FOREWORD

The Occupational Safety & Health Administration (OSHA) has promulgated standards designed to protect employees from the hazards associated with entering and working in confined spaces.

The enclosed document is the University of North Florida's written Confined Space Entry Program developed by the Department of Environmental Health & Safety in compliance with 29 CFR 1910.146.

Components of this program include employee responsibilities, evaluating, testing and entering confined spaces, medical monitoring, training, labeling and record keeping requirements.

All impacted University personnel are expected to become familiar with this program and abide by the procedures contained within. Outside contractors shall be apprised of the areas on campus that could be considered confined spaces and develop their own policy accordingly.

This document will be reviewed, evaluated and updated at least annually and is readily available to employees of UNF and their representatives.

Dr. Anne H. Hopkins.
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I. INTRODUCTION

A confined space is an area which is not designed for human occupancy, has poor ventilation characteristics and limited access. Any or all of these criteria can qualify the work area as a confined space. Examples include boilers, fuel tanks, pipelines, pipe chases, pumping stations, process vessels, septic tanks, sewage digesters, silos, manholes, utility vaults, vats, pits or similar enclosures. The hazards encountered and associated with entering and working in these spaces are capable of causing physical injury, illness and death in unprotected employees. A **permit required confined space is one in which the inherent hazards cannot be removed from the space without entry and protective measures.**

Accidents occur in confined spaces for three basic reasons:

1) Failure to recognize a confined space prior to entry,
2) Failure to monitor the potential hazards associated, and
3) Failure to control those hazards identified.

Therefore, employees should exercise extreme caution when entering or working in such confined spaces.

Entering a confined space may be required for various reasons. The types of hazards involved will be determined by the use of the space and the specific work practices to be conducted. Specific hazards can be divided into three major categories.

1) Physical: Includes temperature extremes, high noise levels, engulfment, radioactivity, electrocution, falling objects, vibration and slick, wet surfaces.
2) Chemical: Includes oxygen deficiency, explosive atmospheres or toxic atmospheres.
3) Biological: Includes infectious agents, animals, insects or certain plants.

One of the most difficult entries to control is an unauthorized entry, especially when there are numerous employees and trades involved. Studies confirm the vast majority of deaths and injuries occur when an employee enters a confined space without the knowledge of their supervisor. The use of a checklist and permit as part of this confined space program will prevent unauthorized access and ensure entry requirements are met.

**WHEN THE AREA MEETS THE CRITERIA FOR A CONFINED SPACE, ALL PRECAUTIONARY REQUIREMENTS SHALL BE ENFORCED.**

This program is designed with guidance from the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH). Although developed by the Department of Environmental Health & Safety (EH&S), it is distributed to and directly enforced by supervisors in the Department of Physical Facilities at the University of North Florida. This program satisfies the requirements of the Occupational Safety & Health Act 29 CFR 1910.146 and Chapter 38I-10 Florida Administrative Code, Workplace Safety and Health Programs. Copies of this program are available in Physical Facilities and EH&S. Questions concerning implementation, applicability or procedures should be directed to EH&S before proceeding.
II. DEFINITIONS

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 any period of time.

Combustible Dust: A dust capable of undergoing combustion or burning when subjected to a source of ignition.

Confined Space: Refers to a space which by design has limited access, unfavorable natural ventilation and is not intended for continuous human occupancy.

Hot Work: Any work involving burning, welding, riveting, or similar high temperature producing operations as well as work which produces a source of ignition, such as drilling, abrasive blasting and space heating/drying.

Immediately Dangerous to Life and Health (IDLH): Those atmospheres capable of causing irreversible health effects, immediate or delayed threat to life and the inability to escape from a confined space.

Inerting: Displacement of the atmosphere in a confined space by a non-reactive gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible. This procedure may produce oxygen deficient atmospheres in the confined space.

Isolation: A process whereby the confined space is removed from service and completely protected against the inadvertent release of material or energy by the following means: blanking off supply lines, misaligning sections of all lines and pipes, a double block and bleed system, electrical lockout of all power sources and blocking or disconnecting all mechanical linkages.

Lower Explosive Limit (LEL): The minimum concentration of a combustible gas, vapor or dust in air (expressed in percent volume), which will ignite if an ignition source is present.

Oxygen Deficiency: Refers to atmospheres containing less than 19.5% oxygen by volume at normal atmospheric pressure. Normal atmospheric oxygen content is around 21%.

Oxygen Enriched Atmosphere: Any oxygen concentration greater than 23.5% at normal atmospheric pressure.

Permissible Exposure Limit (PEL): The maximum 8-hour time weighted average (TWA) concentration of an airborne contaminant to which an employee may be exposed by law as listed in the Occupational Safety and Health Act, 29 CFR 1910 Sub Part Z.

Purging: The method(s) by which gases, vapors or other airborne impurities are displaced from a confined space. The method usually involves injecting fresh air into the confined space using a compressor or blower, thereby forcing contaminated air out.

Respirator: A device designed to protect the wearer from inhalation of harmful atmospheres. The device shall meet the requirements of the UNF Respiratory Protection Program, the Mine Safety and Health Administration (MSHA) and the National Institute of Occupational Safety and Health (NIOSH).
Standby Person: A person trained in emergency rescue procedures and assigned to remain on the outside of the confined space in constant communication with those working inside the confined space. The standby person shall be approved/assigned by the qualified supervisor.

Supervisor: A person designated by Physical Facilities as capable (by education, training or both) of anticipating, recognizing, evaluating and controlling the hazards of a particular confined space. This person shall be capable of specifying control or protective actions and equipment to ensure employee safety. This person shall be responsible for training and be identified on the confined space checklist or entry permit.

Threshold Limit Value (TLV): The maximum 8-hour time weighted average (TWA) concentration of an airborne contaminant to which an employee may be exposed, as recommended by the American Conference of Governmental Industrial Hygienist (ACGIH). To be used in the absence of OSHA Permissible Exposure Limits (PEL=s).

III. RESPONSIBILITIES

It shall be the responsibility of the director of Physical Facilities to assign supervisors the responsibility for ensuring that applicable sections of this program are implemented when confined space activities are contemplated. This may include atmospheric monitoring, medical and exposure monitoring, training, isolation or lockout, ventilation, rescue and personal protective equipment, maintenance of records and standby personnel. EH&S is available to assist with training and implementation as necessary. In the event outside contractors must enter confined spaces on campus, they shall be apprized of the potential hazards and required to develop a confined space policy specific to their work.

All activities involving confined space entry require completion of a Pre-Entry Checklist (Appendix A). It shall be the responsibility of the supervisor to procure and complete this form before any work is undertaken. During this process, the need for an Entry Permit will be determined (Appendix B). Copies of the completed checklists and permits shall be submitted to EH&S.

FAILURE TO COMPLY WITH THESE SPECIFICATIONS WILL RESULT IN IMMEDIATE CESSION OF THE JOB UNTIL A CHECKLIST/PERMIT IS COMPLETED AND MAY RESULT IN DISCIPLINARY ACTION.

IV. Evaluation

The first step in the program is to evaluate all areas on campus that meet the definition of a confined space to determine what hazards exist. This has been completed and the resultant list includes sanitary sewer manholes and lines, electrical manholes, telephone manholes, valve pits and lift stations. Examples of hazards that can exist in these spaces include noise, oxygen deficiency, hydrogen sulfide (H2S), heat stress, electrocution and drowning. If these hazards cannot be removed from the space prior to entry, then the space must be considered a permit required confined space and the entry shall be labeled with language similar to the following:

DANGER - CONFINED SPACE Hazard, DO NOT ENTER WITHOUT PERMIT

Entry into permit required confined spaces shall not occur without the completion of a permit (Appendix B), the knowledge of a supervisor and the presence of a trained attendant and lead employee. If the hazards can be eliminated at any time after entry, the space may then be downgraded to a non-permit required confined space.
V. Permit System

Entry into an area labeled as a permit required confined space shall be by permit only (Appendix B). The entry permit serves as written authorization and documentation specifying the location and type of work to be done and certifies that all existing hazards have been evaluated by the qualified supervisor. The entry permit also documents that all necessary protective measures have been taken to ensure the safety of each employee. EH&S shall receive copies of completed permits. The supervisor shall be responsible for securing the permit and shall sign off on the permit when the following areas and actions have been reviewed and confirmed:

1) Location and description of the work to be done.

2) Hazards that may be encountered.

3) Complete isolation (lockout/tagout) checklist.
   a) Blanking or disconnecting all supply lines.
   b) Electrical lockout of all fuse boxes/power switches.
   c) Mechanical lockout of all moving equipment.

4) Special clothing and equipment.
   a) Personal protective equipment and clothing including gloves, eye protection, hearing protection, hard hat, foot protection.
   b) Safety harness and lines.
   c) Tools approved for use in accordance with the Hazardous Location Classification (National Electric Code, Intrinsically safe or explosion proof, grounded)
   d) Approved electrical equipment (Ground fault circuit interrupters).

5) Air testing and monitoring (see section VII)

6) Personnel training and complete understanding of the hazards.

7) Standby person(s) as identified on the permit.

8) Emergency procedures and location of first aid equipment.

The permit for a confined space shall be posted in a conspicuous location, close to the entrance. The permit may vary among different activities however, it should serve the same purpose for all departments and activities: to ensure the safety of employees in the confined space.

The training requirements of personnel entering or working in confined spaces shall be based on the nature of the hazards and the work to be performed and may therefore vary with each entry.
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X - indicates requirement
O - indicates determination to be made by qualified supervisor
VI. Entry and Rescue

Confined spaces may be entered without the need for a permit or attendant provided that the Confined Space Entry Checklist (Appendix A) is completed and it is determined that the space can be maintained in a safe condition for entry by mechanical ventilation, lockout/tagout or other authorized procedure. However, the conditions in a confined space have the potential to increase existing hazards or generate additional ones and it is therefore necessary to frequently re-evaluate the space. This includes visual inspection for changes in the physical condition of the space (water intrusion, temperature, leaking pipes, moving parts, etc.) and air monitoring. If these evaluations uncover unsafe conditions (gas alarm, oxygen deficiency, flammable atmosphere, etc.), the employees will immediately leave the space, notify the supervisor and remain outside until the cause has been identified, corrected and approved by the supervisor. If circumstances dictate an interruption of work (lunch break, shift break, etc.), the space must be re-evaluated and the checklist must be updated to reflect new information prior to re-entry. The checklist must remain at the job site for the duration of the work.

Rescue procedures shall be specifically designed for each entry. If the entry is permit required (i.e. space cannot be ventilated to prevent an alarm), there shall be a trained standby person assigned to that confined space with a fully charged, positive pressure, self contained breathing apparatus (SCBA) on hand. Additional duties of the standby person are to maintain unobstructed life lines and communications with all employees in the permit required confined space and to summon rescue personnel as necessary.

UNDER NO CIRCUMSTANCES SHALL THE STANDBY PERSON ENTER THE CONFINED SPACE UNTIL RELIEVED AND ADEQUATE ASSISTANCE IS PRESENT.

However while awaiting rescue personnel, the standby person shall make rescue attempts utilizing the life lines from outside the confined space. Rescue teams entering a confined space shall be equipped in at least the same level of protection as the standby person.

In the event a confined space rescue involves toxic atmospheres, a supplied air respirator or SCBA shall be used for entry. A person summoned or one who recognizes the need for rescue shall seek assistance and await their arrival outside the confined space. Respirators and life lines shall be donned by rescue personnel with the necessary equipment for removal of the victim(s).

VII. Air Monitoring and Testing

Entry into any confined space is prohibited until initial testing of the atmosphere has been done from the outside. Prior to entry, employees shall be fully aware of the potential hazards associated with the space. Deaths have occurred because a presumably safe space was not tested prior to initial entry. Specific equipment shall be calibrated and used to monitor the atmosphere in the space. This includes oxygen content, combustible gas indicators or explosimeters for flammable gases/vapors/dusts and toxic gases/vapors (H₂S). Physical agents (heat, noise, vibration, etc.) will be selected and testing performed to the satisfaction of the qualified supervisor.

Air monitoring in a permit required confined space shall be done on a continuous basis. This means that the monitoring instrument shall be left on during the entire entry and work process. 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 atmosphere develops.

SHOULD ANY DOUBT EXIST AS TO THE POTENTIAL FOR CONTAMINATION ALWAYS MONITOR TO BE SURE.
Non-permit entries shall be monitored as determined by the conditions of the space and the qualified supervisor, but shall include initial entry testing, when conditions or procedures change and upon re-entry following breaks or shift change.

Instruments shall be calibrated in accordance with the manufacturer's instructions and before each day's use. Each calibration shall be recorded on the entry checklist or permit. Entry into any confined space for hot work is prohibited if tests indicate the concentration of flammable gases in the atmosphere are greater than 10% of the lower explosive limit (LEL). In rare cases where the combustible material can be identified, the specific LEL can be obtained and used as the action level. For example, the LEL for methane (swamp gas) is 5%. Most combustible gas meters are calibrated with methane and therefore, when present the action level for evacuating the space is 5%. It is necessary to determine the oxygen level prior to measuring the range of any other parameter. This is especially critical when measuring flammability. Enriched oxygen levels (>23.5%) will allow combustion at lower explosive ranges than lean oxygen levels (<19.5%).

When materials in a confined space 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, few have automatic alarms and therefore require constant personal attention to monitor dust levels. The control of explosive dusts is through elimination of the hazard by preventative measures such as engineering controls (wet methods, local exhaust), good housekeeping, eliminating ignition sources, isolation of dust producing operations and employee training.

The oxygen deficiency measuring instrument is designed to measure the volume of oxygen present in the atmosphere, usually scaled with a range of 0-25%. If the oxygen content in a confined space cannot be maintained between 19.5% and 23.5%, then the space becomes permitted and special precautions shall be taken. These include purging or use of an SCBA at reduced O₂ levels and inerting of the confined space atmosphere at elevated O₂ levels. Most combustible gas detectors combine O₂ sensing capabilities.

Toxic atmospheres exist when contaminants reach levels at or above the PEL's set by OSHA in 29 CFR Part 1910 Sub Part Z or the TLV=s set forth by ACGIH. For instance, the PEL for hydrogen sulfide (H₂S) or sewer gas is 10 parts per million (ppm). Should monitoring indicate that these levels are exceeded, the space becomes permitted and the atmosphere shall be purged until continuous monitoring reveals that acceptable levels have been achieved. If levels approach those considered immediately dangerous to life and health (IDLH), purging shall again be used until the atmosphere has been determined safe. Once monitoring has been initiated, it must be continued until the work process is complete. EH&S is available to assist in the calibration, use and maintenance of monitoring equipment.

a) Pre-entry air test readings:
   i) Oxygen level (Levels #19.5% and ≧23.5% warrant purging)
   ii) Flammability or explosive levels (≧10% of LEL warrants evacuation and inerting). NOTE: inerting will produce oxygen deficient atmospheres.
   iii) Toxic substance levels (Levels ≧PEL or TLV warrant purging.)

b) Post-entry air testing while work is being performed. This shall include the same parameters as identified during pre-entry testing.

VIII. Preparation For Work
Before entering a confined space, employees shall review the specific guidelines appropriate for safe entry and emergency exit. These guidelines shall be compiled by the qualified supervisor and be definitive for the potential hazards.

1) Purging and Ventilation: Environmental control within a confined space is accomplished by purging and ventilating. The method used will be determined by the potential hazards of the space (i.e., temperature), the contaminants anticipated (i.e., O₂ deficiency, flammable gasses, hydrogen sulfide), the work to be performed and the design of the confined space. When ventilating or purging operations are to be performed, the blower control shall be at a safe distance from the confined space. An audible alarm shall be installed in the space to signal a ventilation failure. 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.

When a ventilation system is operational, air quality measurements shall be made before each work shift to ensure that safe environmental levels are established prior to entry. 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 the National Electrical Code (NEC) for hazardous locations, and the bonding requirements of Article 250 of the NEC.

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 of 1 minute each, conducted at 5 minute intervals (see pre-entry checklist, Appendix A). Care shall be taken to prevent the introduction or 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. This includes welding or painting, or where toxic atmospheres 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 place to obtain maximum dilution. However, special precautions shall be taken if the ventilation system partially blocks the exit opening. These precautions include a method for providing communications and respirable air to each worker during exit.

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 employee shall not be exposed to concentrations of contaminants in excess of those specified in OSHA 29 CFR Part 1910 Sub Part Z (Permissible Exposure Limits). Therefore, respiratory protection may be required in addition to engineering controls. The use of respiratory protection will be determined by the qualified supervisor based on air monitoring results. However, when fumes may be generated that contain highly toxic or airborne metal contaminants, the provisions of 29 CFR 1910.252 (Welding, Cutting and Brazing) 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 (fpm) in the welding zone. Therefore, to obtain maximum effectiveness the welder shall re-position the exhaust hood as welding locations are changed to keep the hood in close proximity to the fume source.
Special precautions shall be taken when off-gassing or vaporization of toxic 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 or 10% of the LEL, whichever is 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 local exhaust, then general ventilation procedures shall be used to control the contaminant level. When the problem of off-gassing is due to the application of protective coatings or paint, ventilation shall be continued until the build-up of a flammable or toxic atmospheres 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 setting and continuous monitoring of the inert make-up ventilation is mandatory.

Monitoring shall include measurement of inert gas flow as well as combustible gas analysis. The inerting operation shall be continuously monitored by the qualified supervisor. Since every confined space will have its own infiltration rate, inerting shall continue for the entire duration of the job at a rate that will prevent air from entering the confined space.

2) Isolation\Lockout\Tagging: The isolation procedures shall be specific for each type of confined space. Safety equipment required during this procedure shall be designated by the qualified supervisor and be dependent upon the potential hazards involved. A confined space shall be completely isolated from all other systems by physical disconnection, double block and bleed, or blanking. In continuous systems, where isolation is not possible, such as sewers or utility tunnels, specific written safety procedures shall be instituted.

Blanks used to seal off lines shall be capable of withstanding the maximum working pressure or load of the line, be provided with a gasket on the pressure side to ensure a leakproof seal and be made of chemically nonreactive 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 those 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. If a drain line is located within the confined space, provisions shall be made when necessary to tag it and leave it open. This also shall be recorded on the entry permit.

Additional procedures, which are necessary when the confined space is of a double wall construction shall be determined by the qualified supervisor 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 or disconnects in the open (off) position with a key-type padlock. The only key shall remain with the person working inside the confined space. Each person working in the space should have their own padlock 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 and chains. Equipment with moving mechanical parts shall also be blocked in such a manner that there can be no accidental rotation.

3) Cleaning: Procedures and processes used to clean the inside of a confined space shall be reviewed and authorized by the qualified supervisor prior to the job. The methods and materials chosen shall be dependent upon the product in the space. If the confined space contains a flammable atmosphere above the LEL for the product, 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 confined space if at all possible.

Special procedures shall be adopted to handle the hazards created by the cleaning process itself. These include cooling the space prior to entry if steam is used as a cleaning agent, ventilation shall be maintained during neutralization procedures to prevent the build-up of toxic materials. Steaming shall not be used as a cleaning method when the product stored was a liquid with an autoignition temperature less than that of the steam. The pipe or nozzle of the steam hose shall be grounded to decrease the generation of static electricity that could accumulate during steaming procedures. These and other hazards and controls shall be evaluated by the qualified supervisor.

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

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

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

   c) All electrical tools, cords and equipment shall be of heavy duty type with heavy duty insulation and visually inspected for defects before use.

   d) 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, but not eliminate it. Explosions can arise by tools overheating, sparks produced by striking and grinding, or discharge of accumulated electrostatic charges developed from the flow of compressed air.

   e) Lighting used in confined spaces shall be of explosion proof design and be equipped with guards. Only equipment listed by the Underwriter’s Laboratories (UL) for use in Division 1 atmospheres, or approved by the Mine Safety and Health Administration (MSHA) or the U. S. 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 American National Standards Institute (ANSI) Z111.1965 or the most recent revision. **Under no circumstances will matches or open flames be used in a confined space for illumination.**

f) Cylinders of compressed gases shall never be taken into a confined space, shall be secured in the upright position at all times and shall be
turned off at the cylinder valve when not in use. Exempt cylinders include SCBA's or resuscitation equipment.

g) Ladders shall be adequately secured or of a permanent type which provides the same degree of safety as required in 29 CFR 1910 Sub Part D (Walking\Working Surfaces).

h) Scaffolding and staging shall be properly designed to carry maximum expected loads and be equipped with traction type planking meeting the requirements of 29 CFR 1910.28 (Safety Requirements for Scaffolding).

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

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

k) 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 MSHA for methane and by UL for all cases.

For permit required entries there should always be someone readily available in the area of the confined space who is currently trained in cardiopulmonary resuscitation (CPR) and basic first-aid procedures. Since irreversible brain damage can occur in approximately 4 minutes during oxygen deficiency, it is essential that resuscitation be prompt.

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.

IX. Training

The supervisor shall be responsible for training personnel and for ensuring that confined space entries are completed in an approved fashion. EH&S is available to assist in providing instructional resources and initial training. Personnel who work in the vicinity of confined spaces shall be made aware of the associated hazards during orientation. The nature of the hazards encountered in a confined space must be considered when structuring an effective training program. The training program shall be based on the specific hazard(s) to be encountered and given to all individuals who will perform the work or may be assigned as standby or rescue.

1) Qualifications of Instructors: 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:

a) Types of confined spaces associated with work at UNF

b) Hazards involved in these spaces: chemical, physical and biological

c) Work practices and techniques

d) Testing requirements, exposure limits and action levels

e) Safety equipment: respirators, clothing, life lines and rescue procedures
2) Training Criteria: Personnel who are required to work in a confined space or support those working in confined spaces shall have training in the following areas:

a) Emergency entry and exit procedures
b) Use of applicable respirators
c) First-aid
d) Lockout\tagout procedures
e) Safety equipment use
f) Communications and Rescue
g) Permit system
h) Work practices

3) Training Methods: The method and approach of training will be determined by the previous experience and skill of the employees, with the exception of a newly hired person who should receive a complete and thorough safety orientation. Basic types of recommended training are:

a) Orientation of all new employees. This type of training would consist of classroom sessions along with a review of work settings to give the employee a basic understanding of what to expect.

b) On-the-job training. After the employee 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.

c) Retraining should be performed annually. Many activities are complex, infrequently conducted and constantly updated. It is important 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.

For training to be effective, classroom sessions and on-the-job or simulated conditions are recommended methods. Classroom sessions should cover all applicable regulations as well as specific hazards associated with working in confined spaces. On-the-job training should be closely supervised until the employee has a complete understanding of all procedures and potential hazards. Testing of the employee should take place to evaluate their competency and determine if retraining is necessary.

4) Training Evaluation: The effectiveness of the training program can be determined by several means. Observation of the employee by the supervisor to ensure safe work practices are being followed shall constantly be conducted.

Testing the employee for knowledge of the operations and hazards shall be conducted after each training session. A reduction in the accident rate due to safe work practices and techniques which have been learned and are being practiced can serve as a clear indicator of employee retention and training effectiveness. Appendix C provides additional guidance for training program content.

X. Medical Examinations
Medical requirements for employees who might enter a confined space should take into consideration the increased hazard potential of working in the spaces. In these settings, employees must rely more heavily upon their physical, mental and sensory attributes, especially under emergency conditions. Employees should be evaluated by an Occupational Physician to insure that they are physically and mentally able to wear respirators per the requirements of the UNF Respiratory Protection Program. Because of the additional stress placed on the cardiopulmonary system, some pathologic conditions such as heart disease or those associated with hypoxemia, may preclude the use of respiratory protective equipment.

Employees who work in confined spaces shall have a preplacement physical examination made available to them. The department shall provide to the physician 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 equipment the employee may be required to use. A copy of this written program will also be provided by EH&S.

The physical examination should include at a minimum:

1) A demonstration of the employee's ability to use negative and positive pressure respirators per the UNF Respiratory Protection Program.

2) A demonstration of the employee's 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 assigned duties and the detection of any diseases or abnormalities which may prohibit work in confined spaces.

Following completion of the examination, the physician shall provide the department with a written statement specifying any condition or abnormality found which would restrict or preclude the employee's ability to work in a confined space.

Periodic medical examinations (minimum three years) shall be made available to employees required to work in confined spaces at the discretion of the physician. A post-employment examination shall also be conducted per the requirements of the UNF Respiratory Protection Program.

XII. Labeling and Posting

All warning signs shall be printed both in English and the predominant language of the non-English reading employees who may be required to enter the space (i.e. Spanish). Where established symbols exist, they shall also be used. Impacted employees who are unable to read labels and posted signs shall receive information regarding hazardous areas and shall be verbally informed of the instructions printed on the signs.

All entrances to any permit required confined space shall be posted. Signs shall include, but not necessarily be limited to the following:

DANGER
CONFINED SPACE
ENTRY BY PERMIT ONLY

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

RESPIRATOR REQUIRED FOR ENTRY
LIFELINE REQUIRED FOR ENTRY
NO HOT WORK PERMITTED
Emergency procedures, including phone numbers for emergency medical services, University Police Department, EH&S and Jacksonville Fire and Rescue Department shall be posted conspicuously within the immediate area of the confined space, on the entry permit or at the telephone to be used in the work area.

XII. Safety Equipment and Clothing

The entry permit shall include a list of the necessary protective equipment to be used in the confined space as determined by the qualified supervisor. The department supervisor shall be responsible for the proper use, inspection and maintenance of the safety equipment. Should any question arise concerning type of equipment or application, contact EH&S before proceeding.

Those items normally used to protect against traumatic injury include: safety glasses/goggles, hard hats, protective footwear, gloves and chemical resistant clothing.

1) Eye Protection: If eye-irritating substances are present in the work space, safety goggles shall be required. If both the face and eyes are exposed to a hazard, as during scraping, sanding or spraying, a full face shield with goggles shall be used. During welding operations, special goggles or shields shall be required in accordance with OSHA 29 CFR 1910.252 (Welding, Cutting and Brazing).

2) Head Protection: Head protection shall be required in areas where overhead hazards exist and shall meet the requirements of OSHA 29 CFR 1910.135 (Occupational Head Protection).

3) Foot Protection: Foot protection shall meet or exceed the requirements of OSHA 29 CFR 1910.136 (Occupational Foot Protection) and shall provide additional protection from other hazards identified by the qualified supervisor (i.e. chemical resistance, grounding, etc).

4) Body Protection: Body protection shall include standard work clothing as specified by the qualified supervisor (leather work boots, cotton shirt and pants, leather gloves and hard hat). Specific conditions may require chemical resistant coveralls and gloves designed for the substances expected in the space. If the hazards of heat or cold 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 proof), riveting (heat resistant) and abrasive blasting (abrasion resistance) shall be provided to and worn by impacted employees.

5) Hearing Protection: Hearing protection shall be required when engineering controls are unable to control the noise level and when the ambient noise level exceeds the allowable limit in Table G-16 of OSHA 29 CFR 1910. If high noise levels are present, contact EH&S for further guidance on recommended monitoring procedures.

6) Respiratory Protection: Respiratory protection shall be determined by the supervisor based upon conditions and air monitoring results of the confined space and the work to be performed. Half-face respirators are not recommended for use in any atmosphere >10 times the PEL. The minimum service life of the SCBA shall be determined prior to entering the space, based on the maximum work period, plus twice the expected escape time required.

The respirators used shall be NIOSH and MSHA approved devices and shall be fitted and maintained in accordance with the UNF Respiratory Protection Program.

7) Hand Protection: Hand protection can range from canvas to metal mesh gloves depending upon the conditions of the confined space. Gloves made of impervious rubber or similar
material are to be worn to protect against chemical insult. Heat protective gloves are required when employee's handle objects with temperatures greater than 60°C (140°F). Where a current flow through of more than 5 milliamperes may result from contact with energized electrical equipment, employees shall wear insulated gloves that have been visually inspected before each use. Above 5,000 volts, rubber gloves in accordance with OSHA 29 CFR 1910.137 (Occupational Hand Protection) shall be worn.

8) Additional Safety Equipment: Additional safety equipment that is necessary to protect the employee in a permit required confined space include a safety belt with "D" rings for attaching a life line. The combination of a body harness or safety belt with life line shall be used when an employee is required to enter the space and conduct air testing; when an employee is working in an area where entry for 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 IDLH.

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 in diameter, then a wrist type harness shall be used.

When it is determined by the qualified supervisor that none of the special hazards associated with confined space pose an immediate threat to life, then life lines shall be readily available but are not required during entry work procedures.

Other protective measures shall include:

a) Safety nets used to protect employees working 10 feet above ground or grade level when other protective devices are impractical.

b) Life jackets shall be worn if the workers are exposed to falls into liquid over 4 feet in depth.

c) Insulated floor mats when hot work requires use of electrical energy in wet locations.

When employees enter a confined space, a barricade shall be erected where inadvertent entry may occur. The barricade shall indicate warning of the danger present. 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 qualified supervisor shall be responsible for on-site maintenance of the barricade system.

XIII. Recordkeeping

The department shall maintain a written record of training including safety drills and equipment inspections for at least one (1) year after the last date of training, inspection, test or maintenance or until the date of the next session.

Where atmospheric testing indicates the presence of a toxic substance, records shall be maintained in accordance with existing federal regulations. This includes the dates and times of measurements, duties and location of the employee within the confined space, sampling and analytical methods used, number, duration and results of the samples taken, PEL concentrations calculated, types of personal protective equipment worn, and employee's names. Completed data sheets shall be maintained as specified below.

Where medical monitoring is conducted for respiratory protection and over-exposure, records shall be maintained for the duration of employment plus thirty (30) years.
APPENDIX B
CONFINED SPACE ENTRY PERMIT

LOCATION OF WORK: ____________________________________________

DESCRIPTION OF WORK: ________________________________________

EMPLOYEES ASSIGNED: _________________________________________

ENTRY DATE: ___________ ENTRY TIME: ___________ EXIT TIME: ___________

ISOLATION CHECKLIST:
Blanking/Disconnecting Lines
Electrical Devices
Mechanical Devices
Other: ___________________________

HAZARDOUS WORK CHECKLIST:
Burning
Welding
Brazing
Open Flame
Other: ___________________________

HAZARDS EXPECTED:
Corrosive Materials:
Flammable Materials:
Drains
Toxic Materials:
Deposits
Spark Producing Operations:
Method
Inspection
Neutralized with:

Pressure Systems:
Hot work:
Cleaning (chemical):

PERSONAL SAFETY CHECKLIST:
Ventilation Requirements
Clothing
Head, Hand, Foot Protection
Eye, Hearing Protection
Life lines and Harness
Lighting
Communications
Training Completed
Buddy System
Standby Person
Emergency Egress Procedures
Respirators
Barricades

ATMOSPHERIC MONITORING:
Calibrations:(Date, Time)
Oxygen Meter:
Flammability:
Toxics Meter:
Analyze
Oxygen: %
Flammability: %
Toxics: ppm
Particulate: mg/m³

Monitoring Comments: _________________________________________

Tests Performed By: ___________________________ PERMIT EXPIRES: ___________

EMERGENCY PROCEDURES RECEIVED:
Standby Person: ___________________________ Rescue Person: ___________________________

Emergency Telephone #: ___________________________

Supervisor Approval:
PF Safety Officer Approval:

APPENDIX A
CONFINED SPACE ENTRY CHECKLIST

COMPLETE PRIOR TO WORK AND BRING THIS CHECKLIST TO THE JOB SITE

DATE OF JOB: ___________________________

LOCATION: ______________________________

OBJECTIVE: ____________________________________________________________

SUPERVISOR: ___________________________

EMPLOYEES: ______________________________

AIR MONITORING - REQUIRED PRIOR TO ENTRY

Oxygen (19.5% -22% safe condition): __________

Explosive Atmospheres (<10% of LEL or no audible alarm safe condition): ______________

Other: (H₂S, CO, etc.): ______________

Frequency (periodic, continuous): __________

VENTILATION (required for unsafe conditions noted above): ________________________________

ISOLATION (electrical, mechanical, gas, fluid, steam): ______

CLOTHING/EQUIPMENT (safety glasses, gloves, boots, coveralls, respirators, safety harness, communications): ______

________________________________________

BARRICADE: ____________________________

ENTRANCE METHOD:

EMERGENCY PROCEDURES:

SUPERVISORS SIGNATURE:

DATE: ________________________________ DEPARTMENT: ______________________________

APPENDIX C

TRAINING PROGRAM CONTENT

The supervisor 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 areas that shall be covered in training:
1) The types of confined spaces that are found in the workplace: 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 such as scaffolding or ladders. Chemical hazards discussed should include the product which has been stored or cleaning agents used in the space that may contribute to the air contamination during work procedures.

3) Atmospheric testing of the confined space: This phase of the instruction should emphasize the contaminants which should be tested for, the permissible exposure limits and action levels for entry.

4) Cleaning and purging: Cleaning methods to be discussed should include steaming, water rinse, chemical, 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 employees 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 employee should be able to recognize a hazard by visual observation of connecting lines in a confined space. The lockout of electrical circuits and mechanical disconnects to complete confined space isolation should be explained as should the employee's responsibilities in this area.

7) Safety equipment and clothing: The employee should be aware of the proper use and care of personal protective equipment. This should include the type of protective shoes, gloves, face protection, protective clothing, head protection, safety belts and harnesses and hearing protection. Information should also include the rationale for their use. A major area of discussion will be the use of respirators: the types required, their use, fit testing, cleaning and proper storage. It should be emphasized that different types of respirators are required for different atmospheres and the dangers involved when the wrong type of unit is used. The mandatory wearing of safety belts should also be stressed. The use of safety belts and life lines should be demonstrated so that each employee understands the importance of having the rescue system available, 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 shall be fully trained in emergency exit procedures. Additional training should include first-aid and CPR. This should include on-site entry and rescue drills.

11) Permit system used by the University: Information covered on the permit shall include: purpose of the permit; location where the permit will be posted on site; responsible persons; emergency information and hazards to be expected. See Appendix B.

12) Documentation of training: Satisfactory completion of the safety training and refresher courses shall be entered into the employee's permanent record.

APPENDIX D
HAZARDS OF CONFINED SPACES
Hazards specific to a confined space are dictated by the material stored or used in the space, the activity to be carried out in the space and the external environment. These can be categorized as atmospheric, physical, and biological hazards.

Hazardous atmospheres encountered in confined spaces can be further divided into four distinct categories: flammable, toxic, irritant/corrosive and asphyxiating.

1) Flammable Atmospheres: A flammable atmosphere generally arises from enriched oxygen atmospheres, vaporization of flammable liquids, byproducts of work, chemical reactions, combustible dusts or desorption of chemicals from inner surfaces of the confined space.

An atmosphere becomes flammable when the ratio of oxygen to combustible material in the air is neither too rich nor too lean to burn. Combustible gases or vapors will accumulate when there is inadequate ventilation in areas such as a confined space. Flammable gases such as hydrogen sulfide, acetylene, butane, propane, hydrogen, methane, natural or manufactured gases or vapors from glues, mastics and waterproofing compounds can be trapped in confined spaces. Since many of these gases are heavier than air, they will seek the lowest levels. In a closed top tank, it should also be noted that lighter than air gases may rise and develop a flammable level at the top of the confined space.

The byproducts of work procedures can generate flammable or explosive conditions within a confined space. Specific kinds of work such as spray painting can release explosive gases and vapors. Welding in a confined space will burn up oxygen and can release explosive gases thereby changing the conditions in the space to those conducive to explosion.

Chemical reactions forming flammable atmospheres occur when surfaces are initially exposed to the atmosphere, or when chemicals combine to form flammable gases. This condition can arise when dilute sulfuric acid reacts with iron to form hydrogen gas or when calcium carbide makes contact with water to form acetylene. Other examples include 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, can spontaneously ignite upon exposure to air.

Combustible dust concentrations are usually found during the process of loading, unloading and conveying grain products, fertilizers, finely ground chemical products and other combustible materials. High charges of static electricity, accumulating during periods of low humidity (below 50%), can cause certain substances to accumulate sufficient energy to produce sparks and ignite a flammable atmosphere. 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 can 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 can desorb the remaining gas from the porous surface of the confined space.

2) Toxic Atmospheres: The substances to be regarded as toxic in a confined space can cover the entire spectrum of gases, vapors fumes, aerosols and finely divided airborne dust. The sources include manufacturing processes, product storage and operations performed in the space.
Toxic gases can be evolved when acids are used for cleaning. Hydrochloric acid can react with iron sulfide to produce hydrogen sulfide (H$_2$S). H$_2$S is also formed from the decay of organic matter such as leaves, silage, and sewage. During loading, unloading, formulating and production, toxic gases can be produced which are not part of the planned operation.

Toxic solvents such as trichloroethylene, methyl chloroform and dichloromethane are used for cleaning and degreasing. Acrylonitrile has been encountered as an ingredient in protective coatings applied to tank interiors. Trichloroethane and dichloroethylene are widely used as cleaning agents because they are among the least toxic of the chlorinated aliphatic hydrocarbons. However, deaths have occurred from asphyxiation and explosions from failure to thoroughly purge and inert confined spaces.

The compatibility of materials must be considered when structural members and equipment are introduced into confined spaces. The previous history of the space must be carefully evaluated to avoid reactions with residual chemicals, wall scale and sludge, which can be highly reactive. Cases of incompatibility have occurred during the use of chemical cleaning agents. The initial step in chemical cleaning usually is the conversion of the scale or sludge into liquid state which may cause poisonous gases to be liberated.

Another hazardous gas that may build up in a confined space is carbon monoxide (CO). This odorless, colorless gas having the same density as air is formed during combustion of organic materials such as wood, coal, gas, oil and gasoline. It can also be formed from microbial decomposition of organic matter in sewers, silos and fermentation tanks. CO is an insidious gas because of its lack of warning properties mentioned above. Early stages of intoxication are nausea and headache. CO can be fatal at 1000 parts per million (ppm) in air and is considered dangerous at 200 ppm. It acts to bind with the hemoglobin of the blood in the place of oxygen resulting in death through asphyxiation.

CO is relatively abundant and any untested atmosphere must be suspect. It must also be noted that a safe reading on a combustible gas indicator (explosimeter) does not ensure that CO is not present. CO must be tested for specifically as formulation can result from chemical reactions or work activities and fatalities are not confined to any specific industry. There have been accidents in sewage treatment plants, paint and varnish industry and welding operations.

3) Irritant (corrosive) Atmospheres: Irritant or corrosive atmospheres can be divided into primary and secondary groups. The primary irritants exert no systemic effects because the products formed by them on tissues of the respiratory tract are non-irritant and other effects are so violent as to obscure any systemic action. Examples of primary irritants are chlorine, ozone, hydrochloric acid, hydrofluoric acid, sulfuric acid, nitrogen dioxide, ammonia and sulfur dioxide. A secondary irritant is one that may produce systemic toxic effects in addition to surface irritation. Examples of secondary irritants include benzene, carbon tetrachloride, ethyl chloride, trichloroethane, trichloroethylene and chloroprene.

Irritant gases are widely used throughout 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.

Prolonged exposure to 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 impacted nerve system. The danger in this situation is that the employee is usually not aware of any increase in his exposure to toxic substances.

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

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, 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. The number of employees in a confined space and the amount of work 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 inverting 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 by asphyxiation. The use of nitrogen to inert a confined space has claimed more lives than carbon dioxide. The total displacement of oxygen with nitrogen will cause immediate collapse and death. Carbon dioxide and argon are both heavier than air and can lie in a tank or manhole for hours or days after opening. Since these gases are colorless and odorless, they pose an immediate hazard to health unless appropriate oxygen measurements and ventilation are adequately carried out.

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 of 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% the physiologic effects are increased breathing volume, accelerated heart beat, very poor coordination, rapid fatigue and intermittent respiration. Between 6-10% the effects are nausea, vomiting, inability to perform and unconsciousness. Less than 6% results in spasmatic breathing, convulsive movements and death in minutes.

5) Mechanical Safety Hazards: If activation of electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated to prevent inadvertent activation before work in a confined space commences. 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, employees should completely isolate the space. To do so means closing all valves and disconnecting or blanking all pipes. Other special precautions must be taken in cases where flammable liquids or vapors may recontaminate the confined space. The lines that are disconnected/blanked should be inspected and tested for leaks 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.
6) Communication Problems: Communication between the employee inside the space and the standby person outside is of utmost importance. If the employee should suddenly feel distressed and not be able to summon help, an injury could become fatal. Frequently, the body positions that are assumed in a confined space make it difficult for the standby person to detect an unconscious employee. When visual monitoring of personnel is not possible because of the design of the space, a voice activated explosion proof communication system shall be instituted.

7) 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 space. The extent of the 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:

   a) Type of confined space to be entered,
   b) Access to the entrance,
   c) Number and size of openings or barriers within the space,
   d) The occupancy load,
   e) The time requirement for exiting in the event of fire or vapor incursion,
   f) The time required to rescue injured employees.

8) Physical Hazards: The hazards described in this section are non-chemical, physiologic stressors. These include thermal, noise, vibration and fatigue while working in a confined space.

9) Thermal Effects: Four factors effect the interchange of heat between man and the environment. These include air temperature, air velocity, moisture content of the air and radiant heat. 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, employees will continue to function until the body temperature reaches about 100.9°F to 102.9°F. When this body temperature is exceeded, employees are less efficient and are prone to heat exhaustion, heat cramps or heat stroke. 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 situations is chilling of the extremities so that activity is restricted. 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 employee and must be considered in allowing for movement in the confined space and exit time. Therefore, air temperature of the space becomes an important consideration when evaluating working conditions.

10) Noise: Noise problems are usually intensified in confined spaces because the interior tends to cause sound to reverberate and thus expose the employee to higher sound levels than those found in an open environment. This intensified noise increases the risk of hearing damage 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 space. If the employees inside are not able to hear commands or danger signals due to excessive noise, the probability of severe accidents will increase.
11) Vibration: Whole body 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, is more localized in creating injury to the fingers and hands of employees using tools like pneumatic hammers and rotary grinders.

12) General: Some physical hazards cannot be eliminated because of the nature of the 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 employees or materials falling, improper use of guard rails and lack of maintenance to insure employee 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, employees must review and enforce safety precautions to prevent injury.

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 employee. If the employee is above the opening, the system must include a rescue arrangement operated from outside the confined space by which the employee can be lowered and removed without injury.

Confined spaces present many hazards that are inherent by design and exacerbated by definition. However through proper training, evaluation and controls, duties can be conducted in a safe and efficient manner.
REFERENCES

