately be removed from the inerted space. Without respiratory protection, exposure to this atmosphere (which has no warning properties) can lead to rapid asphyxiation and death.

5.3 Fires and Explosions

The atmosphere within a confined space is rendered inert by reducing the oxygen content and thus eliminating possibility of fires and explosions. The percentage of oxygen in the inert atmosphere is typically kept below 50 % of the limiting oxygen concentration specified in NFPA 69 (see NFPA 69, Table C-1). For conformance with this standard, targets set for initiation of inert entry are less than 10 % LFL and less than 50 % of the minimum O_2 for combustion, with a maximum of 4 % O_2. When measurable LFL within the equipment of the effluent gas is between 0 % and 10 %, repeat measurements should be taken to ensure that the % LFL is stable or decreasing and that the instruments are calibrated on a gas appropriate for measuring the effluent flammables. Further monitoring requirements are noted in 6.10.

Personnel shall immediately be removed from the inert confined space when the following conditions exist:

— O_2 at or above 5 % volume,

— flammability reaches 10 % LFL or greater (if hot work is being performed in the inerted space),

— flammability reaches 20 % LFL or greater (where cold work is being performed),

— temperature in the inerted space increases 5 °F (3 °C) in 15 minutes (see 6.10).

Caution—Special monitoring equipment is typically required to monitor flammability limits accurately at reduced oxygen levels (typical catalytic instruments do not provide reliable readings below 10 % O_2). See manufacturer's specifications for guidance.

This standard specifically recommends against entry into spaces using a concept of "over UFL" (e.g. "too rich to burn") for protection against ignition.

Some practitioners specify 0 % O_2 and 0 % LFL before permitting entry.

The procedure used to render the atmosphere inert should be continued at a rate sufficient to prevent oxygen from entering the space for as long as work is conducted in the space. Purging may also be required to prevent a spontaneous combustion of pyrophoric materials. Contamination of the confined space with air may be caused by leaks into the space or the use of a contaminated purge gas (see 6.4). Prior to purging, check purge gas source and composition. The oxygen content of the confined space shall be continuously monitored (see 6.10). Even though the mixture inside the inert confined space is not flammable (because of the reduced oxygen content), effluent gas leaving the space from an open manway may mix with outside air and result in a fire and/or explosion hazard for personnel outside the space. For many catalysts, an increase in carbon monoxide and/or temperature may indicate oxygen intrusion causing spontaneous combustion of pyrophoric material.

Whenever personnel are working near the point of entrance, steps should be taken to assure the atmosphere at that point is not a hazardous atmosphere, or that such personnel are properly protected. Workers near any openings in the inerted confined space releasing effluent can be subject to low oxygen levels.

For a fire or explosion to occur, there must be an adequate amount of oxygen, the correct amount of vapors mixed with the air, and an ignition source. For the fire or explosion hazard to exist, the mixture of flammable vapor(s) and air must be within the flammability limits for the particular vapors (see Figure 1). Any mixture of vapor and air between the upper and lower flammability limits will therefore ignite when exposed to an ignition source.

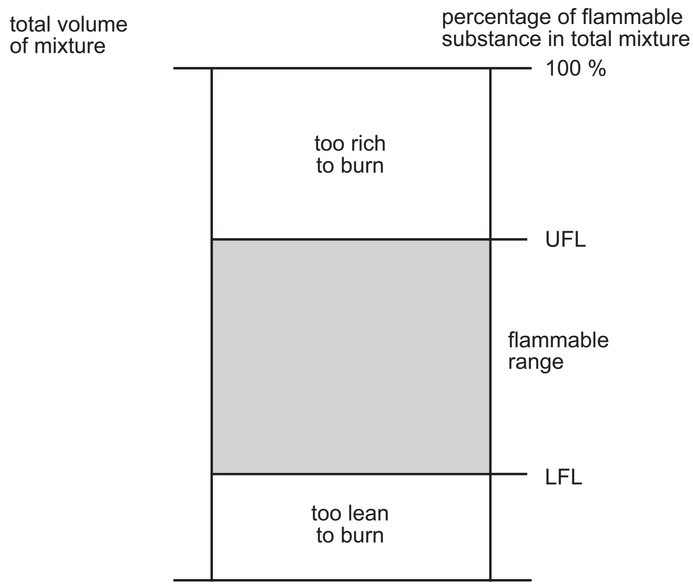

Figure 1—Depiction of Flammable Limits

The flammability limits of many hydrocarbon vapors range from 1 % to 10 % vapor-to-air mixture; however, the flammability limits of oxygenated materials (alcohol and glycols) and hydrogen are much wider. Table 2 provides data on flammability ranges for some typical materials.

Pyrophoric materials can promote fires. These substances ignite spontaneously when they are exposed to air or oxygen. For example, iron sulfide can be found on some vessel surfaces and within certain unregenerated catalysts including hot "clinkers" removed from a reactor vessel. Section 5.4 discusses pyrophoric hazards.

5.4 Pyrophoric Hazards

During normal operations, certain catalysts often accumulate pyrophoric deposits of iron and/or sulfur from the hydrocarbons that pass through the catalyst bed. In some cases, when the catalyst is exposed to air, or another source of oxygen, the pyrophoric deposits will begin to generate heat due to oxidation. If allowed to continue, this could generate a potential ignition source. Inerting is one method used to reduce or minimize this hazard. Even with slow oxidation there can be products of combustion which may be hazardous to people working outside the inert confined space. Work practices should protect personnel from exposure to the effluent gases.

Spent catalyst removed from reactors should be evaluated for pyrophoric potential while on site and when reviewing potential hazards during shipping.

Heated storage tanks which have operated with an oxygen-deficient atmosphere may also accumulate pyrophoric iron sulfide or pyrophoric carbonaceous deposits. Deliberately maintaining 3 % to 5 % O_2 in an inert blanket is generally considered sufficient to slowly oxidize pyrophorics and is used as prevention against their accumulation. This is also a level which allows slow oxidation (and heat release) to begin when it may not be desired.

Table 2—Flammable Range and Limiting Oxygen Concentrations for Example Substances

Substance	LFL % vol	UFL % vol	Minimum O_2 % vol for Combustion in N_2
Data source	USBM Bulletin 627		NFPA 69, Appendix C-1
Hydrogen	4	75	5
Hydrocarbons			
Benzene	1.3 (100 °C)	7.9 (100 °C)	11.4
Ethyl benzene	1.0 (100 °C)	6.7 (100 °C)	9.0
Toluene	1.2 (100 °C)	7.1 (100 °C)	9.5
NOTE The published values for the following hydrocarbon product mixtures are examples			
Gasoline	1.3	7.1	12
Kerosene	0.7	5.0	10 (at 150 °C)
Jet fuel (JP-4)	1.3	8.0	11.5
Petrochemicals			
Acetone	2.6	12.8	11.5
Carbon disulfide	1.3	50.0	5
Ethyl alcohol	3.3	19.0	10.5
Ethyl ether	1.9	36.0	10.5
Hydrogen sulfide	4.0	44	7.5
Propylene oxide	2.8	37	7.8
NOTE The ranges for LFL to UFL are examples for the substances in air. Minimum oxygen concentrations are for the substances in nitrogen. Except where noted, both sets of data are for ambient temperature at sea level. Data for specific materials may be found in MSDSs or other references.			

5.5 Physical Hazards

Physical hazards that may exist in inert confined spaces, in the work area associated with the inert entry work, or both include (but are not limited to) the following.

5.5.1 Potential Physical Hazards within the Inert Confined Space

The following hazards are unique or most likely inside the inert confined space.

a) Catalyst beds inside a reactor may pose particular hazards, including:

1) catalyst engulfing workers,

2) catalyst beds not supporting workers’ weight,

3) buildup of pressure under a catalyst bed causing the crust to rupture violently,

4) catalyst buildup attached to walls falling on entrants,

5) clinkers deep inside beds remaining hot.

b) Elevated temperatures increasing physical stress on entrants.

c) Discharge of steam, high-pressure air, water, hydrocarbons, or chemicals into the confined space as a result of inadequate isolation of the space from potentially hazardous materials (by blinding or disconnecting and blanking all lines connected to the space), with the exception of the inert gas purge line.

d) Unintentional operation of electrical or mechanical equipment allowed by inadequate isolation and lockout/tagout of equipment.

e) Restrictive work space.

f) The presence of radioactive materials or other radiation sources (see 6.7).

g) Sharp or abrasive objects/surfaces on trays, lugs, brackets, and internal supports.

h) Failure of internal structures within the inert confined space which may not support the worker(s) weight.

5.5.2 Potential Physical Hazards in Associated Areas Outside the Confined Space

The following hazards can exist outside the confined space:

a) cluttered or obstructed work space caused by poor housekeeping;

b) congestion at the job site caused by life-support hoses, breathing-air systems and the presence of standby attendants, rescue and emergency response equipment;

c) weather enclosures around entry points to an inert blanketed vessel can function as a partially confined space causing accumulation of inerted atmosphere leading to oxygen deficiency or an accumulation of flammable or toxic effluent material;

d) the presence of standing water, increasing the risk of electrocution or slipping/falling;

e) presence of noninvolved personnel in the “hot zone;”

f) activities related to catalyst loading/unloading (e.g. forklifts, trucks, lifting equipment, loads in motion).

5.5.3 Potential Hazards Affecting Work Both Inside and Outside the Confined Space

The following hazards can exist either inside or outside the confined space:

a) insufficient levels of illumination, improper lighting, glare, and shadows;

b) noise exceeding acceptable levels;

c) use of communications or other equipment (such as video inspection equipment) that is not intrinsically safe or not approved for service in or near the inert confined space;

d) adverse weather conditions such as lightning and high winds.

5.6 Hazardous Chemicals

Hazardous chemicals can cause irritation, injury, immediate or delayed illness, or death depending upon the characteristics of the chemicals, the concentration, route of entry and magnitude of exposure, and individual susceptibility. The possible routes of exposure depend on the characteristics of the substance and the nature of the exposure. They can affect human tissue at the point of contact or at body parts remote from the point of contact.

Irritants cause minor or transient (but possibly painful) injuries that heal without scars and produce no known aftereffects.

Many hydrocarbons and solvents are irritants; however, at higher exposure levels, hydrocarbons and solvents can cause central nervous system effects including dizziness, headaches, and confusion. Corrosives destroy tissue and leave permanent scars. Examples of corrosives are sulfuric acid and caustic soda (NaOH). Acutely toxic substances are those that by a single dose or short-term exposure may cause symptoms ranging from a simple headache or nausea to disablement or death (such as hydrogen sulfide).

A hazard evaluation should determine what chemical(s) are likely to be encountered both in the inert confined space and the associated work areas. This should include a review of MSDSs and established regulatory corporate and other relevant exposure values; some additional useful exposure references are listed in the Bibliography. Since the entry personnel will have complete respiratory protection, their vulnerability is most related to skin exposure. For personnel outside the inerted confined space, all routes of entry are of concern. For these people, the primary source of exposure to potentially toxic materials is the effluent gases leaving the confined space. The hazard evaluation should address safeguard needs for all personnel in these work areas impacted by the inert entry work and effluent. A determination should be made regarding the PPE (see Section 7) and administrative controls (see Section 4) required for nonentry personnel. Testing and monitoring requirements for toxic substances are covered in 6.10.

One hazardous chemical somewhat unique to refinery catalytic reactor operations using nickel catalyst is nickel carbonyl [$Ni(CO)_4$—nickel tetracarbonyl). Nickel carbonyl is a highly volatile (a gas above 110 °F) chemical that can be formed by reaction of carbon monoxide with nickel. The exposure route of concern is inhalation. Concentrations of only a few parts per million (ppm) for short durations can cause severe acute symptoms; a concentration of 30 ppm for 30 minutes has been estimated to be lethal to humans. The odor, described as a “damp cellar” or “sooty,” is normally detected at about 1 ppm to 3 ppm. This odor threshold is two orders of magnitude above exposure limits and is not low enough to provide adequate warning of potentially dangerous exposures. In addition, there is often a delay in the onset of symptoms (dizziness, headache, respiratory distress) of 12 to 36 hours after exposure. Carbon monoxide in the inert gas can lead to formation of nickel carbonyl [see 6.4 g)].

6 Pre-entry Considerations

6.1 General

The safeguards prescribed in 6.2 through 6.10 should be addressed as part of the prejob planning conference [see 4.1 g)]. Entry into an inert confined space shall be considered a PRCS entry into an IDLH environment subject to good practice and regulatory requirements (in the United States, the federal OSHA regulation is 29 *CFR* 1910.146).

6.2 Permits

The written permit provides a basic control tool for safely conducting the work to be done. A properly completed permit not only includes all the elements required by regulations for PRCS but also includes information specific to the special concerns associated with inert entry. The written permit authorizing inert confined space entry shall be separate from any other permits and include, but is not limited to, the following.

a) Identification of the space to be entered and the work to be performed.

b) A drawing showing internal configuration, if it is not readily apparent to all involved.

c) The date and duration of the permit.

d) The results of initial and periodic tests on oxygen, as well as flammable and other hazardous chemicals, including the name or initials of the testers and time when the tests were performed.

e) Identification of the PPE, testing equipment, communications equipment, standby rescue equipment, and alarm systems required.

f) Any additional information or other requirements for the job to be performed safely (e.g. low voltage lighting, continuous monitoring of oxygen and LFL).

g) The names of persons authorized to be entrants within the space.

h) The names of attendants.

i) Identification of the hazards in the space, at the point of entry, and at the emission points.

j) Identification of measures used to isolate the space, and to control the hazards in the space before entry. (Inclusion of a simple drawing of the isolation locations can assist communication and provide an additional safeguard.)

k) Specification of acceptable entry and evacuation conditions (temperature, oxygen level and LFL).

l) Identification of rescue and emergency services and the specific means for summoning those services for timely response.

m) Identification of communications procedures used by authorized entrants and attendants to maintain contact during entry.

n) Identification, by name, of persons authorized to serve as entry supervisor.

o) Identification of the person, by name, currently serving as entry supervisor.

p) Identification of the entry supervisor who originally authorized the entry (by name or initial).

q) Identification of any additional permits (e.g. hot or cold work) issued to authorize work in the inert space.

The written permit shall be signed both by the issuer and the recipient of the permit. Following the completion of the work, all permits shall be signed by recipients and an authorized issuer and maintained for a period conforming to owner policy and regulatory requirements. In the United States, this retention period is at least one year for OSHA PRCS compliance.

A good management practice for maintaining control of the inert entry operation uses entry/exit logs to record and provide data on who is inside the vessel and working in the "hot zone." Similar logs can be used to record instrument readings (when were readings taken, what was measured, what instruments were used, who took the readings and what were the results). Use of these logs should supplement a facility's or contractor's own entry permit. Use of these logs provides recognition that the special circumstances, precautions and information required for safe inert entry are not comprehensively addressed by typical hot work and confined space entry permits.

6.3 Breathing Air

Safe inert entry depends on reliable respiratory protection. Ensuring that breathing air is "OK" is the first significant element of a respiratory protection program. Two primary considerations for breathing air are as follows.

a) Quality assurance on breathing air as described in 7.2 h). This is particularly important for "synthetic" air blended from components. Most companies use a "before-use" on-site testing program in addition to certificates of quality ensuring that the air meets the requirements of 7.2 g). CGA SA-16 reinforces the need for control of blended air quality.

b) Assurance of sufficient quantity of breathing air including a backup supply. This has both safety and productivity considerations.

Annex A is a potentially useful resource for reviewing breathing air practices.

6.4 Inert Gas

Nitrogen is the most commonly used inert gas for work on petroleum and petrochemical facilities. Carbon dioxide and argon may also be used. None of these have warning properties detectable by sense of smell. The source of the inerting gas should be verified and periodically checked to ensure that the inert atmosphere is maintained and oxygen level controlled below specified target values. The following considerations should be checked.

a) The composition of the gas will adequately inert the atmosphere. (Some facilities use a maximum 0.5 % O_2 as a quality assurance limit.)

b) There is an adequate flow of inert gas into the confined space to maintain an inert atmosphere.

c) There is an adequate supply of the inerting gas, including a contingency “backup” supply (cascade, plant supply, portable membrane or molecular sieve nitrogen “generators”).

d) That recycling inert gas does not allow the oxygen level to increase above specified target values, recognizing that oxygen intrusion into the inert-blanketed confined space is a serious fire-hazard concern.

e) That the internal pressure of the inert confined space is not increasing because of the inerting gas. (*Bottom measurements and observation of back pressure can be used in most cases since inert gas is often introduced at the bottom of the vessel and flows out the top. Buildup of pressure indicates an inert gas path blockage such as by a crust of catalyst with a risk of energy release if the catalyst is disturbed: this should be resolved before entry is authorized.*)

f) That the temperature of the inert gas is maintained in conformance with targets. (*Recycle coolers have been used to maintain temperature control.*)

g) Monitoring carbon monoxide, which when present in the inert gas can combine with nickel from catalyst or stainless steel to form gaseous nickel carbonyl.

Both the source and inert-space atmosphere should be continuously monitored. Any loss in control (flow, pressure, temperature, oxygen content) shall require immediate evacuation of entrants.

6.5 Lockout/Tagout (Isolation)

The confined space must be isolated from sources of potentially hazardous energy and materials. All energy sources connected to the confined space shall be locked and/or tagged out to prevent injuries to personnel or damage to equipment that might occur if the equipment were inadvertently activated.

Also, all vessels shall be isolated from all sources of hazardous materials by blinding or disconnecting and blanking all lines connected to the space (with the exception of the purge gas line). Both ANSI Z244 and OSHA 29 *CFR* 1910.147 address lockout/tagout. Vessel isolation should be verified before entry.

6.6 Ignition Sources

All activities that could provide an ignition source such as smoking, welding, grinding, and internal combustion engines should be identified and removed or controlled to prevent the ignition of flammable or combustible materials.

When hot work is required, appropriate precautions should be taken. Materials used for tents/enclosures should be of fire-resistant composition and construction.

6.7 Radiation Sources

Radiation sources, if present, should be removed or shielded and locked. Before removing any radioactive source project personnel should seek instructions from the site's radiation safety officer. Specific requirements vary depending on the state issuing a radiation license. Plants which have a "general" license may not be authorized to remove sources and shall seek the services of a company with the appropriate "specific" license to perform such work. Removed sources that are to be stored on site must be secured and stored in accordance with state and federal guidelines and required documentation maintained.

6.8 On-site Conditions

A qualified person or persons should ensure that the following are provided as appropriate.

a) Fire equipment, such as fire extinguishers or charged fire water hose lines. Personnel should be knowledgeable in their proper use.

b) Adequate illumination. If artificial illumination is required, it should consist of equipment approved for use in flammable atmospheres.

c) Pneumatic tools powered with nitrogen to prevent the introduction of air into the inert atmosphere.

d) Protection from electrical shock provided by ground fault circuit interruption (GFCI) or a 12-volt system if the confined space is damp or wet.

e) Demarcation around an area's open manway beyond which personnel cannot enter without proper respiratory protection equipment (the "hot zone").

f) Posted PRCS signs.

g) Ventilation in the hot zone, if necessary. If an enclosure or partial enclosure is built over the point of entrance to protect personnel from weather, care must be taken to ensure the purge gases do not accumulate. This may require ventilation to allow adequate dilution, or cessation of work until the enclosure is no longer needed.

h) Careful coordination and review of work planned near the inert space, especially near the entrance point, for incompatibility with access for possible rescue operations.

6.9 Confined Space Temperatures and Heat Stress

Where ambient atmospheric conditions allow, a maximum temperature of about 100 °F (38 °C) is preferred for the inert confined space. Where stable higher temperatures are necessary in the workspace, the exposure time shall be reduced. In general, the higher the temperature and humidity within the confined space and the more strenuous the work load, the greater the heat stress. For further information, refer to the ACGIH *TLV® Handbook* to determine the recommended threshold limit heat exposure value that will apply to a given work environment.

If heat stress appears to be a potential problem, temperatures inside the confined space should be checked initially and then continuously monitored. Temperature monitoring is important since a temperature rise is often the first indication of oxygen intrusion. Often, the temperature instrumentation normally used to monitor process conditions in a confined space can still be used for surveillance of temperatures in the work area. If temperature indicators have been disconnected or do not function properly, an alternative method of measuring temperature shall be considered (e.g. a temperature gauge lowered via a hand line into the confined space work area). Workers subjective temperature observations are influenced by work activity and respirator air flow and typically lag objective measurements.

Some facilities recirculate inert gases through a chiller system as a means of cooling workers and the vessel content's "heat sink." As an added benefit this may permit earlier vessel entry. Excess humidity increases heat stress; this could be from water spray deliberately introduced to assist inhibition of pyrophoric deposits, or could be an indication of intrusion of humid air (which means oxygen will also be intruding into the inert space). As part of a heat stress program the work/rest cycles and/or entry durations should be adjusted as needed to prevent heat-related problems among entrants. Depending on temperature and work activity, various facilities limit workers to periods in the inert atmosphere ranging from as short as 30 minutes to a maximum of four hours. Use of personal cooling suits or vests may help reduce heat stress.

6.10 Testing and Monitoring

The atmosphere in the inert confined space shall be tested to determine if entry is permissible (less than 10 % LFL maximum and less than 4 % O_2). LFL testing shall be done without the purge gas flowing; oxygen level measurements may be made with purge gas flowing. The entry employees (and any representatives) shall be given the opportunity to observe testing during the pre-entry evaluation. Personnel potentially exposed during testing shall wear appropriately protective respiratory protection and not work alone. The oxygen content of the confined space and the effluent must be monitored continuously while work is in progress in the confined space. The following additional criteria should be considered for monitoring.

SPECIAL MONITORING EQUIPMENT is typically required to monitor flammability limits accurately at oxygen levels below 10 % O_2. Meters based on catalytic sensing of hydrocarbons generally do not work. Those using other hydrocarbon sensing technologies (such as infrared) may provide proper readings if calibrated for inert testing. The instrument manufacturer should be consulted to ensure that whatever equipment is chosen is used in its proper application.

Instrumentation (such as temperature indicators) already installed in the inert confined space for process control during normal operations may be available as an additional means for the owner to conduct supplemental monitoring and auditing of conditions. This may be able to detect changes in areas below the work zone and provide early warning.

SIGNIFICANCE OF TEMPERATURE CHANGE: If the inert confined space contains a significant mass (such as catalyst), then increases in the bulk temperature require significant heat input. Thus, even small changes (less than 5 °F) in bulk temperature may indicate significant events such as air intrusion and provide advance warning prompting immediate worker evacuation from the confined space until the reason for the change can be investigated. Prudence suggests the need to evacuate workers from the confined space if there is a 5 °F (3 °C) rise in 15 minutes.

The atmosphere in the area around openings to the inerted confined space should also be monitored, particularly if there is an enclosure or partial enclosure at the opening.

Equipment used to analyze and monitor the confined space atmosphere conditions must be properly calibrated to ensure accurate readings for oxygen and LFL. The items in Table 3 should be monitored for the duration of the inert entry work.

7 Personal Protection

7.1 General

Each employee involved with entry and work (including sampling and testing) in and near inert confined spaces must understand the hazards involved (see Section 5). Evaluation of these hazards will determine the selection and use of PPE and training requirements. The responsible employer shall conduct a hazard assessment as good practice. In

Table 3—Continuous Monitoring During Inert Entry

Item to be Monitored	Section Number	Generally Accepted Criteria or Response	Possible Monitoring Methods
Oxygen concentration in inert confined space	5.3, Table 2	Entry < 50 % O_2 for combustion < 4 % max for entry Evacuate at 5 % O_2	Direct-reading continuous oxygen analytical instrumentation
Oxygen concentration in breathing air	7.2	Normal—20.8 % to 20.9 % Investigate if not "normal"	Direct-reading continuous oxygen analytical instrumentation
Breathing air system performance	7.2	Normal	Pressure and flow
Immediate availability of backup air supply	6.3, 7.2	Available	Pressure
Immediate availability of backup inert gas supply	6.4	Available	Pressure
Flammability in inerted confined space	5.3	Entry = < 10 % LFL Hot work = < 10 % LFL Cold work = < 20 % LFL	Instrumentation specifically suited for measurement in inert atmosphere
Temperature in inerted confined space	6.9	Per heat stress criteria	Temperature measurement equipment
Temperature rise	6.10	Evacuate if 5 °F (3 °C) rise in 15 minutes	Temperature measurement equipment
Communication with confined space entrants	7.4	Active communication	Visual and intercom monitoring Voice and "work sounds"

the United States, OSHA 29 *CFR* 1910.132 on PPE requires that this determination be certified in writing. This section of API 2217A provides guidance to assist hazard assessment leading to determination of proper personal protection. That evaluation should include the needs of all support personnel working in the vicinity of the actual entry work. This includes evaluating and informing support personnel and other potentially affected people working in the area. With this awareness, contractors and owner's representative can further evaluate hazards potentially affecting their personnel and determine necessary PPE to be used within the restricted area.

7.2 Respiratory Protection

The following measures should be evaluated and implemented as necessary by a qualified person.

a) As a minimum, person(s) required to enter the inert confined space shall wear a positive-pressure, full-facepiece, pressure-demand air-line respirator *with two separate sources of air in addition to an auxiliary self-contained escape air supply of sufficient capacity to allow emergency escape (for a total of three independent air supplies)*. This equipment shall be NIOSH or MSHA approved (or equivalent). *Normal open or closed-circuit self-contained breathing apparatus shall not be used for rescue entry into inert spaces (see 7.2.9)*.

b) All equipment shall be physically inspected before each use to ensure its physical integrity and cleanliness.

c) Personnel required to be in the area of point of entrance shall wear at least a positive-pressure, full-facepiece, air-line respirator if any part of their body may break the plane of the vessel of entry, or if they may reasonably be exposed to a hazardous atmosphere. If they are stationed as potential rescuers then they shall be suited and equipped the same as entry personnel [see item e)].

d) The helmet, hood, or suit should be sufficiently secure to prevent inadvertent removal by the entrant.

e) When persons are in an inert confined space, at least one attendant shall be readily available (fully suited for immediate entry) outside the point of egress for the purpose of communications and to initiate emergency response. This attendant requirement begins before the entry plane is broken and lasts until all entry personnel have exited.

f) Breathing air may be supplied to respirators from cylinders or suitable air compressors. At least two independent sources shall be used.

g) Compressed breathing air should (as a minimum) meet the requirements of the specification for Quality Verification Level D (*formerly called Type I, Grade D*), breathing air as described in the latest edition of CGA G-7.

h) A quality assurance program should be established by the user of the air to confirm the quality of the compressed breathing air (one suggested verification regimen is provided in ANSI Z88.2).

i) If a compressor is used, it shall be located to prevent entry of contaminated air into the air-supply system. Compressor exhausts should be routed away from air intakes. Oil lubricated compressors must be equipped with carbon monoxide and high-temperature alarms.

j) Breathing-air couplings shall be incompatible with outlets for nonrespirable plant air or other gas systems to prevent the inadvertent cross connection of air-line respirators with nonrespirable gases.

k) A minimum of two independent sources of air shall be provided for each person working in an inert confined space. These are in addition to the self-contained escape bottle. A third source of air is appropriate when complicated internals or limited access to the work area hinder emergency egress from the confined space.

l) A trained person must continually monitor the air supply of the workers in and near the confined space.

m) An emergency alarm, either audible or visible, should be used to indicate a reduction in breathing-air supply or pressure. All personnel should evacuate the confined space when the emergency alarm is activated.

n) All persons wearing respirators shall be trained in the proper fit and use of the specific specialized equipment selected for use in the inert atmosphere. This training should satisfy the OSHA 29 *CFR* 1910.134 requirements for proper fit testing, selection, use, and maintenance of respirators as well as required medical evaluation and surveillance for respirator users. In areas not subject to OSHA requirements, comparable fit-testing and training requirements shall be implemented.

7.3 Clothing

Appropriate clothing must be worn to provide protection from the hazards identified during the prejob planning. Articles of clothing must provide protection against any harmful substances and/or conditions present in or near the inert confined space. A hazard evaluation shall be used to determine PPE needs. The procedure mandated by OSHA 29 *CFR* 1910.132 meets this requirement.

7.4 Communications

A reliable and effective communication system is necessary to provide a continuous uninterrupted link between those within the inert confined space and the attendant(s) and/or others on the outside. Some practitioners require continuous visual contact with entry personnel which may require multiple entrants where multilevel catalyst beds are being serviced. Visual contact permits the use of hand signals for evacuation warning. If communication is interrupted, personnel should immediately be evacuated from the confined space and should not return until a reliable communication link can be assured. The communication system must be rated as intrinsically safe if used inside the confined space or in an electrically classified area.

7.5 Attendant(s) Responsibilities

Attendant(s) are required while work is being performed in an inert confined space. During an inert entry the attendants' requirements and responsibilities include special considerations as well as all the normal regulatory permit required confined space requirements. The highest priority duties are monitoring the breathing air, the atmosphere within the confined space (including both temperature and oxygen level) and maintaining communications with the entrant. Some facilities require that these duties be done by a dedicated attendant (or console operator), separated from duties of the attendant at the entry location. Entry attendants should only be concerned with specific duties at the entry location (such as managing equipment, passing equipment in and out of the confined space and initiating rescue). Attendant(s) shall have no other duties than those assigned, should be appropriately trained and qualified, and be thoroughly familiar with the following:

a) respiratory protection equipment being used;

b) inert confined space entry procedures that are applicable to his or her duties;

c) requirement to ensure entry personnel are properly equipped with appropriate PPE and respiratory protection before entering confined space;

d) coordinate and assist with ingress and egress of all entrants;

e) how to identify and maintain an accurate count of authorized entrants;

f) effective use of communications systems (voice, video monitor);

g) recognizing changes in conditions (such as oxygen level, temperature or gas flow) which can be early signs of increased risk to the entrants;

h) confined space physical and/or health hazards, including possible behavioral effects of hazards on entrants (to assist in recognizing potential problems at an early stage);

i) emergency rescue equipment, if the attendant is responsible for initiating rescue;

j) emergency first aid, cardiopulmonary resuscitation (CPR), and bloodborne pathogens, if the attendant will be performing as a rescuer;

k) the types of unsafe conditions, situations or behaviors inside or outside the space which should cause the attendant to order an evacuation;

l) emergency notification procedures to initiate rescue and when and how to use them;

m) requirement to remain outside of permitted space during entry operations until properly relieved by another attendant;

n) needs and procedures to warn and deny unauthorized access to the permit space and to the adjacent work area;

o) housekeeping requirements at entry point.

7.6 Entrant(s) Responsibilities

Entrant(s) working in an inert confined space should be appropriately trained, qualified and thoroughly familiar with the following:

a) hazards that may be encountered during inert confined space entry;

b) recognizing potentially hazardous changes in conditions (such as temperature or airflow);

c) respiratory protection equipment used for inert entry;

d) proper PPE to meet entry permit requirements;

e) inert confined space entry procedures;

f) proper use of equipment and safe work practices for working in an inert confined space;

g) effective use of communications systems, including ability to effectively communicate with entry team and plant operations;

h) procedures for communication with attendant to monitor entrant status;

i) emergency notification procedures;

j) evacuation procedures;

k) emergency rescue equipment and use of retrieval equipment;

l) understanding and use of fall protection systems in place.

7.7 Rescue and Emergency Services

Planning for rescue and emergency aid should recognize and emphasize the acute nature of hazards that are IDLH and the very limited time available for successful rescue and treatment. Before entry into an inert confined space is authorized, provisions must be made for addressing medical emergencies that may arise during the work. Personnel trained in CPR, first aid (including burn treatment), and the use of appropriate rescue equipment (see 7.8) must be continuously available at the work location during all work in the inert confined space. Emergency response provisions shall include timely access to professional medical treatment. This planning shall ensure conformance to all regulatory requirements such as in OSHA 29 *CFR* 1910.146(k) in the United States.

7.8 Emergency Rescue Equipment

The equipment necessary for rescuing personnel working in an inert confined space shall be immediately available at the inert entry work site. Normal open or closed-circuit self-contained breathing apparatus shall not be used for rescue entry into inert spaces. Qualified and proficient rescue personnel meeting regulatory requirements shall be available for timely response and able to use the on-site equipment. Response may be divided into two phases for:

1) retrieval from the confined space, and

2) movement from the immediate confined space entry “hot zone” to a location where medical assistance is available.

There shall be documented prior arrangements established with a local ambulance service and off-site medical facility and/or hospital.

This equipment includes, but may not be limited to the following.

a) Phase 1, located at the entry site.

   1) Provisions and means for summoning assistance.

   2) Hoisting device to extricate personnel from the confined space.

   3) Extra supplied air breathing equipment for entry during rescue. *This shall be comparable to the equipment used by the entrant workers*.

   4) Extra protective clothing for entry during rescue.

   5) First-aid kit.

   6) Fire extinguishers.

   7) Emergency oxygen should be on hand and the personnel acting as attendants should be certified to use the device.

   8) Automated external defibrillator (AED) with trained personnel available.

b) Phase 2, may be brought to site.

   1) Additional ropes and harnesses.

   2) Additional hoisting equipment.

   3) Basket stretchers.

   4) A means of lowering injured persons to the ground.

   5) Rescue tools, including jacks, pry bars, a cutting torch, a chain fall.

   6) Transportation for injured personnel.

OSHA 29 *CFR* 1910.146—nonmandatory Appendix F and ANSI Z117.1 may provide useful reference material while reviewing rescue programs. The overall rescue program shall meet regulatory requirements and be documented.

8 Other Considerations

Work in an inert confined space presents many unique hazards that may not be encountered in a typical confined space entry. The performance of such work and the special precautions and equipment necessary are commonly obtained via specialized contractors. Inert confined space entries do not occur frequently in the petroleum industry and the decision to perform this work activity must be carefully reviewed and approved by the facility/location management before such work takes place.

8.1 Key Items to Recognize for Safe Inert Entry

When considering the use of inert entry, the following aspects should be included in consideration of whether to use inert entry and the precautions needed.

a) If inert entry is not necessary, use another method.

b) Inert gas blankets provide protection and introduce hazards:

— protection against combustion by excluding oxygen,

— hazard because of oxygen deficiency,

— hazard because of lack of warning properties.

c) Entry into inert confined space requires more protective procedures than specified for regulatory (e.g. OSHA in the United States) PRCS entry, such as:

— special respiratory protection—multiple (two plus escape bottle) independent air supplies,

— dedicated standby personnel—no duties permitted other than those specified,

— rescue capability immediately available at the job site,

— continuous monitoring required.

d) Oxygen intrusion into the inert-blanketed confined space is a serious fire-hazard concern.

e) Presence of carbon monoxide in the inert gas stream can combine with nickel from catalyst or stainless steel to form gaseous nickel carbonyl.

f) Backup supplies are required to be immediately available for both inert purge gas and breathing air.

g) Temporary enclosures (e.g. such as weather tents erected from scaffold and tarpaulins over manholes to prevent rain water to enter inerted vessel) can become secondary confined space hazards.

8.2 Safety of Nonentry Personnel

Inert entry work can be accomplished without incident when done by experienced personnel using proper planning, trained people and appropriate equipment. However, nonentry persons may be more vulnerable. Oxygen-deficient inert atmosphere gases provide no warning of their deadly nature. There is history of incidents associated with inert entry projects showing that uninformed persons working around the inert entry activity can be at significant risk when unaware of the inert gas hazard or activity. The hot zone should be conspicuously marked by barricades and signs noting the oxygen deficiency hazard and lack of warning properties. There should be a positive method to prevent entry into the space when the area is not being worked and under active on-site supervision, such as during inclement weather, shift change, etc. (Some facilities use a locked lid or cable grid over the manway during inactive periods.) Areas where inert gas is vented should always be barricaded/cordoned off.

Unplanned, unauthorized entry and subsequent attempts at rescue have had tragic results (as documented by some references in the Bibliography). This is why precautions for these administrative controls are important. Use of signs, barriers, positive vessel closure, security personnel and communication with people who may be in the inert entry vicinity can raise awareness and help prevent unknowing entry or exposure to potentially hazardous effluent.

Annex A

State of Maine Checklist for Breathing Air Quality and Use

http://www.maine.gov/labor/workplace_safety/respiratory/chbr.htm

Check that at your facility:

General

- ☐ Compressed breathing air meets the requirements for Grade D breathing air.
- ☐ Compressed oxygen is not used in respirators that have previously used compressed air.
- ☐ Oxygen concentrations greater than 23.5 % are used only in equipment designed for oxygen service or distribution.
- ☐ Breathing air couplings are incompatible with outlets for other gas systems.
- ☐ Breathing gas containers are marked with appropriate NIOSH certification.

Breathing Air Cylinders

- ☐ Cylinders are tested and maintained according to DOT 49 *CFR* Parts 173 and 178.
- ☐ A certificate of analysis for breathing air has been obtained from the supplier.
- ☐ Moisture content in the cylinder does not exceed a dew point of –50°F at 1 atmosphere pressure.

Compressors

- ☐ Are constructed and situated to prevent contaminated air from getting into the system.
- ☐ Are set up to minimize moisture content.
- ☐ Are equipped with in-line air purifying sorbent beds and/or filters that are maintained or replaced following manufacturer's instructions.
- ☐ Are tagged with information on the most recent change date of the filter and an authorizing signature.
- ☐ Carbon monoxide does not exceed 10 ppm in the breathing air from compressors that are not oil lubricated.
- ☐ High-pressure and carbon monoxide alarms are used on oil lubricated compressors, or that the air is monitored often enough to ensure that carbon monoxide does not exceed 10 ppm if only a high-temperature alarm is used.

Bibliography

[1] API Standard 2015, *Safe Entry and Cleaning of Petroleum Storage Tanks*

[2] API Recommended Practice 2016, *Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks*

[3] ACGIH [9], *Threshold Limit Values® for Chemical Substances and Physical Agents in the Work Environment and Biological Exposure Indices®*

[4] AIHA [10], *Emergency Response Planning Guidelines (ERPG)*

[5] CGA G-7.1 [11], *Commodity Specification for Air*

[6] CGA Safety Alert SA-17, *Safety Alert—Hazards of Nitrogen/Inert Gas Creating an Oxygen-Deficient Atmosphere*

[7] CGA Safety Bulletin SB-2, *Oxygen-Deficient Atmospheres*

[8] CGA Safety Bulletin SB-15, *Avoiding Hazards in Confined Work Spaces During Maintenance, Construction and Similar Activities*

[9] CSB Case Study No. 2006-02-I-DE [12], *Confined Space Entry—Worker and Would-be Rescuer Asphyxiated*

[10] CSB Safety Bulletin No. 2003-10-B, *Hazards of Nitrogen Asphyxiation*

[11] CSB Video, *Hazards of Nitrogen Asphyxiation*

[12] DOE-HDBK-1046-2008 [13], *DOE Handbook: Temporary Emergency Exposure Limits for Chemicals: Methods and Practice*

[13] IChE (UK) [14], *Hazards of Nitrogen and Safe Handling of Catalysts (BP Process Safety Series)*

[14] NFPA [15], *Fire Protection Guide to Hazardous Materials*

[15] NFPA 326, *Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*

[16] NFPA 704, *Identification of the Hazards of Materials for Emergency Response*

[17] NIOSH Publication No. 2005-149 [16], *NIOSH Pocket Guide to Chemical Hazards*

---

[9] American Conference of Governmental Industrial Hygienists 1330 Kemper Meadow Drive, Cincinnati, Ohio 45240-1634, (Tel.) 513-742-2020, www.acgih.org.

[10] American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, Virginia 22031, (Tel.) 703-849-8888, (Fax) 703-207-3561, www.aiha.org.

[11] Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, Virginia 20151-2923, (Tel.) 703-788-2700, www.cganet.com.

[12] U.S. Chemical Safety and Hazard Investigation Board, Office of Prevention, Outreach, and Policy, 2175 K Street NW, Suite 400, Washington, DC 20037-1848, (Tel.) 202-261-7600, www.csb.gov.

[13] U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585, www.hss.doe.gov.

[14] Institution of Chemical Engineers (UK), IChemE, Davis Building, Railway Terrace, Rugby, Warwickshire, CV21 3HQ, UK, (Tel.) +44 (0)1788 578214, (Fax) +44 (0)1788 560833, (E-mail) sales@icheme.org, www.icheme.org.

[15] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-7471, www.nfpa.org.

[18] OSHA 29 *Code of Federal Regulations* (*CFR*) Parts 1910 and 1926 [17]

[19] OSHA 29 *CFR* Part 1910.119, *Process Safety Management of Highly Hazardous Chemicals*

[20] USBM Bulletin 680 [18], *Investigation of Fire and Explosion Accidents in the Chemical, Mining, and Fuel Related Industries—A Manual*; NTIS PB87113940

[21] USBM Bulletin 627, *Flammability Characteristics of Combustible Gases and Vapors*; NTIS AD701576

[16] National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (CDC), NIOSH/CDC, Education and Information Division, 4676 Columbia Parkway, Cincinnati, Ohio 45226, www.cdc.gov/niosh. Searchable on-line at http://www.cdc.gov/niosh/npg/npg.html, or order from http://wwwn.cdc.gov/pubs/niosh.aspx#2008 Publications.

[17] U.S Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC 20210, www.osha.gov.

[18] U.S. Bureau of Mines (part of NIOSH/CDC), Pittsburgh Research Laboratory, P.O. Box 18070, Pittsburgh, Pennsylvania 15236, www.cdc.gov/niosh/mining. These older USBM documents are available from the U.S. Commerce National Technical Information Service (NTIS), www.ntis.gov.

energy API®

2009 Publications Order Form

Effective January 1, 2009.
API Members receive a 30% discount where applicable.
The member discount does not apply to purchases made for the purpose of resale or for incorporation into commercial products, training courses, workshops, or other commercial enterprises.

Available through IHS:

Phone Orders:	1-800-854-7179	(Toll-free in the U.S. and Canada)
	303-397-7956	(Local and International)
Fax Orders:	303-397-2740	
Online Orders:	global.ihs.com	

Date: ______________________

☐ **API Member** (Check if Yes)

Invoice To (☐ Check here if same as "Ship To")

Name:
Title:
Company:
Department:
Address:

City: State/Province:
Zip/Postal Code: Country:
Telephone:
Fax:
Email:

Ship To (UPS will not deliver to a P.O. Box)

Name:
Title:
Company:
Department:
Address:

City: State/Province:
Zip/Postal Code: Country:
Telephone:
Fax:
Email:

Quantity	Title	SO★	Unit Price	Total
	Std 2015, Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks		$130.00	
	RP 2016, Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks		$186.00	
	Publ 2026, Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service		$60.00	
	RP 2220, Contractor Safety Performance Process		$80.00	
	RP 2221, Contractor and Owner Safety Program Implementation		$147.00	

☐ Payment Enclosed ☐ P.O. No. (Enclose Copy) ______________

☐ Charge My IHS Account No. ______________

☐ VISA ☐ MasterCard ☐ American Express
☐ Diners Club ☐ Discover

Credit Card No.:
Print Name (As It Appears on Card):
Expiration Date:
Signature:

Subtotal	
Applicable Sales Tax (see below)	
Rush Shipping Fee (see below)	
Shipping and Handling (see below)	
Total (in U.S. Dollars)	

★ To be placed on Standing Order for future editions of this publication, place a check mark in the SO column and sign here:

Pricing and availability subject to change without notice.

Mail Orders – Payment by check or money order in U.S. dollars is required except for established accounts. State and local taxes, $10 processing fee, and 5% shipping must be added. Send mail orders to: **API Publications, IHS, 15 Inverness Way East, c/o Retail Sales, Englewood, CO 80112-5776, USA.**

Purchase Orders – Purchase orders are accepted from established accounts. Invoice will include actual freight cost, a $10 processing fee, plus state and local taxes.

Telephone Orders – If ordering by telephone, a $10 processing fee and actual freight costs will be added to the order.

Sales Tax – All U.S. purchases must include applicable state and local sales tax. Customers claiming tax-exempt status must provide IHS with a copy of their exemption certificate.

Shipping (U.S. Orders) – Orders shipped within the U.S. are sent via traceable means. Most orders are shipped the same day. Subscription updates are sent by First-Class Mail. Other options, including next-day service, air service, and fax transmission are available at additional cost. Call 1-800-854-7179 for more information.

Shipping (International Orders) – Standard international shipping is by air express courier service. Subscription updates are sent by World Mail. Normal delivery is 3-4 days from shipping date.

Rush Shipping Fee – Next Day Delivery orders charge is $20 in addition to the carrier charges. Next Day Delivery orders must be placed by 2:00 p.m. MST to ensure overnight delivery.

Returns – All returns must be pre-approved by calling the IHS Customer Service Department at 1-800-624-3974 for information and assistance. There may be a 15% restocking fee. Special order items, electronic documents, and age-dated materials are non-returnable.

THERE'S MORE WHERE THIS CAME FROM.

API provides additional resources and programs to the oil and natural gas industry which are based on API Standards. For more information, contact:

API MONOGRAM® LICENSING PROGRAM
Phone: 202-962-4791
Fax: 202-682-8070
Email: certification@api.org

API QUALITY REGISTRAR (APIQR®)
> ISO 9001 Registration
> ISO/TS 29001 Registration
> ISO 14001 Registration
> API Spec Q1® Registration
Phone: 202-962-4791
Fax: 202-682-8070
Email: certification@api.org

API PERFORATOR DESIGN REGISTRATION PROGRAM
Phone: 202-682-8490
Fax: 202-682-8070
Email: perfdesign@api.org

API TRAINING PROVIDER CERTIFICATION PROGRAM (API TPCP™)
Phone: 202-682-8490
Fax: 202-682-8070
Email: tpcp@api.org

API INDIVIDUAL CERTIFICATION PROGRAMS (ICP®)
Phone: 202-682-8064
Fax: 202-682-8348
Email: icp@api.org

API ENGINE OIL LICENSING AND CERTIFICATION SYSTEM (EOLCS)
Phone: 202-682-8516
Fax: 202-962-4739
Email: eolcs@api.org

API PETROTEAM (TRAINING, EDUCATION AND MEETINGS)
Phone: 202-682-8195
Fax: 202-682-8222
Email: petroteam@api.org

API UNIVERSITY™
Phone: 202-682-8195
Fax: 202-682-8222
Email: training@api.org

Check out the API Publications, Programs, and Services Catalog online at www.api.org.

energy API

1220 L Street, NW
Washington, DC 20005-4070
USA

202.682.8000

Additional copies are available through IHS
Phone Orders: 1-800-854-7179 (Toll-free in the U.S. and Canada)
303-397-7956 (Local and International)
Fax Orders: 303-397-2740
Online Orders: global.ihs.com

Information about API Publications, Programs and Services
is available on the web at www.api.org

Product No. K2217A4