WERC Design Contest **ESP# WERC - 2018 - 2002**

Experiment Safety Plan **Rev 0**

An Experiment Safety Plan (ESP) is required for every experiment conducted and performed by students in the WERC Design Contest. The purpose of the ESP is to assure the safety of all by identifying the safest possible methods to conduct an experiment. By signing below the individual(s) conducting the experiment, College of Engineering Safety Specialist (COE Safety), and the faculty advisor acknowledge responsibility for the following requirements.

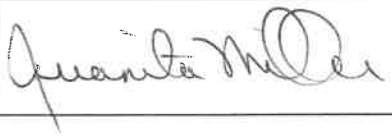
1) Appropriate Personal Protective Equipment (PPE) ***must always*** be worn while in the lab (as described in the ESP). **The minimum required PPE to enter a research/teaching lab is (1) long pants, (2) closed toe shoes, (3) lab coat or long sleeve shirt, and (4) safety glasses with side shields.**

2) For safety reasons, no researcher is permitted to work alone in the lab at any time. Because the labs are open 24/7, there may be occasions (such as a late night or over weekends) when there are no other people working in the lab. If you plan to work during a time when the lab might be expected to be empty, please plan ahead and coordinate your work schedule with another lab member.

3) ESP approval occurs in two phases.

   a. Phase I is the preparation of a written safety plan. Upon approval of the written plan, by email from COE Safety, researcher(s) may order equipment and necessary supplies, and assemble experiment for transport to NMSU. Phase I also includes an evaluation by COE Safety (and if appropriate by EH&S) to establish controls of hazardous operations, avoid the purchase of inappropriate supplies, and establish expected waste(s) streams.

   b. Phase II approval will occur onsite at the event and requires evaluation of the assembled experiment, and a "dry run" of the experimental procedure. . High Hazard work may be subject to approval by official university boards, including any work with radioactive materials or radiation producing machines, certain biological materials, animals and/or human subjects.

		Date
ESP Phase I approval: **COE Safety**		02/28/18
ESP Phase II approval **COE Safety**		

4) By signing below, both faculty advisor and researchers(s) understand that the CHO can approve/disapprove any part of the ESP. The CHO can further assemble a committee of individuals with appropriate technical or EH&S background to assist in reviewing the ESP. It is the goal of the CHO to help the researcher(s) find the safest method(s) of conducting an experiment. The CHO, or any faculty member, may stop lab activity of individuals not following good lab practices.

	Name	Signature	Date
School and Team	University of Idaho - Gypsos	NA	NA
Faculty Advisor	Dr. David Drown		
Researcher	Nathan Myers		
Researcher	Nigel Hebbeln		

Researcher	Lillian Malloy		
Researcher	Abdullah Alnafisah		
Researcher			
Researcher			
EH&S (at request of COE Safety)			

NMSU WERC Design Contest Experimental Safety Plan (ESP)

This document must be typed.

Task # (as given on WERC Website)	2	
Name/Title of Experiment:	Sulfate Removal of Industrial Wastewater via Ettringite Precipitation	
Booth Number:		
Location Inside/Outside	Inside	
Emergency Contacts (Required):	EMERGENCY	911
Function	Name	Contact Phone (at Event)
Experiment Coordinator	Stefan Perez	915-731-5710
Safety Coordinator	Juanita Miller	575-415-7999
Compliance Officer/Samples	Jalal Rastegary	915-540-5391
Faculty Advisor	Dr. David Drown	208-892-3130
Responsible Researcher	Nathan Myers	208-249-4531
Responsible Researcher		

Required attachments to the ESP:

Attachment 1: Experiment Scope

Attachment 2: Drawing of the Experimental Layout including PFD

Attachment 3: Normal Operations, Startup and Shutdown Procedures

Attachment 4: Emergency Shutdown Procedure and medical emergency instructions.

Attachment 5: Waste Management Procedure

Attachment 6: Hazard Identification and Mitigation

Attachment 7: Material Safety Data Sheets

Attachment 1 – Experiment Scope

The goal of the project is to reduce the sulfate concentration below 250 mg/L. The samples will be analyzed using conductivity and turbidity probes. This project will demonstrate ettringite precipitation to remove sulfate from mine impacted waters. The process consists of two stages. The first involves a semibatch reaction in which calcium hydroxide is added incrementally to the mine water and aluminum hydroxide in a beaker in order to maintain the pH of the solution to promote ettringite precipitation to occur. Once the reaction is completed, the solution will be sent through a gravity filter - the water of which will be sent to stage 2. Carbon dioxide gas will be sparged through the solution to neutralize the water. This will precipitate out calcium carbonate. The solution will be sent through another gravity filter to separate out the solids. The resulting water is the treated water. The full bench scale has not been tested to completion, so the timeline is not yet known.

Mine water will be made by supersaturating deionized water with calcium sulfate – resulting in a sulfate concentration range of 1500-1800 mg/L. The goal of the project is to reduce the sulfate concentration below 250 mg/L. The samples will be analyzed using conductivity and turbidity probes.

Stoichiometry:

Stage 1:

$6Ca^{2+} + 3SO_4^{2-} + Al_2(OH)_6(s) + 37H_2O \rightarrow Ca_6Al_2(SO_4)_3(OH)_{12}25H_2O(s) + 6\ H_3O^+$

Stage 2:

$Ca^{2+} + CO_2(g) + 2OH^- \rightarrow CaCO_3(s) + H_2O$

Equipment used:

Stirring hot plate

Stir bar

2 L beakers (2)

Gravity filter (2)

pH sensor/temperature sensor (2)

pH controller (2)

Valves (2)

Screw Motor (1)

Flowmeter (1)

Peristaltic Pump (1)

Chemicals used:

DI water

Calcium sulfate

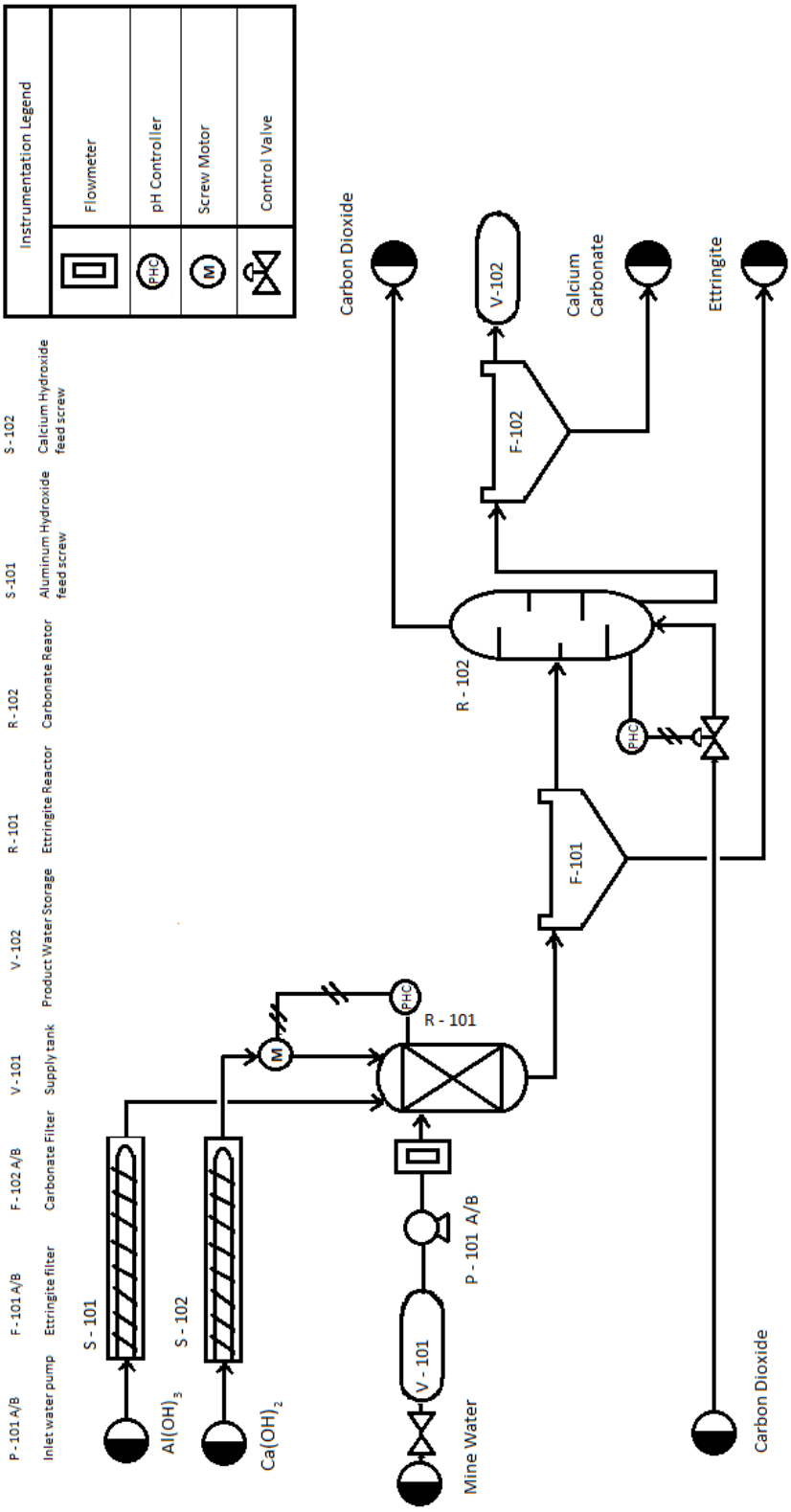
Aluminum hydroxide

Calcium hydroxide

Carbon dioxide gas

Attachment 2 - Drawing of the Experimental Layout including P&ID

Provide a detailed drawing of the experiment including P&ID's showing all inputs and outputs for equipment.



Attachment 3 – Normal Operations, Startup and Shutdown Procedures

*Provide a **step-wise** procedure that describes **in detail** how the work will be performed. The procedure should begin and end with the equipment in the normal idle (inoperative) state.*

*Include a statement of the required PPE **at the beginning** of the procedure, and at every location in the procedure where the PPE requirements change.*

Include details of how you will meet the required elements of your chosen task (e.g. run time, run rate, sample rate etc.)

Indicate where hazardous feedstock chemicals will be stored, how they will be transported to the location of the experimental work, how they will be transferred from storage vial into the experimental apparatus, and how they will be returned to storage.

Fill out the Take into account those items for which you indicate "yes" on the NMSU Lab Hazard Assessment Checklist, which is found at the end of this document..

As seen in the PFD on the previous page, the apparatus will consist of two stages. The process is currently semi-batch, but the goal is to make the process continuous with the aid of controllers by the time of the competition. The mine water and the optimum amount of aluminum hydroxide will be added to the 2 L beaker. The stir plate will be turned on. Using a pH probe and a controller, incremental doses of the calcium hydroxide will be added to raise and maintain the pH of the solution to 11.4-12.4. Once the reaction is completed – the majority of the ettringite has precipitated, the solution will be sent through a gravity filter. The liquid from the gravity filter will be sent on to stage 2. Once the 2 L beaker from stage 2 is filled, the carbon dioxide gas will be sparged through the solution to neutralize the water to approximately 8.5. This will also precipitate out calcium carbonate. The solution will be sent through a gravity filter, the liquid of which will be the treated water product.

Safety glasses, long pants, and closed toe shoes will be required in the lab while preparing samples, running the procedure, and testing the samples for sulfate concentration, and gloves will be utilized when handling lime.

The overall flowrate of the project will be maintained at 22 mL/min and the concentration of sulfate below 250 mg/L.

The reagents are not hazardous, but will still be handled with care – using metal spatulas and scoops along with trays to weigh out and distribute correct amounts of power reagents from the storage containers to the bench scale apparatus. The carbon dioxide gas will be connected via tube directly to the apparatus and will not require special handling. All of the aluminum hydroxide that is weighed out will be used during the experiment, but there is a chance that there will be leftover calcium hydroxide. This should not be contaminated as it is in a tray so it can be placed back into the original bin, but it can also be disposed of as it is a stable compound.

Attachment 4 -. Emergency Shutdown Procedure

*Provide a **step-wise** procedure that describes how the equipment will be brought to a safe state in the event of an emergency. The description should include a detailed explanation of how to attend to potential medical emergencies that may result.*

All pumps and motors will be attached to a surge protector power strip. Power will first pass through an on off switch before entering the surge protector. In the event of an emergency, this switch can be flipped to cut power to all portions of the process at once. The control valves used in the process will be fail to close.

Attachment 5 - Waste Management Procedure

Prepare a Waste Management Procedure that provides the exact nature and estimated volumes of all wastes to be generated in performing these experiments. NMSU will provide containers and forms to be filled out by the researcher for proper disposal of materials. An example Waste tracking form is attached for reference.

As the full procedure is not yet up and running, the exact amounts of waste generated with each stage are unknown and have been estimated based off of data collected thus far. To treat 20 ml/min of water, there is approximately 1.16 ml/min out of ettringite slurry in the first stage. The second stage of the process (carbonation stage) has yet to be completed but the outlet concentration should have no more 82.2 mg/min in the slurry. Calcium carbonate is known as an EPA safer chemical (verified to be of low concern based on experimental and modeled data), but it should stored in a dry, tightly sealed container to avoid releasing it into the environment and disposed of in the trash. While it is non-hazardous, it should be stored separately from acids, alum, ammonium salts, fluorine, mercury, hydrogen, heat, sparks, and open flame. Ettringite is also a non-hazardous solid, but it should be disposed of in the same manner as calcium carbonate.

Identify ALL HIGH hazards associated with the experiment. The analysis must consider

- *all sources of energy (electric, chemical, hydraulics, mechanical, compressed gases),*
- *extreme conditions of pressure or temperature (from flame or steam to cryogenics),*
- *chemical storage,*
- *housekeeping,*
- *fire, and/or*
- *biological hazards.*

Examples of HIGH hazards to include (list not exhaustive):

- *substances that are highly reactive, radioactive, highly flammable, pyrophoric, highly toxic, mutagenic, teratogenic, carcinogenic, or have very low exposure limits,*
- *high voltage, high RF, x-ray, laser (class 3b or 4),*
- *high temperatures, and*
- *high pressure or pressurizing vessels.*

When in doubt about whether a substance represents a HIGH HAZARD, ask for assistance.

For each HIGH hazard (use the checklist as a guide to identifying these hazards, chme.nmsu.edu/files/2013/11/Lab-PPE-selection1.pdf), provide the following information:

1. *description of the HIGH hazard;*
2. *operational and engineering controls that will be used (based on identified industry best-practices used in addressing this safety hazard);*
3. *required PPE (beyond minimum) when this HIGH hazard is present; and*
4. *special training (beyond minimum) that is necessary.*

- Energy sources: energy hazards in the system will include compressed CO_2 gas, mechanical hazards from the feed screws for both the aluminum and calcium hydroxide, and the raw water feed pump, electrical hazards from the power supply for the raw water feed pump and the power supply for the systems controllers, and chemical hazards from the raw materials.
- Extreme conditions: This system has no extreme conditions.
- Chemical Storage: Chemicals will be stored in plastic containers.
- Housekeeping: All spills of liquids and powders will be cleaned imediately. Liquids will be keep away from power supplies and electronics to prevents shock hazards.
- This system has no fire or biological hazards

1. Mechanical Hazards: Mechanical parts of the feed pump and screws would contain pinch points possible of causing physical harm
    1. The best practice for making mechanical hazards safe is to install guards and covers.
    2. No extra PPE will be required when operating this equipment.
    3. No extra training will be required when operating this equipment.
2. The compressed gas can pose a possible hazard by creating pressure in the system.

    1. All air lines will be inspected before use to ensure no blockages have formed that could cause pressure spikes in the system. System should be operated in a well ventilated area, like a large room.
    2. No extra PPE or training will be needed to operate this portion of the system
3. Chemical Hazards are due to the caustic nature of calcium hydroxide and aluminum hydroxide.
    1. Chemicals will be stored in airtight containers to mitigate particle release to the surrounding air.
    2. No extra PPE will be required
4. Electrical Hazards: These come in the form of power supplies and controllers.
    1. Electrical systems will be stored in areas away from water sources to ensure electrical shocks don't occur.

Attachment 7 – Safety Data Sheets (SDS) for All Chemicals Used/Generated in Experiment

See attached files for safety data sheets.

Attachment 8 – NMSU Job Hazard Assessment Checklist

NMSU Lab (JHA) Hazard Assessment (Questions EH&S -http://safety.nmsu.edu or 575-646-3327) Sept.2012

Are the following activities performed in the lab?		**Chemical Hazards**	
Activity	Y/N	Potential Hazard	Applicable PPE
Working with small volumes (<4 liters) of corrosive liquids.	If yes	Eye or skin damage.	Safety glasses or goggles. Light chemical-resistant gloves. Lab coat.
Working with large volumes (>4 liters) of corrosive liquids, small to large volumes of acutely toxic corrosives, or work which creates a splash hazard.[1]	If yes	Poisoning, increased potential for eye and skin damage.	Safety goggles. Heavy chemical-resistant gloves. Lab coat and chemical-resistant apron.
Working with small volumes (<4 liters) of organic solvents or flammable organic compounds.	If yes	Skin or eye damage, potential poisoning through skin contact.	Safety glasses or goggles. Light chemical-resistant gloves. Lab coat.
Working with large volumes (>4 liters) of organic solvents, small to large volumes of very dangerous solvents, or work which creates a splash hazard.[1]	If yes	Major skin or eye damage, potential poisoning through skin contact. Fire.	Safety goggles. Heavy chemical-resistant gloves. Flame-resistant lab coat (e.g. Nomex).
Working with toxic or hazardous chemicals (solid, liquid, or gas)[1, 2]	If yes	Skin or eye damage, potential poisoning through skin contact.	Safety glasses (goggles for large quantities). Light chemical-resistant gloves. Lab coat.
Working with acutely toxic or hazardous chemicals (solid, liquid, or gas)[1, 2, 3]	If yes	Increased potential for eye or skin damage, increased potential poisoning through skin contact.	Safety goggles. Heavy chemical-resistant gloves. Lab coat.
Working with an apparatus with contents under pressure or vacuum.	If yes	Eye or skin damage.	Safety glasses or goggles, face shield for high risk activities. Chemical-resistant gloves. Lab coat, chemical-resistant apron for high risk activities.
Working with air or water reactive chemicals.	If yes	Severe skin and eye damage. Fire.	Work in inert atmosphere, when possible. Safety glasses or goggles. Chemical-resistant gloves. Lab coat, flame resistant lab coat for high risk activities (e.g. Nomex). Chemical-resistant apron for high risk activities.
Working with potentially explosive chemicals.	If yes	Splash, detonation, flying debris, skin and eye damage. Fire.	Safety glasses, face shield, and blast shield. Heavy gloves. Flame-resistant lab coat (e.g. Nomex).
Working with low and high temperatures.	If yes	Burns, splashes. Fire.	Safety glasses. Lab coat. Thermal insulated gloves, when needed.
Minor chemical spill cleanup.	If yes	Skin or eye damage, respiratory damage.	Safety glasses or goggles. Chemical- resistant gloves. Lab coat. Chemical-resistant apron and boot/shoe covers for high risk activities. Respirator as needed. Consider keeping Silver Shield gloves in the lab spill kit.

Attachment 8 –NMSU Job Hazard Assessment Checklist

NMSU Lab (JHA) Hazard Assessment (Questions EH&S-http://safety.nmsu.edu or 575-6463327) Sept.2012

Are the following activities performed in the lab?		**Biological Hazards**	
Activity	Y/N	Potential Hazard	Applicable PPE
Working with human blood, body fluids, tissues, or blood borne pathogens (BBP).[5]	If yes	Exposure to infectious material.	Safety goggles with face shield or facemask plus goggles, latex or nitrile gloves, lab coat or gown.
Working with preserved animal and/or human specimens.	If yes	Exposure to infectious material or preservatives.	Safety glasses or goggles, protective gloves such as light latex or nitrile for unpreserved specimens (select protective glove for preserved specimens according to preservative used), lab coat or gown.
Working with radioactive human blood, body fluids, or blood borne pathogens (BBP).	If yes	Cell damage, potential spread of radioactive contaminants, or potential BBP exposure.	Safety glasses (goggles for splash hazard), light latex or nitrile gloves, lab coat or gown.
Working with agents or recombinant DNA classified as Biosafety Level 1 (BSL-1).	If yes	Eye or skin irritation.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves for broken skin or skin rash, lab coat or gown.
Manipulation of cell lines, viruses, bacteria, or other organisms classified as Biosafety Level 2 (BSL-2). 5	If yes	Exposure to infectious material, particularly through broken skin or mucous membranes.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves, lab coat or gown.
Manipulation of infectious materials classified as Biosafety Level 2 facility with BSL-3 practices (BSL-2+).	If yes	Exposure to infectious materials with high risk of exposure by contact or mucous membranes.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves (double), lab coat or disposable gown (preferred), surgical mask.
Manipulation of infectious materials classified as Biosafety Level 3 (BLS-3).	If yes	Exposure to infectious materials with high risk of exposure, particularly through the inhalation route.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves (double), full disposable gown or Tyvek suite (preferred), respirator, shoe cover or dedicated shoe.
Working with live animals (Animal Biosafety Level 1, ABL-1).	If yes	Animal bites, allergies.	Safety glasses or goggles for protection from splash or other eye hazard, light latex, nitrile or vinyl gloves for broken skin or skin rash, lab coat or gown. Consider need for wire mesh glove.
Working with live animals (Animal Biosafety Level 2).[5]	If yes	Animal bites, exposure to infectious material, allergies.	Safety glasses or goggles for protection from splash or other eye hazard, light latex, nitrile or vinyl gloves, lab gown, hair cover, shoe covers, surgical mask. Consider need for wire mesh glove.

Attachment 8 –NMSU Job Hazard Assessment Checklist

NMSU Lab (JHA) Hazard Assessment (Questions EH&S -http://safety.nmsu.edu or 575-646-3327) Sept.2012

Are the following activities performed in the lab?		**Radiological Hazards**	
Activity	Y/N	Potential Hazard	Applicable PPE
Working with solid radioactive materials or waste.	If yes	Cell damage, potential spread of radioactive materials.	Safety glasses, impermeable gloves, lab coat.
Working with radioactive materials in hazardous chemicals (corrosives, flammables, liquids, powders, etc.).	If yes	Cell damage or spread of contamination plus hazards for the specific chemical.	Safety glasses (or goggles for splash hazard), light chemical-resistant gloves, lab coat. Note: Select glove for the applicable chemical hazards above.
Working with ultraviolet radiation.	If yes	Conjunctivitis, corneal damage, skin redness.	UV face shield and goggles, lab coat.
Working with infrared emitting equipment (e.g. glass blowing).	If yes	Cataracts, burns to cornea.	Appropriate shaded goggles, lab coat.

NMSU Lab (JHA) Hazard Assessment (Questions EH&S -http://safety.nmsu.edu or 575-646-3327) Sept.2012

Are the following activities performed in the lab?		**Laser Hazards**	
Activity	Y/N	Potential Hazard	Applicable PPE
Open Beam			
Performing alignment, trouble-shooting or maintenance that requiresWorking with an open beam and/or defeating the interlock(s) on any Class 3 or Class 4	If yes	Eye damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters.
Viewing a Class 3R laser beam with magnifying optics (including eyeglasses).	If yes	Eye damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters.
Working with a Class 3B laser open beam system with the potential for producing direct or specular reflections.	If yes	Eye damage, skin damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters, appropriate skin protection.[7]
Working with a Class 4 laser open beam system with the potential for producing direct, specular, or diffuse reflections.	If yes	Eye damage, skin damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters, appropriate skin protection[7].
Non-Beam			
Handling dye laser materials, such as powdered dyes, chemicals, and solvents.	If yes	Cancer, explosion, fire.	Gloves, safety glasses, flame-resistant lab coat or coveralls.
Maintaining and repairing power sources for large Class 3B and Class 4 laser systems.	If yes	Electrocution, explosion, fire.	Electrical isolation mat, flame-resistant lab coat or coveralls.

Attachment 8 –NMSU Job Hazard Assessment Checklist

NMSU Lab (JHA) Hazard Assessment (Questions EH&S -http://safety.nmsu.edu or 575-646-3327)Sept.2012

Are the following activities performed in the lab?		**Physical Hazards**	
Activity	Y/N	Potential Hazard	Applicable PPE
Working with cryogenic liquids.	If yes	Major skin, tissue, or eye damage.	Safety glasses or goggles for large volumes, impermeable insulated gloves, lab coat.
Removing freezer vials from liquid nitrogen	If yes	Vials may explode upon rapid warming. Cuts to face/neck and frostbite to hands	Face shield, impermeable insulated gloves, lab coat.
Working with very cold equipment or dry ice.	If yes	Frostbite, hypothermia.	Safety glasses, insulated gloves (possibly warm clothing), lab coat.
Working with hot liquids, equipment, open flames (autoclave, Bunsen burner, water bath, oil bath).	If yes	Burns resulting in skin or eye damage.	Safety glasses or goggles for large volumes, insulated gloves (impermeable insulated gloves for liquids, steam), lab coat.
Glassware washing.	If yes	Lacerations.	Heavy rubber gloves, lab coat.
Working with loud equipment, noises, sounds, alarms, etc.	If yes	Potential ear damage and hearing loss.	Earplugs or ear muffs as necessary.
Working with a centrifuge.	If yes	Imbalanced rotor can lead to broken vials, cuts, exposure.	Safety glasses or goggles, lab coat, latex, vinyl, or nitrile gloves.
Working with a sonicator.	If yes	Ear damage, exposure.	Safety glasses or goggles, lab coat, latex, vinyl, or nitrile gloves, ear plugs.
Working with sharps.	If yes	Cuts, exposure.	Safety glasses or goggles, lab coat, latex, vinyl, or nitrile

Are the following activities performed in the lab?		**Nanomaterial Hazard**	
Activity	Y/N	Potential Hazard	Applicable PPE
Working with engineered nanomaterials [8].	If yes	Inhalation, exposure, dermal exposure.	Goggles, gloves, lab coat.

1 Use a chemical exhaust hood or other engineering control whenever possible. Activities conducted outside a hood or other engineering control (local bench exhaust) may need to be evaluated for a respiratory hazards. A respirator may be required & a respiratory protection program must be in place per EH&S Respiratory Protection Program. In addition to engineering controls and PPE, consider personal clothing that provides adequate skin coverage.

2 Dusty solids should be separately evaluated for the need to use respiratory protection.

3 For a list of acutely toxic chemicals, visit safety.nmsu.edu and navigate to Chemical Safety.

4 Chemical-resistant gloves are to be selected based on chemical(s) in use (see glove quide).

5 Use a Biosafety cabinet to minimize exposure or evaluatd by Biosafety Officer.

6 Laser pointers, copiers, and readers are not currently subject to general or specific PPE requirements.

7 Appropriate skin protection can include lab coat, gloves, sun block, barrier cream.

8 Nanomaterial work is to be evaluated for respiratory protection.

September 6, 2012 (after UCLA LHATS developed by http://www.ehs.ucla.edu/)

Attachment 9 – NMSU Waste Tracking Form (to be filled out at event)

Write Firmly- 2 Copy Form

NMSU Hazardous Waste/Material Tracking Form

Contents Hazards(Circle) Flammable Reactive Oxidizer Toxic Acid Base

Container Size in (ml or L) (Print) →

Container Type (Circle) → Glass Plastic Metal Fiber

Contents State (Circle) → Solid Liquid Sludge Gas

Chemical Contents (and diluent,including water,if applicable)	Concentration(%,M,PPM)	vol.(mL or L)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
Total Volume of Contents (mL or L) →		

Generator's Name and Title		Phone #
Dept	Building	Room

EH&S Staff Use Only

Bay (circle) → Flam Poison Acid Base Bio UW

Initials	Sub Category	Process Drum	No 022757
Date received	Waste Codes:		

Attachment 9 – NMSU Waste Tracking Form (to be filled out at event)

NMSU CHEMICAL DISPOSAL PROCEDURES

1. Label each container to identify the contents **(Use NMSU Hazardous Waste/Material Tracking Form).**
   - **1.1 Circle Contents Hazards: Flammable, Reactive, Oxidizer, Toxic, Acid, Base.**
   - **1.2** Write in Container Size: (250 mL, 4L, etc.).
   - **1.3** Circle Container Type: Glass, Plastic, Metal, or Fiber.
   - **1.4** Circle Chemical State: Liquid, Solid, Sludge, or Gas.
   - **1.5** Write in added chemical names (and their diluent, including water, if applicable), concentration (%, molarity, or ppm), and their volume in milliliters or liters. If necessary, make an estimate based on your "knowledge of process". **Do not abbreviate. Do not use chemical notations or structures.**
   - **1.6** When no more waste is to be added to container, write in total volume of contents in milliliters or liters.
   - **1.7** Write in the Generator (name of person completing the form or lab supervisor), Phone #, Department, Building, and Room #.
   - **1.8** Lower portion is for Environmental Health and Safety (EH&S) use only- **Leave Blank.**
   - **1.9** If more chemicals need to be listed, use as many extra, separate tracking forms as needed.
   - **1.10** Containers not labeled appropriately will be returned to the generator.
   - **1.11** Secure forms to container with plastic ties or adhesive tape.

2. Compatible chemicals may be collected in a single waste container and individual containers may be packaged in secondary containers according to the subclasses listed below **(not all inclusive).** Call EH&S for assistance with highly hazardous materials or **unknown compatibility.**
   - **A.** Flammables (Non-Halogenated Organic Solvents: Methanol, Acetone).
   - **B.** Halogenated Organics (Chlorinated Solvents: Methylene Chloride, Chloroform)
   - **C.** Combustibles (Oils, Coolant, Latex Paint).
   - **D.** Poisons (Pesticides, Weak Organic Acids).
   - **E.** Inorganic Acids (Hydrochloric, Sulfuric).
   - **F.** Inorganic Bases (Sodium Hydroxide, Potassium Hydroxide).

   Always package separately the following high hazard compounds: Cyanide, Sulfide, Water/Air Reactive, Mercury, Organometallic, Undiluted Organic Peroxides, Strong Oxidizers, Strong Reducing Agents, Flammable Solids, Strong/Undiluted Amines, Polymerizables (Monomers), Radioactive, Biohazardous, Gas Cylinders, and Explosives.

3. **Empty containers must be rinsed (a minimum of three times)** with water or an appropriate solvent until less than 3% of the compound is present. Collect rinsate in the appropriate waste container. After rinsing, glass containers should be placed in a glass collection box for regular disposal. If the container is metal, plastic, or fiber, first **puncture** the container prior to disposal in the regular trash. If containers cannot be effectively rinsed, complete a tracking form and turn in as hazardous waste.

4. **Unknowns are not acceptable.** Waste components must be determined by knowledge of process or analytical method.

5. Package glass chemical containers for turn-in in a sturdy transport box with cardboard separators or packing material to prevent breakage. If you need additional boxes, notify EH&S when calling in a pick up request. Only combine compatible waste containers in a single transport box. Do not seal boxes, EH&S Personnel will inspect paper work and hazardous waste containers before transport.

6. At any one time, a research group may accumulate up to a **maximum of 55 gallons** of waste or one quart of Acutely Hazardous Waste in a designated **Waste Accumulation Point.** The storage containers must be **closed (finger tight)** and under the generator's control, i.e. in the same room **(See NMSU Waste Accumulation Point Inspection Checklist at www.nmsu.edu/safety).**

7. After tracking forms are completed, call EH&S **(646-3327)** to schedule removal of chemicals. Containers should be called in for pick up when **75% full** to comply with EPA regulations. Please do not overfill containers, always leave 10% headspace. Detailed **hazardous waste training** is provided by EH&S Staff. Please call for dates and times or visit our web site at **www.nmsu.edu/safety.**

Carbon dioxide

Safety Data Sheet P-4574

This SDS conforms to U.S. Code of Federal Regulations 29 CFR 1910.1200, Hazard Communication.

Date of issue: 01/01/1980 Revision date: 10/17/2016 Supersedes: 07/19/2016

SECTION: 1. Product and company identification

1.1. Product identifier

Product form	:	Substance
Name	:	Carbon dioxide
CAS No	:	124-38-9
Formula	:	CO2
Other means of identification	:	Medipure® Carbon Dioxide, Extendapak® EX-2, Refrigerant gas R744, carbonic anhydride, carbonic acid gas

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture	:	Industrial use. Use as directed.

1.3. Details of the supplier of the safety data sheet

Praxair, Inc.
10 Riverview Drive
Danbury, CT 06810-6268 - USA
T 1-800-772-9247 (1-800-PRAXAIR) - F 1-716-879-2146
www.praxair.com

1.4. Emergency telephone number

Emergency number	:	Onsite Emergency: 1-800-645-4633

CHEMTREC, 24hr/day 7days/week
— Within USA: 1-800-424-9300, Outside USA: 001-703-527-3887
(collect calls accepted, Contract 17729)

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

GHS-US classification

Liquefied gas H280

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :

GHS04

Signal word (GHS-US) : WARNING

Hazard statements (GHS-US) :
H280 - CONTAINS GAS UNDER PRESSURE; MAY EXPLODE IF HEATED
OSHA-H01 - MAY DISPLACE OXYGEN AND CAUSE RAPID SUFFOCATION
CGA-HG01 - MAY CAUSE FROSTBITE
CGA-HG03 - MAY INCREASE RESPIRATION AND HEART RATE

Precautionary statements (GHS-US) :
P202 - Do not handle until all safety precautions have been read and understood
P261 - Avoid breathing gas
P262 - Do not get in eyes, on skin, or on clothing
P271+P403 - Use and store only outdoors or in a well-ventilated place
CGA-PG05 - Use a back flow preventive device in the piping
CGA-PG10 - Use only with equipment rated for cylinder pressure
CGA-PG06 - Close valve after each use and when empty
CGA-PG02 - Protect from sunlight when ambient temperature exceeds 52°C (125°F)

2.3. Other hazards

Other hazards not contributing to the classification : Asphyxiant in high concentrations

Contact with liquid may cause cold burns/frostbite

WARNING: Concentration levels of carbon dioxide above about 1 percent are dangerous. Praxair recommends continuous monitoring with alarms to indicate unsafe conditions before and during potential personnel exposure. Use appropriate monitoring devices to ensure a safe oxygen level (minimum of 19.5 percent) and a safe carbon dioxide level.

2.4. Unknown acute toxicity (GHS US)

No data available

SECTION 3: Composition/Information on ingredients

3.1. Substance

Name : Carbon dioxide

CAS No : 124-38-9

Name	Product identifier	%
Carbon dioxide	(CAS No) 124-38-9	99.5 - 100

3.2. Mixture

Not applicable

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures after inhalation : Remove to fresh air and keep at rest in a position comfortable for breathing. . If not breathing, give artificial respiration, with supplemental oxygen given by qualified personnel. If breathing is difficult, qualified personnel should give oxygen. Call a physician.

First-aid measures after skin contact : MAY CAUSE FROSTBITE. For exposure to liquid, cold vapor, or solid carbon dioxide (dry ice), immediately warm frostbite area with warm water not to exceed 41°C (105°F). Water temperature should be tolerable to normal skin. Maintain skin warming for at least 15 minutes or until normal coloring and sensation have returned to the affected area. In case of massive exposure, remove clothing while showering with warm water. Seek medical evaluation and treatment as soon as possible.

First-aid measures after eye contact : Immediately flush eyes thoroughly with water for at least 15 minutes. Hold the eyelids open and away from the eyeballs to ensure that all surfaces are flushed thoroughly. Contact an ophthalmologist immediately.

First-aid measures after ingestion : Ingestion is not considered a potential route of exposure.

4.2. Most important symptoms and effects, both acute and delayed

No additional information available

4.3. Indication of any immediate medical attention and special treatment needed

None.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Use extinguishing media appropriate for surrounding fire.

5.2. Special hazards arising from the substance or mixture

Explosion hazard : Heat of fire can build pressure in container and cause it to rupture. Containers are equipped with a pressure relief device. (Exceptions may exist where authorized by DOT.) No part of the container should be subjected to a temperature higher than 125°F (52°C).

Reactivity : No reactivity hazard other than the effects described in sub-sections below.

5.3. Advice for firefighters

Firefighting instructions : **WARNING! Liquid and gas under pressure.**

Evacuate all personnel from the danger area. Use self-contained breathing apparatus (SCBA) and protective clothing. Immediately cool containers with water from maximum distance. Stop flow of gas if safe to do so, while continuing cooling water spray. Remove ignition sources if safe to do so. Remove containers from area of fire if safe to do so. On-site fire brigades must comply with OSHA 29 CFR 1910.156 and applicable standards under 29 CFR 1910 Subpart L—Fire Protection.

Other information : Containers are equipped with a pressure relief device. (Exceptions may exist where authorized by DOT [U.S.] or TC [Canada].).

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures : **WARNING! Liquid and gas under pressure.**. **Rapid release of gaseous carbon dioxide through a pressure relief device (PRD) or valve can result in the formation of dry ice, which is very cold and can cause frostbite.**.

6.1.1. For non-emergency personnel

No additional information available

6.1.2. For emergency responders

No additional information available

6.2. Environmental precautions

Try to stop release.

6.3. Methods and material for containment and cleaning up

For containment : Prevent waste from contaminating the surrounding environment. Discard any product, residue, disposable container, or liner in an environmentally acceptable manner, in full compliance with federal, provincial, and local regulations. If necessary, call your local supplier for assistance.

6.4. Reference to other sections

See also sections 8 and 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Avoid breathing gas

Do not get in eyes, on skin, or on clothing

This gas is heavier than air and in an enclosed space tends to accumulate near the floor, displacing air and pushing it upward. This creates an oxygen-deficient atmosphere near the floor. Ventilate space before entry. Verify sufficient oxygen concentration

WARNING: Concentration levels of carbon dioxide above about 1 percent are dangerous. Praxair recommends continuous monitoring with alarms to indicate unsafe conditions before and during potential personnel exposure. Use appropriate monitoring devices to ensure a safe oxygen level (minimum of 19.5 percent) and a safe carbon dioxide level

Wear leather safety gloves and safety shoes when handling cylinders. Protect cylinders from physical damage; do not drag, roll, slide or drop. While moving cylinder, always keep in place removable valve cover. Never attempt to lift a cylinder by its cap; the cap is intended solely to protect the valve. When moving cylinders, even for short distances, use a cart (trolley, hand truck, etc.) designed to transport cylinders. Never insert an object (e.g, wrench, screwdriver, pry bar) into cap openings; doing so may damage the valve and cause a leak. Use an adjustable strap wrench to remove over-tight or rusted caps. Slowly open the valve. If the valve is hard to open, discontinue use and contact your supplier. Close the container valve after each use; keep closed even when empty. Never apply flame or localized heat directly to any part of the container. High temperatures may damage the container and could cause the pressure relief device to fail prematurely, venting the container contents. For other precautions in using this product, see section 16.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions : Store in a cool, well-ventilated place. Store and use with adequate ventilation. Store only where temperature will not exceed 125°F (52°C). Firmly secure containers upright to keep them from falling or being knocked over. Install valve protection cap, if provided, firmly in place by hand. Store full and empty containers separately. Use a first-in, first-out inventory system to prevent storing full containers for long periods

This gas is heavier than air and in an enclosed space tends to accumulate near the floor, displacing air and pushing it upward. This creates an oxygen-deficient atmosphere near the floor. Ventilate space before entry. Verify sufficient oxygen concentration.

7.3. Specific end use(s)

None.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Carbon dioxide (124-38-9)		
ACGIH	ACGIH TLV-TWA (ppm)	5000 ppm
ACGIH	ACGIH TLV-STEL (ppm)	30000 ppm
USA OSHA	OSHA PEL (TWA) (mg/m³)	9000 mg/m³
USA OSHA	OSHA PEL (TWA) (ppm)	5000 ppm
USA IDLH	US IDLH (ppm)	40000 ppm
ACGIH	Not established	
USA OSHA	Not established	

Carbon dioxide (124-38-9)		
ACGIH	ACGIH TLV-TWA (ppm)	5000 ppm
ACGIH	ACGIH TLV-STEL (ppm)	30000 ppm
USA OSHA	OSHA PEL (TWA) (mg/m³)	9000 mg/m³
USA OSHA	OSHA PEL (TWA) (ppm)	5000 ppm

8.2. Exposure controls

Appropriate engineering controls : Use a local exhaust system with sufficient flow velocity to maintain an adequate supply of air in the worker's breathing zone. Mechanical (general): General exhaust ventilation may be acceptable if it can maintain an adequate supply of air. **WARNING: Concentration levels of carbon dioxide above about 1 percent are dangerous.** Praxair recommends continuous monitoring with alarms to indicate unsafe conditions before and during potential personnel exposure. Use appropriate monitoring devices to ensure a safe oxygen level (minimum of 19.5 percent) and a safe carbon dioxide level.

Materials for protective clothing : Wear work gloves and metatarsal shoes for cylinder handling. Protective equipment where needed. Select in accordance with OSHA 29 CFR 1910.132, 1910.136, and 1910.138.

Eye protection : Wear safety glasses when handling cylinders; vapor-proof goggles and a face shield during cylinder changeout or whenever contact with product is possible. Select eye protection in accordance with OSHA 29 CFR 1910.133.

Skin and body protection : As needed for welding, wear hand, head, and body protection to help prevent injury from radiation and sparks. (See ANSI Z49.1.) At a minimum, this includes welder's gloves and protective goggles, and may include arm protectors, aprons, hats, and shoulder protection as well as substantial clothing.

Respiratory protection : When workplace conditions warrant respirator use, follow a respiratory protection program that meets OSHA 29 CFR 1910.134, ANSI Z88.2, or MSHA 30 CFR 72.710 (where applicable). Use an air-supplied or air-purifying cartridge if the action level is exceeded. Ensure that the respirator has the appropriate protection factor for the exposure level. If cartridge type respirators are used, the cartridge must be appropriate for the chemical exposure. For emergencies or instances with unknown exposure levels, use a self-contained breathing apparatus (SCBA).

Thermal hazard protection : Wear cold insulating gloves when transfilling or breaking transfer connections.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Gas
Appearance	:	Colorless gas.
Molecular mass	:	44 g/mol
Color	:	Colorless.
Odor	:	Odorless.
Odor threshold	:	No data available
pH	:	3.7 (carbonic acid)
Relative evaporation rate (butyl acetate=1)	:	No data available
Relative evaporation rate (ether=1)	:	Not applicable.
Melting point	:	No data available
Freezing point	:	No data available
Boiling point	:	-78.5 °C (-109.3°F)
Flash point	:	No data available
Critical temperature	:	31 °C (87.7°F)
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Flammability (solid, gas)	:	No data available
Vapor pressure	:	57.3 bar (831 psig)
Critical pressure	:	73.7 bar (1069 psig)
Relative vapor density at 20 °C	:	762
Relative density	:	1.22
Relative gas density	:	1.52
Solubility	:	Water: 2000 mg/l Completely soluble.
Log Pow	:	0.83
Log Kow	:	Not applicable.
Viscosity, kinematic	:	Not applicable.
Viscosity, dynamic	:	Not applicable.
Explosive properties	:	Not applicable.
Oxidizing properties	:	None.
Explosion limits	:	No data available

9.2. Other information

Gas group	:	Liquefied gas
Additional information	:	Gas/vapor heavier than air. May accumulate in confined spaces, particularly at or below ground level

SECTION 10: Stability and reactivity

10.1. Reactivity

No reactivity hazard other than the effects described in sub-sections below.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

None.

10.4. Conditions to avoid

None under recommended storage and handling conditions (see section 7).

10.5. Incompatible materials

Alkali metals, Alkaline earth metals, Acetylide forming metals, Chromium, Titanium > 1022°F (550°C), Uranium (U) > 1382°F (750°C), Magnesium > 1427°F (775°C).

10.6. Hazardous decomposition products

Electrical discharges and high temperatures decompose carbon dioxide into carbon monoxide and oxygen. The welding process may generate hazardous fumes and gases.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Not classified

Skin corrosion/irritation : Not classified

pH: 3.7 (carbonic acid)

Serious eye damage/irritation : Not classified

pH: 3.7 (carbonic acid)

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified

Reproductive toxicity : Not classified

Specific target organ toxicity (single exposure) : Not classified

Specific target organ toxicity (repeated exposure) : Not classified

Aspiration hazard : Not classified

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general : No ecological damage caused by this product.

12.2. Persistence and degradability

Carbon dioxide (124-38-9)	
Persistence and degradability	No ecological damage caused by this product.

Carbon dioxide (124-38-9)	
Persistence and degradability	No ecological damage caused by this product.

12.3. Bioaccumulative potential

Carbon dioxide (124-38-9)	
BCF fish 1	(no bioaccumulation)
Log Pow	0.83
Log Kow	Not applicable.
Bioaccumulative potential	No ecological damage caused by this product.

Carbon dioxide (124-38-9)	
BCF fish 1	(no bioaccumulation)
Log Pow	0.83
Log Kow	Not applicable.
Bioaccumulative potential	No ecological damage caused by this product.

12.4. Mobility in soil

Carbon dioxide (124-38-9)	
Mobility in soil	No data available.
Ecology - soil	No ecological damage caused by this product.

Carbon dioxide (124-38-9)	
Mobility in soil	No data available.
Ecology - soil	No ecological damage caused by this product.

12.5. Other adverse effects

Effect on ozone layer : None

Global warming potential [CO2=1] : 1

Effect on the global warming : When discharged in large quantities may contribute to the greenhouse effect

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste treatment methods : May be vented to atmosphere in a well ventilated place. Discharge to atmosphere in large quantities should be avoided. Do not discharge into any place where its accumulation could be dangerous. Contact supplier if guidance is required.

Waste disposal recommendations : Do not attempt to dispose of residual or unused quantities. Return container to supplier.

SECTION 14: Transport information

In accordance with DOT

Transport document description : UN1013 Carbon dioxide, 2.2

UN-No.(DOT) : UN1013

Proper Shipping Name (DOT) : Carbon dioxide

Class (DOT) : 2.2 - Class 2.2 - Non-flammable compressed gas 49 CFR 173.115

Hazard labels (DOT) : 2.2 - Non-flammable gas

Additional information

Emergency Response Guide (ERG) Number : 120

Other information : No supplementary information available.

Special transport precautions : Avoid transport on vehicles where the load space is not separated from the driver's compartment. Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. Before transporting product containers: - Ensure there is adequate ventilation. - Ensure that containers are firmly secured. - Ensure cylinder valve is closed and not leaking. - Ensure valve outlet cap nut or plug (where provided) is correctly fitted. - Ensure valve protection device (where provided) is correctly fitted.

Transport by sea

UN-No. (IMDG) : 1013

Proper Shipping Name (IMDG) : CARBON DIOXIDE

Class (IMDG) : 2 - Gases

MFAG-No : 120

Air transport

UN-No. (IATA) : 1013

Proper Shipping Name (IATA) : Carbon dioxide

Class (IATA) : 2

Civil Aeronautics Law : Gases under pressure/Gases nonflammable nontoxic under pressure

SECTION 15: Regulatory information

15.1. US Federal regulations

Carbon dioxide (124-38-9)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory	
SARA Section 311/312 Hazard Classes	Immediate (acute) health hazard Sudden release of pressure hazard

15.2. International regulations

CANADA

Carbon dioxide (124-38-9)
Listed on the Canadian DSL (Domestic Substances List)

Carbon dioxide (124-38-9)
Listed on the Canadian DSL (Domestic Substances List)

EU-Regulations

Carbon dioxide (124-38-9)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

15.2.2. National regulations

Carbon dioxide (124-38-9)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances) Listed on the Canadian IDL (Ingredient Disclosure List) Listed on INSQ (Mexican National Inventory of Chemical Substances) Listed on CICR (Turkish Inventory and Control of Chemicals)

15.3. US State regulations

Carbon dioxide(124-38-9)	
U.S. - California - Proposition 65 - Carcinogens List	No
U.S. - California - Proposition 65 - Developmental Toxicity	No
U.S. - California - Proposition 65 - Reproductive Toxicity - Female	No
U.S. - California - Proposition 65 - Reproductive Toxicity - Male	No
State or local regulations	U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List U.S. - Pennsylvania - RTK (Right to Know) List

Carbon dioxide (124-38-9)				
U.S. - California - Proposition 65 - Carcinogens List	U.S. - California - Proposition 65 - Developmental Toxicity	U.S. - California - Proposition 65 - Reproductive Toxicity - Female	U.S. - California - Proposition 65 - Reproductive Toxicity - Male	Non-significant risk level (NSRL)
No	No	No	No	

Carbon dioxide (124-38-9)
U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List U.S. - Pennsylvania - RTK (Right to Know) List

SECTION 16: Other information

Other information : When you mix two or more chemicals, you can create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you produce the mixture. Consult an industrial hygienist or other trained person when you evaluate the end product. Before using any plastics, confirm their compatibility with this product

Fumes and gases produced during welding and cutting processes can be dangerous to your health and may cause serious lung disease. KEEP YOUR HEAD OUT OF FUMES. DO NOT BREATHE FUMES AND GASES. Use enough ventilation, local exhaust, or both to keep fumes and gases from your breathing zone and the general area. Short-term overexposure to fumes may cause dizziness, nausea, and dryness or irritation of the nose, throat, and eyes; or may cause other similar discomfort. Contaminants in the air may add to the hazard of fumes and gases. One such contaminant, chlorinated hydrocarbon vapors from cleaning and degreasing activities, poses a special risk. DO NOT USE ELECTRIC ARCS IN THE PRESENCE OF CHLORINATED HYDROCARBON VAPORS—HIGHLY TOXIC PHOSGENE MAY BE PRODUCED. Metal coatings such as paint, plating, or galvanizing may generate harmful fumes when heated. Residues from cleaning materials may also be harmful. AVOID ARC OPERATIONS ON PARTS WITH PHOSPHATE RESIDUES (ANTI-RUST, CLEANING PREPARATIONS)—HIGHLY TOXIC PHOSPHINE MAY BE PRODUCED

The opinions expressed herein are those of qualified experts within Praxair, Inc. We believe that the information contained herein is current as of the date of this Safety Data Sheet. Since the use of this information and the conditions of use are not within the control of Praxair, Inc, it is the user's obligation to determine the conditions of safe use of the product

Praxair SDSs are furnished on sale or delivery by Praxair or the independent distributors and suppliers who package and sell our products. To obtain current SDSs for these products, contact your Praxair sales representative, local distributor, or supplier, or download from www.praxair.com. If you have questions regarding Praxair SDSs, would like the document number and date of the latest SDS, or would like the names of the Praxair suppliers in your area, phone or write the Praxair Call Center (Phone: 1-800-PRAXAIR/1-800-772-9247; Address: Praxair Call Center, Praxair, Inc, P.O. Box 44, Tonawanda, NY 14151-0044)

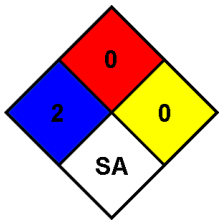
Praxair asks users of this product to study this SDS and become aware of the product hazards and safety information. To promote safe use of this product, a user should (1) notify employees, agents, and contractors of the information in this SDS and of any other known product hazards and safety information, (2) furnish this information to each purchaser of the product, and (3) ask each purchaser to notify its employees and customers of the product hazards and safety information

NFPA health hazard : 2 - Intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical attention is given.

NFPA fire hazard : 0 - Materials that will not burn.

NFPA reactivity : 0 - Normally stable, even under fire exposure conditions, and are not reactive with water.

NFPA specific hazard : SA - This denotes gases which are simple asphyxiants.



HMIS III Rating

Health : 1 Slight Hazard - Irritation or minor reversible injury possible

Flammability : 0 Minimal Hazard

Physical : 3 Serious Hazard

SDS US (GHS HazCom 2012) - Praxair

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.