# Model

# Engineering Design Documentation Package

September 2009

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Acknowledgement: The University of Utah student team and faculty advisor Kevin Whitty are thanked for submitting much of the material for this model engineering design package.



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# Job Safety Assessment Form
## Chem-E-Car
## 2009 National Competition – *Updated August 2009*

| | |
|---|---|
| **University**: University of Utah ChemE Car | **Vehicle Name:** Louise |
| **JSA Author Contact Name**: Derek Harris | **Author Email:** XX@utah.edu |
| **Faculty Supervisor:** Kevin Whitty | **Supervisor Email:** YY@utah.edu |
| **Revision #**: 2 | **Revision Date**: August 7, 2009 |

**Purpose of Experiment / Equipment:** Briefly describe your Chem-E-Car's design, intended mode for operation (source of power), intended mode for control (stopping), and major hazards and their control.

**Describe your car's design:** Glacial acetic acid and sodium bicarbonate react in a pressure vessel built out of stainless steel. The reaction is: $NaHCO_3 + CH_3COOH = NaCH_3COO + CO_2 + H_2O$. The resulting pressurized $CO_2$ is fed through a pressure regulator to limit the driving pressure. A pressure relief valve on the pressure vessel is set to open at 10% higher than the maximum anticipated operating pressure. The $CO_2$ gas flows through high pressure tubing to a pneumatic motor, which drives a chain-and-sprocket gearing system, which ultimately drives the rear axle and wheels of the car.
The reaction is slightly endothermic.

**Power source:** Pressure generated by production of $CO_2$ resulting from a chemical reaction of glacial acetic acid and sodium bicarbonate. Byproducts are water, carbon dioxide and solid precipitate. Carbon dioxide is the source of power for the car.

**Stopping mechanism:** The car will stop when the reaction is exhausted. We will vary the amount of the limiting reactant (acetic acid) to control the distance the car travels.

**Hazards inherent in design:** Glacial acetic acid has toxic exposure hazards. The gas generated is stored in a pressure vessel resulting in pressure hazards.

**Safety measures:** The pressure vessel will be hydrostatically tested according to the procedure in the rules. The vessel will be equipped with a pressure gauge and a relief device. The relief will be sized appropriately. All components exposed to pressure will be rated for the pressures expected. Management controls will be used to insure that the reactants are charged in the proper quantities.

Appropriate PPE will used for car prep and chemical loading ( long pants, long sleeves, non-porous shoes, safety glasses, splash goggles, chemical gloves, and an apron). Chemical loading will be done in the chemical prep area. Proper chemical containment will be used in the prep area.

**Expected Operating Conditions:**

| Temperature | Pressure |
|---|---|
| Normal: 68°F | Normal: 225 psig |
| Minimum: 60°F | Minimum: 15 psig |
| Maximum: 80°F | Maximum: 280 psig |

This page applies to your home institution – not the competition site. Please attach a floor diagram of the laboratory where you will be building and testing your vehicle. List the location of available safety equipment and spill response supplies on this diagram.

**Personal Protective Equipment (PPE) :** Check all PPE worn during operation of this Chem-E-Car. Do not list these in the procedure section.

| | | | |
|---|---|---|---|
| ☒ Long Pants | ☒ Safety Glasses | ☐ Hard Hat | ☒ Apron |
| ☒ Long Sleeves | ☒ Splash Goggles | ☐ Insulated Gloves | ☐ Ear Protection |
| ☒ Non-porous Shoes | ☒ Face Shield | ☒ Chemical Gloves | ☐ Other: |

**Available Safety Equipment** – Provide the location of each item shown below at your home institution where your vehicle will be operated and tested. Show the location of this equipment on your provided floor plan. If not available, type "NA" in the field.

| Item | Location |
|---|---|
| Fire Extinguisher: | Outside MEB (Merrill Engineering Bldg.) 3520C/By Southwest doors |
| Eyewash: | Outside MEB 3520C |
| Safety Shower: | Outside MEB 3520C |
| Telephone: | Outside MEB 3520D |
| First Aid Kit: | Outside MEB 3520H, South side |
| Spill Containment | Outside MEB A, Northwest corner |
| Other: | |

**Spill Response Supplies** - Provide the location of each item shown below at your home institution where your vehicle will be operated and tested. Show the location of this equipment on the attached floor plan. If not available, type "NA" in the field.

| Item | Location |
|---|---|
| Spill Kit: | Outside MEB 3520C |
| Floor-Dri: | Near MEB 3520 aka the equipment, instruments and tools room |
| Spill Dikes: | Outside MEB 3520C |
| Sodium Bicarbonate: | In bases cabinet MEB 3520a |
| Drain Plugs: | |
| Spill Pillows: | Outside MEB 3520C |
| Mercury Spill Kit: | Outside MEB 3520C |
| Other: | |
| Other: | |

**Disallowed Activities:** All activities listed below are not allowed and will result in a multi-year disqualification of your university from ChemE car competition and possible fines.

| Item |
|---|
| (a) No transport of chemicals in private, university or rental vehicles either to or from the competition. |
| (b) Chemicals must not be stored in hotel rooms or other facilities not rated for chemical storage. Approved chemical storage will be provided at the host site. |
| (c) No vehicle testing in hotel or dorm hallways, warehouses, or other facilities that are not designed for chemical handling. This includes your university and the competition site. |
| (d) No improper disposal of chemicals at the conclusion of the competition. All chemicals shipped to the competition site must be disposed of in a safe and environmental fashion following all local, state and national regulatory measures. Chemical disposal will normally be provided by the host site. |

**Disallowed Vehicles:** All of the items listed below are not allowed.

| Item | Explanation |
|---|---|
| (a) Flames and/or smoke | Both inside and outside the vehicle, except for commercial internal combustion engines. See ChemE car rules for using commercial internal combustion engines. |
| (b) Liquid Discharge | Liquid may not be discharged under normal operating conditions. |
| (c) Open and/or improperly secured containers | Containing chemicals having an NFPA rating of 2 or greater. All containers with these chemicals must have secure lids and must be secured to the vehicle. All containers brought to the starting line must have lids, be properly labeled, and proper personal protective equipment must be used. |
| (d) Chemical pouring at starting line | Any chemicals with an NFPA rating of 2 or greater. Use a holding vessel on vehicle, with valve, to load starting chemicals. |
| (e) Regulated Chemicals | A number of chemicals are listed by OSHA as a special hazard. See list below. OSHA has a special regulation for each chemical. See www.osha.gov for details. |
| (f) Highly Reactive / Unstable Chemicals | Any chemical, raw material, intermediate or product with an NFPA reactivity / instability rating of 4. |
| (g) Hydrogen peroxide | Hydrogen peroxide at concentrations of greater than 30% are not allowed. |

**Regulated chemicals:** asbestos, coal tar pitch volatiles, 4-nitrobiphenyl, alpha-napthylamine, methyl chloromethyl ether, 3,3'-dichlorobenzidine, bis-chloromethyl ether, beta-naphthylamine, benzidine, 4-aminodiphenyl, ethyleneimine, beta-propiolactone, 2-acetylaminofluorene, 4-dimethylaminoazo-benezene, n-nitrosodimethylamine, vinyl chloride, inorganic arsenic, benzene, 1,2-dibromo-3-chloropropane, acrylonitrile, ethylene oxide, formaldehyde, 4,4'-Methylenedianiline, 1,3-butadiene, methylene chloride.

**Vehicle Primary Hazards Checklist:** Check the left hand column box if the hazards listed below exist on the vehicle. Then check the applicable means of control for each hazard.

| **Hazard (check if present)** | **Control** |
|---|---|
| ☒ (a) Pressure | Anything greater than 1 psig? **Must meet all requirements below:**<br>☒ Pressure gauge (must read to 2x max. operating pressure)<br>☒ Emergency relief device set to no more than 1.1 times max. operating pressure. Relief sizing calculations must be provided.<br>☒ Emergency relief device in proper location.<br>☒ Pressure certification – see Pressure Vessel Testing Protocol<br>☒ Proper management system to prevent over or mis-charging.<br>☒ All car components exposed to pressure must be certified to operate at that pressure. Provide manufacturer's pressure specifications.<br>☒ No PVC, cPVC or polyethylene terephthalate (PETE or PET) plastics in pressure service<br>**Must have measurements or calculations to prove maximum operating pressure.**<br>**See ChemE car rules for more details on these requirements.** |
| ☒ (b) Toxic | Any chemicals with an NFPA toxicity of 2 or greater?<br>☒ Doubly contained and handled properly. |
| ☒ (c) Flammable | Any chemicals with an NFPA flammability rating of 2 or higher?<br>☒ Doubly contained and handled properly |
| ☒ (d) Reactive | Any chemicals with an NFPA instability / reactivity rating of 2 or 3?<br>**Chemicals with a 4 rating are not allowed.**<br>☒ Doubly contained and handled properly. |
| ☐ (e) Temperature | Any exposed surface greater than 150 deg. F or under 32 deg F?<br>☐ Insulation or barrier to prevent contact. |
| ☐ (f) Electrical | Exposed wiring and electrically energized components are ignition, electrocution, and a shorting / fire hazard. Alligator clips and twisted wire connections are not allowed – use binding posts or banana plugs for a more secure connection.<br>☐ Proper electrical insulation and connections provided. |
| ☒ (g) Mechanical | Any fast moving parts (meshing gears, belts or chains) that are pinch hazards?<br>☒ Guards present and adequate. |
| ☐ (h) Oxygen | All components exposed to oxygen must be<br>☐ certified for oxygen service.<br>☐ thoroughly cleaned of contaminants as per instructions in rules.<br>☐ not used previously for other types of service. |

**Fabrication & Operation Additional Hazard Detail Check List:** Check all hazards that are likely to be encountered during your Chem.-Car construction and operation. List the major source(s) of the hazard and describe how the hazard(s) will be controlled. If both construction and hazard columns are checked in an individual row, then the hazards should be identified separately for both the construction and operation.

| Hazard | Present During | | Control Method(s)[1] | PPE Required[1] |
|---|---|---|---|---|
| | Construction? | Operation? | | |
| Pressure | ☐ | ☒ | 1. Pressure testing of pressure vessel<br>2. Pressure gauge reading 2 x max. pressure<br>3. All components rated for max. P<br>4. Relief device sized appropriately and in proper location. | |
| Toxicity | ☐ | ☒ | All chemical containers will be properly labeled. Proper PPE will be used for all chemical transfers. Chemical mixing and transfers will be done with a tray to provide spill containment. Spills will be cleaned up using proper PPE and absorbant materials. | Safety goggles, long sleeve shirt, lab coat, pants, impervious shoes, nitrile gloves. |
| Flammability | ☐ | ☒ | Glacial acetic acid is flammable. All transfers involving glacial acetic acid will be done at a temperature below the flash point temp. of 104 F. | |
| Reactivity / Instability | ☐ | ☒ | The glacial acetic acid and sodium bicarbonate are very reactive. Both chemicals will be stored separately. All transfer and mixing containers will be properly cleaned prior to re-use. | Safety goggles, long sleeve shirt, lab coat, pants, impervious shoes, nitrile gloves |
| Hot Surfaces/ High Temp > 150 F | ☐ | ☐ | | |
| Cold Surfaces/ Low Temp < 0 C | ☐ | ☐ | | |

| | | | | |
|---|---|---|---|---|
| Electrical | ☐ | ☐ | | |
| Arc welding | ☐ | ☐ | | |
| Gas welding | ☐ | ☐ | | |
| Lathe | ☐ | ☐ | | |
| Milling machine | ☐ | ☐ | | |
| Handheld power tools | ☒ | ☐ | Use safety glasses for all power tools, review operating procedure prior to use. Avoid electrocution hazards due to water and exposed electrical. | Safety glasses |
| Drill press | ☐ | ☐ | | |
| Other mechanical hazards | ☐ | ☒ | Pinch points due to gears from turbine. These will be protected by plastic sheeting. | |
| Paint spraying | ☐ | ☐ | | |
| Ionizing radiation | ☐ | ☐ | | |
| Laser radiation | ☐ | ☐ | | |
| Asphyxiates | ☐ | ☒ | Carbon dioxide. Operate car only in ventilated area. | |
| Open flames | ☐ | ☐ | | |
| Potential Spills | ☐ | ☒ | Neutralize with sodium bicarbonate. Dilute with water. Contain using spill pillows in spill control kit. | Face shield, long sleeve shirt, lab coat, pants, impervious shoes, nitrile gloves |
| Other: | ☐ | ☐ | | |
| Other: | ☐ | ☐ | | |

# Chemical Information Page

Fill in as much data below as available. If data are not available, leave the field blank.

**Chemical Quantities:** List below the chemical names, concentrations, and total quantity of chemical required for the competition.

| Chemical Name | Chemical State Solid, Liquid, Gas | Concentration Required Be sure to list units! | Total Quantity Required for Competition Be sure to list the units! |
|---|---|---|---|
| Glacial acetic acid | Liquid | 99% by weight | 1000 ml |
| Sodium bicarbonate | Solid | 99% by weight | 1000 gm |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Chemical Properties and Hazards for ALL CHEMICALS, including reactants, intermediates and products.**

| Chemical Name | Physical State S, L, G | NFPA Ratings* | | | | Incompatible Chemicals List chemicals present within the laboratory, and any others that may come in contact. | Flash Point Temp. | Flammability Limits | |
|---|---|---|---|---|---|---|---|---|---|
| | | H | F | S | Sp. | | | LFL | UFL |
| Glacial acetic acid | L | 2 | 2 | 2 | | Sodium bicarbonate | 104 F | 4% | 16% |
| Sodium bicarbonate | S | 0 | 0 | 0 | | Glacial acetic acid | N/A | N/A | N/A |
| Sodium acetate | S | 1 | 1 | 0 | | | 1125 F | N/A | N/A |
| Carbon dioxide | G | 1 | 0 | 0 | | | N/A | N/A | N/A |
| Water | L | 0 | 0 | 0 | | | N/A | N/A | N/A |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

*__NFPA Ratings:__ **H** – Health, **F** – Flammability, **S** – Stability, **Sp.** – Special

**Chemical Toxicology, Regulation and Disposal:** List the same chemicals that appear above, in the same order.

| Chemical Name | Toxicology | | | Hazardous Waste Number | OSHA Regulated? | Personal Protective Equipment Specific to this Chemical |
|---|---|---|---|---|---|---|
| | TWA | PEL | Other | | | |
| Glacial acetic acid | 10 ppm | 10 ppm | | P058 | ☐ | Use nitrile gloves, latex gloves are not suitable. |
| Sodium bicarbonate | 15 mg/m**3 | 5 mg/m**3 | | | ☐ | |
| Sodium acetate | 15 mg/m**3 | 5 mg/m**3 | | | ☐ | |
| Carbon dioxide | 5000 ppm | | | | ☐ | |
| Water | | | | | ☐ | |
| | | | | | ☐ | |
| | | | | | ☐ | |
| | | | | | ☐ | |

**Chemical Reactions:** Provide details below on any chemical reaction(s) that occur in your process. Please show the species involved, the stoichiometry and the heat of reaction, if available. Also list side reactions and any other reactions that may impact safety.

Glacial Acetic Acid + Sodium Bicarbonate ----> Sodium Acetate + Water + Carbon Dioxide
CH3COOH + NaHCO3 ----> NaCH3COO + H2O + CO2
Reaction is slightly endothermic.

Molecular weights: Glacial acetic acid: 60.05, Sodium bicarbonate: 84.01, Sodium acetate: 136.08, Carbon dioxide: 44

**Job Safety Assessment Form**
**Safe Operating Procedures Page**

Provide step-by-step details for each of the sections shown below. Identify the hazards, the control methods and the personal protective equipment (PPE) required. Provide adequate detail so that the reviewers of this document will have adequate understanding of your procedure to pass judgment on the safety of your vehicle.

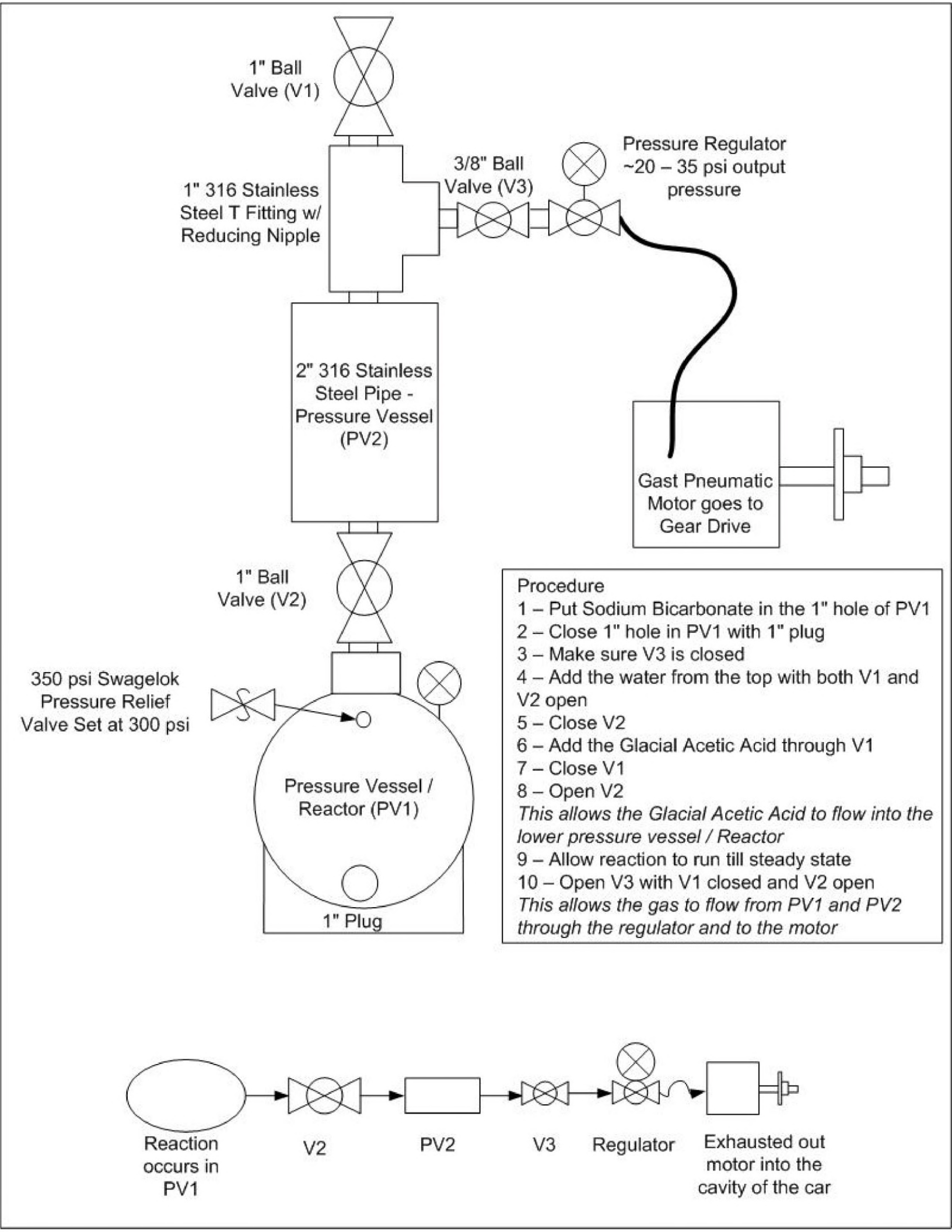
The **Emergency Shutdown** section should have only one or two steps required to stop your vehicle and bring it to a safe state.
The **Start-Up Procedure** section should list all the steps required to prepare your chemicals and vehicle.
The **Run Time Procedure** should describe all steps to operate your vehicle at the starting line of the competition.
The **Shutdown Procedure** should describe the steps normally taken to shutdown your vehicle at the end of your competitive run.
The **Cleanup / Waste Disposal** section should list all the steps required to clean your vehicle of all chemicals and proper chemical disposal.

| Sequence of Steps | Potential Hazards | Procedure to Control Hazard | PPE or Equipment Required |
|---|---|---|---|
| **Emergency Shutdown** | | | |
| Open ball valve V1 slowly to relieve pressure in car. Leave valve V1 open. | 1. Carbon dioxide gas is a potential asphyxiation hazard.<br>2. Glacial acetic acid liquid may also discharge presenting a toxic hazard. | 1. Stay clear of discharge. Insure adequate ventilation in area.<br>2. Wear PPE during all stages of operation of the vehicle. | Safety goggles, long sleeve shirt, pants, lab coat, nitrile gloves. |
| **Start-up Procedure** | | | |
| 1. Weigh out designated mass of sodium bicarbonate in a beaker using the scale.<br>2. Measure designated volume of glacial acetic acid using a graduated cylinder. Leave in graduated cylinder.<br>3. Measure out in graduated cylinder required water based on sodium bicarbonate solubility. Add 20% extra to insure all dissolved.<br>4. Open 1” plug in pressure vessel. | 1. Over charge of sodium bicarbonate.<br>2. Overcharge of glacial acetic acid.<br>3. Spill hazard<br>4. Pressure hazard. | 1. Weigh using beaker with red line indicating max. quantity.<br>2. Use graduated cylinder with red max. quantity line.<br>3. Use spill tray<br>4. Check pressure gauge. Open plug slowly. Make sure valves V2 and V3 | Safety goggles, long sleeve shirt, pants, lab coat, nitrile gloves |

| | | | |
|---|---|---|---|
| | | are open. | |
| 5. Carefully pour sodium bicarbonate powder thru hole. | 5. Spill hazard. | 5. Use spill tray below vessel. | |
| 6. Close 1" hole in PV1 with 1"plug. Tighten fully. | 6. Leak hazard. | 6. Fully tighten plug. Insure that threads are not cross threaded. | |
| 7. Close valve V3 to insure that liquid does not enter regulator. | 7. None | 7. None | |
| 8. Close valve V2. | 8. None | 8. None | |
| 9. Pour the glacial acetic acid thru valve V1. | 9. Spill hazard or reaction hazard | 9. Use spill tray. Insure that valve V2 is closed. Insure that vehicle is upright. | |
| 10. **Leave valve V1 open until vehicle is ready to go at starting line. This will insure that no pressure builds up in PV2**. | 10. None | 10. None | |
| 11. Check pressure gauge – it should read 0 psig or very low. Vehicle is now ready to transport to starting line. | 11. Pressure or leak hazard. | 11. If pressure builds or leak occurs, invoke emergency shutdown procedure. | |
| **Run Time Procedure** | | | |
| 1. Position vehicle carefully at starting line. | 1. Pressure hazard | 1. Observe pressure gauge at all times to insure. | Safety goggles, long sleeve shirt, pants, lab coat, nitrile gloves |
| 2. Check pressure gauge to insure that there is no pressure in vessel PV1. | 2. Pressure hazard when V2 opened. | 2. Check pressure gauge. Do not run if pressure present. | |
| 3. Quickly close valve V1 and open valve V2. This allows the glacial acetic acid to flow into the lower vessel and react with the sodium bicarbonate solution. | 3. High pressure and possible discharge from relief system | 3. Watch pressure gauge as pressure builds. Make sure pressure does not exceed pressure expected. If it does, invoke emergency shutdown procedure. | |
| 4. Open valve V3 to release gas to pneumatic motor to start car moving. | 4. Carbon dioxide gas leak | 4. If gas leaks, invoke emergency procedure. | |
| **Shutdown Procedure** | | | |
| 1. At completion of run gas pressure should be very low. Check pressure gauge to observe pressure. | 1. None | 1. None | Safety goggles, long sleeve shirt, pants, lab coat, nitrile gloves |

| | | | |
|---|---|---|---|
| 2. Move car back to prep area.<br><br>3. Open relief and/or valve V3 slowly to release residual gas pressure. | 2. Gas leak or liquid discharge.<br>3. Carbon dioxide gas discharge and possible liquid discharge. | 2. Invoke emergency response procedure if leak occurs.<br>3. Discharge gas in well ventilated area. Open valves only with tray containment below vessel. | |
| **Cleanup / Waste Disposal** | | | |
| Note: Sodium bicarbonate is in excess for all runs. Glacial acetic acid should be entirely consumed in reaction.<br>1. Check pressure gauge to insure no pressure in car.<br>2. Check status of valves V1 and V2 – both should be open.<br>3. Open 1" drain plug in reaction vessel and pour liquid into a labeled container.<br>4. Add tap water thru valve V1 to rinse vehicle internals. Pour rinse into same container as step 1. Continue to rinse until vessel cleaned.<br>5. Test liquid with pH test strip. Adjust pH by adding either glacial acetic acid or sodium bicarbonate until pH is netural.<br>6. Pour residue down since with substantial dilution water. | 1. None<br>2. None<br>3. Gas or liquid discharge.<br>4. Water spillage. Spillage of waste liquid.<br>5. Potential skin contact with waste liquid.<br>6. Potential skin contact with waste liquid. | 1. None<br>2. None<br>3. Use spill tray below vehicle.<br>4. Use spill tray below vehicle.<br>5. Use PPE specified.<br>6. Use specified PPE. | Safety goggles, long sleeve shirt, pants, lab coat, nitrile gloves |

## 2. Flow Diagram of Car




Procedure

1 – Put Sodium Bicarbonate in the 1" hole of PV1
2 – Close 1" hole in PV1 with 1" plug
3 – Make sure V3 is closed
4 – Add the water from the top with both V1 and V2 open
5 – Close V2
6 – Add the Glacial Acetic Acid through V1
7 – Close V1
8 – Open V2

*This allows the Glacial Acetic Acid to flow into the lower pressure vessel / Reactor*

9 – Allow reaction to run till steady state
10 – Open V3 with V1 closed and V2 open

*This allows the gas to flow from PV1 and PV2 through the regulator and to the motor*

## 3. Design Basis for Maximum Operating Pressure

The spreadsheet on the next page calculates the pressure expected in the vehicle based on differing amounts of glacial acetic acid. The calculation assumes the reaction occurs stoichiometrically. It also assumes complete reaction and accounts for the liquid volume of the water product. The attached figure shows the pressure as a function of glacial acetic acid in ml. As expected, it is very close to a straight line – the volume occupied by the water volume does not have much of an effect.

The pressure required depends on the performance of the Gast pneumatic motor. Specifications are provided in Section 5 of this report. We will regulate the pressure down to 20 psi, which is the lowest pressure that the motor will operate at. It is clear that this motor will produce a lot more torque than we need, even at the low pressures.

At 20 psi the motor will operate at a speed from 1000 rpm and higher – we will need to provide a lot of gear reduction to the drive wheels. We will provide gear reduction adequate for the car to complete the maximum 100 ft course in 20 seconds.

Assuming we operate at 20 psi and 1000 rpm, the air requirement is 5 cfm from the Gast motor spec. From the attached spreadsheet we will select a target gas volume of about 2 cubic feet, which will give us an operating time of about 24 seconds – more than enough time to complete the max. 100 ft course. The 2 cubic feet gas volume will require a pressure of about 290 psi. This will be our maximum operating pressure.

## 4. Design Basis for Estimating Relieving Mass Flow Rate

The maximum operating pressure for the vehicle will be 290 psi. We will select a spring operated relief with a set pressure of 300 psig, which is below the 1.1 times the maximum operating pressure requirement.

We could only find a spring operated relief that will operate at 350 psig. However, it is adjustable. We will adjust it an test with pressure to operate at 300 psig.

The specifications for the relief device are shown in Section 5.

We do not know the actual reaction rate. Our experience mixing these materials in an open beaker in the lab shows that the reaction takes seconds to complete. If the reaction occurs in 10 seconds and produces 2 cubic feet of gas (at the maximum operating pressure) then the gas evolution rate is

$(2\ ft^3)(60\ secs/min)/(10\ secs) = 12\ ft^3 / min$

From the figure at the bottom of the specifications for the relief device (see Section 5), for a discharge rate of 12 scfm and a 300 psi set point, the maximum pressure will be about 320 psi.

However, the pressure will never get that high. The pressure will be limited by the amount of reactant we place in the vessel. We will use a number of management control systems to insure that the vehicle is charged with the proper amount of reactants. This will include:

1. A minimum 2 person confirmation of the calculated quantities of material charged.
2. A red line will be place on the graduated cylinder to denote the maximum possible amount of liquid glacial acetic acid that can be added.
3. The mass of sodium bicarbonate powder weighed will be confirmed by at least two people. The weighing will be done in a beaker with a red mark indicating the maximum amount to charge.
4. Once the sodium bicarbonate is charged to vessel PV1, a red tag will be place on the outside of this vessel indicating that it has been charged.
5. Once the liquid glacial acetic acid has been added to vessel PV2, a red tag will be placed on the outside of this vessel indicating that it has been charged.

## 5. Equipment Specifications

i. **Vessel sheet metal**
ii. **Relief device**
iii. **Regulator**
iv. **Stainless steel ball valve**
v. **Stainless steel piping**
vi. **Gast pneumatic motor**

# Macsteel VRN

## STAINLESS STEEL PLATE, SHEET & COIL

### SX304/304L Technical Data

### SX304/304L Technical Data

**Summary**

SX 304 is the most versatile and the most widely used of all stainless steels. Its chemical composition, mechanical properties, weldability and corrosion/oxidation resistance provide the best all-round performance stainless steel at relatively low cost. It also has excellent low temperature properties and responds well to hardening by cold working. If intergranular corrosion in the heat affected zone may occur, it is suggested that SX 304L be used.

**Typical Applications**

SX 304 is used in all industrial, commercial and domestic fields because of its good corrosion and heat resisting properties. Some applications include:

- Tanks and containers for a large variety of liquids and solids.
- Process equipment in the mining, chemical, cryogenic, food, dairy and pharmaceutical industries.

**Chemical Composition (ASTM A240)**

| SX | $^{o}$C | Mn | P | S | Si | Cr | Ni |
|---|---|---|---|---|---|---|---|
| 304<br>304L | 0.08 max<br>0.03 max | 2.0<br>max | 0.045<br>max | 0.030<br>max | 1.0<br>max | 18.0 to<br>20.0 | 8.0 to 10.50<br>8.0 - 12.0 |

**Typical Properties in the Annealed Condition**

The properties quoted in this publication are typical of mill production and unless indicated should not be regarded as guaranteed minimum values for specification purposes.

**1. Mechanical Properties at Room Temperature**

| | 304 | | 304L | |
|---|---|---|---|---|
| | Typical | Minimum | Typical | Minimum |
| Tensile Strength, MPa | 600 | 515 | 590 | 485 |
| Proof Strength, (Offset 0.2 %), MPa | 310 | 205 | 310 | 170 |
| Elongation (Percent in 50mm) | 60 | 40 | 60 | 40 |
| Hardness (Brinell) | 170 | - | 170 | - |
| Endurance (fatigue) limit, MPa | 240 | - | 240 | - |

**2. Properties at elevated temperatures**

All these values refer to 304 only.

304L values are not given because its strength decreases markedly above 425$^{o}$C.

**Time Elevated Temperature Tensile Strength**

| | | | | | |
|---|---|---|---|---|---|
| Temperature, $^{o}$C | 600 | 700 | 800 | 900 | 1000 |
| Tensile Strength, MPa | 380 | 270 | 170 | 90 | 50 |

**Creep data** Stress for a creep rate of 1% in 10 000 h.

| | | | | | |
|---|---|---|---|---|---|
| Temperature, $^{o}$C | 550 | 600 | 650 | 700 | 800 |
| Stress, MPa | 120 | 80 | 50 | 30 | 10 |

**Maximum Recommended Service Temperature**
(Oxidising Conditions)

Continuous Service 925$^{o}$C
Intermittent Service 850$^{o}$C

**3. Properties at Sub-Zero Temperatures (SX304/304L)**

| | | | | |
|---|---|---|---|---|
| Temperature | $^{o}$C | -78 | -161 | -196 |
| Tensile Strength | MPa | 1100/950 | 1450/1200 | 1600/1350 |
| Proof Stress (Offset 0.2%) | MPa | 300/180 | 380/220 | 400/220 |
| Impact Strength (Charpy V-Notch) | J | 180/175 | 160/160 | 155/150 |

**4. Corrosion Resistance**

**Aqueous**
As a rough guide the following examples are given for certain pure acid-water mixtures-

| Temperature $^{o}$C | 20 | | | | | | 80 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concentration, % by mass | 10 | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 40 | 60 | 80 | 100 |
| Sulphuric Acid | 2 | 2 | 2 | 2 | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 2 |
| Nitric Acid | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Phosphoric Acid | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 2 |
| Formic Acid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 0 |

**Key:** 0 = resistant - corrosion rate less than 100 mm/year
1 = partly resistant - corrosion rate 100m to 1000 mm/year
2 = non resistant - corrosion rate more than 1000 mm/year

**4.2 Atmospheric**
The performance of SX 304 compared with other metals in various environments is shown in the following table. The corrosion rates are based on a 10 year exposure.

| Environment | Corrosion Rate (mm/year) | | |
|---|---|---|---|
| | SX 304 | Aluminium-3S | Mild Steel |
| Rural | 0.0025 | 0.025 | 5.8 |
| Marine | 0.0076 | 0.432 | 34.0 |
| Marine Industrial | 0.0076 | 0.686 | 46.2 |

**Thermal Processing**

- **Annealing.** Heat from 1010$^{O}$C to 1120$^{O}$C and cool rapidly in air or water. The best corrosion resistance is obtained when the final annealing is above 1070$^{O}$C and cooling is rapid.

- **Stress relieving.** SX304L can be stress relieved at 450-600$^{O}$C for one hour with little danger of sensitisation. A lower stress relieving temperature of 400$^{O}$C maximum must be used.

- **Hot working**

  Initial forging and pressing: 1150 to 1260$^{O}$C

  Finishing temperature: 900 to 925$^{O}$C

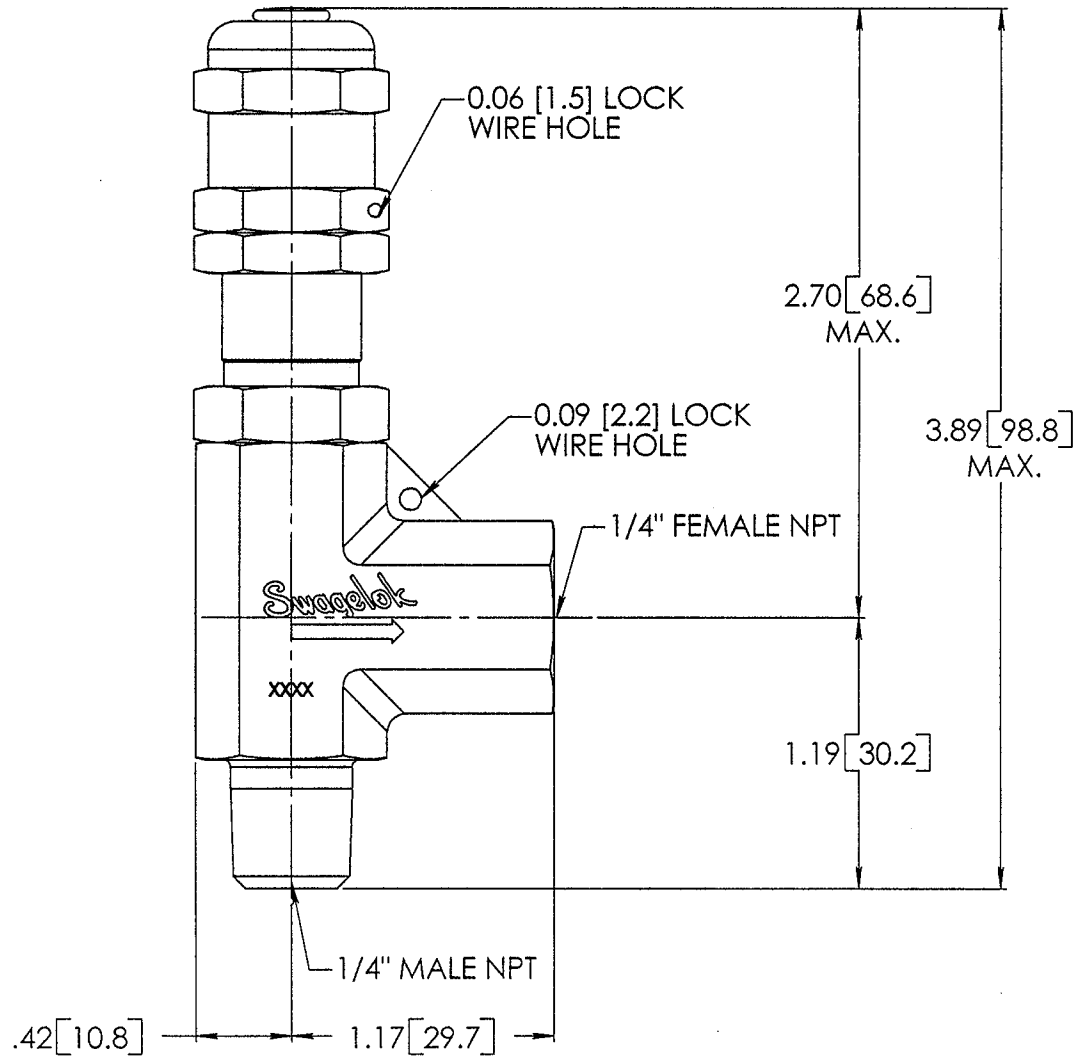
All hotworking operations should be followed by annealing.

***Note:*** *Soaking times to ensure uniformity of temperature are longer for stainless steels than for carbon steels - approximately 12 times.*

**Cold Working**

SX 304 / 304L being extremely tough and ductile, are readily fabricated by old working. Typical operations include bending, forming, deep drawing and upsetting.

PART NO. SS-4R3A5

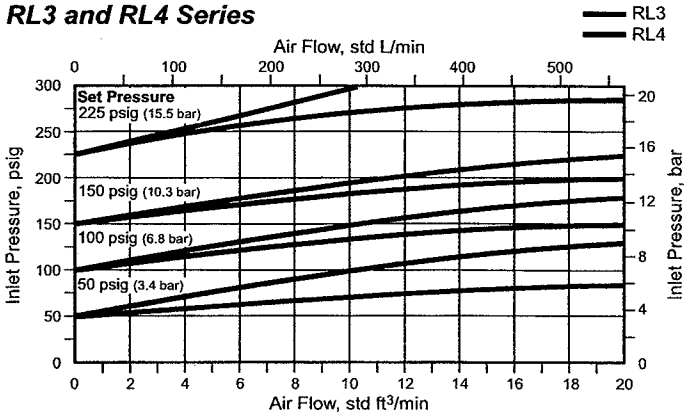



| | | | |
|---|---|---|---|
| CUSTOMER DRAWING<br>Swagelok | - DRAWING NOT TO SCALE.<br>- DIMENSIONS ARE INCHES NEXT TO [MILLIMETERS].<br>- DRAWING IS SUBJECT TO CHANGE WITHOUT NOTICE. | DRAWN BY RCR 04-04-03<br>APPROVED BY JMH 04-04-03 | TITLE R3 SERIES RELIEF VALVE<br>PART NO. SS-4R3A5 |

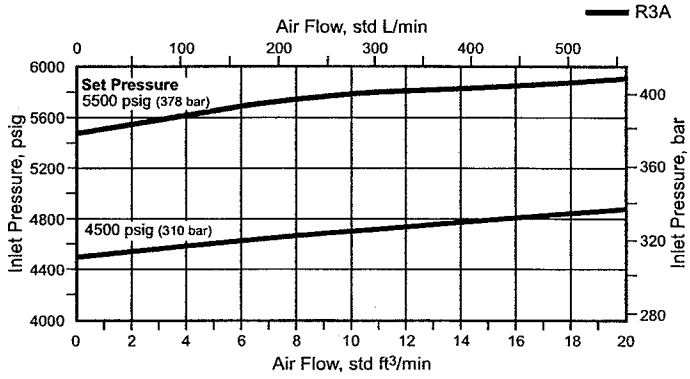
# Flow Data at 70°F (20°C)

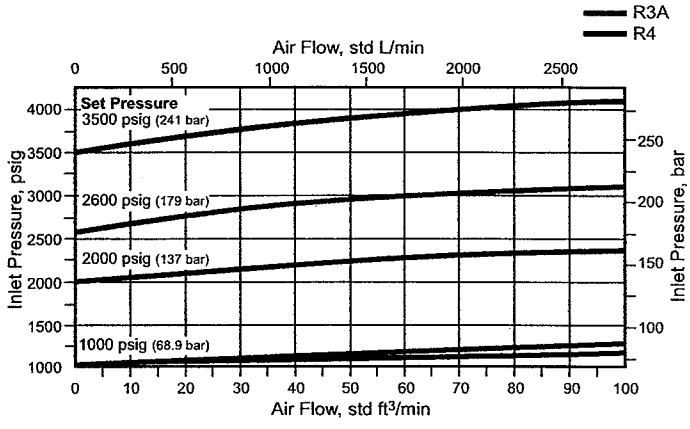
## Air Flow

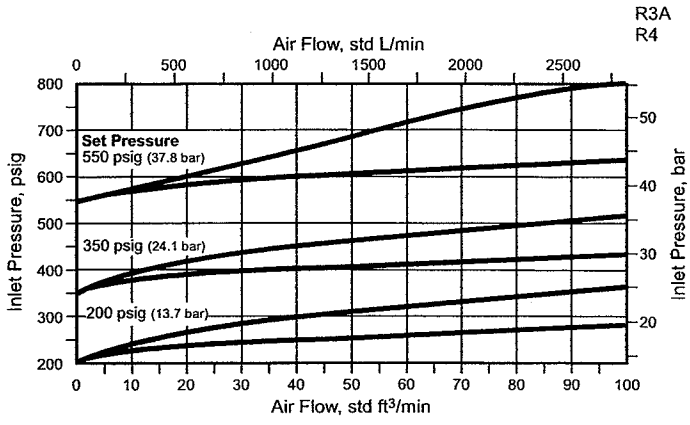
### *RL3 and RL4 Series*




### *R3A and R4 Series*

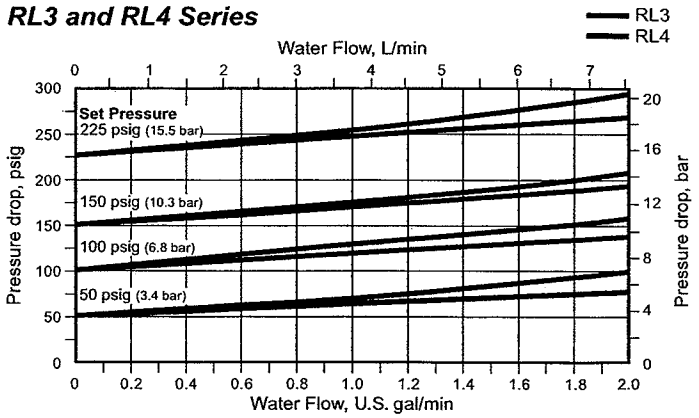


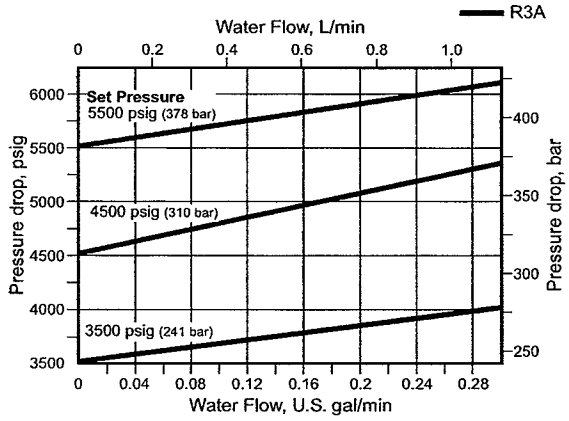



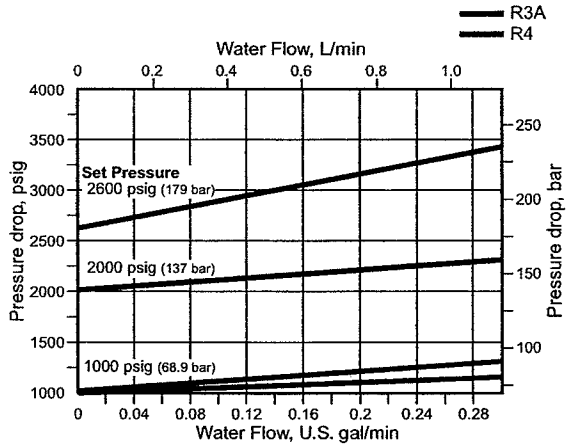

## Water Flow

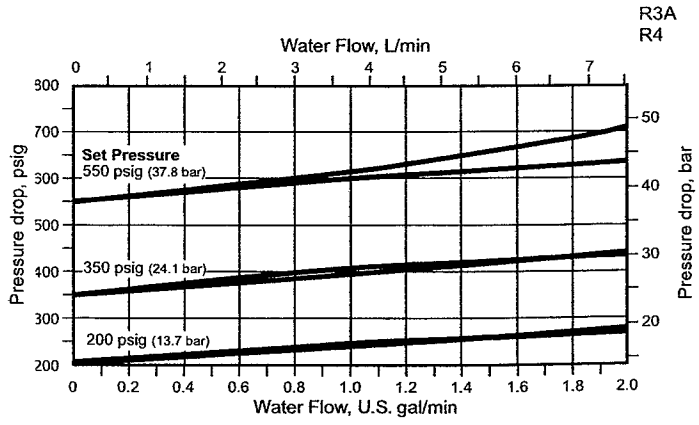
### *RL3 and RL4 Series*




### *R3A and R4 Series*

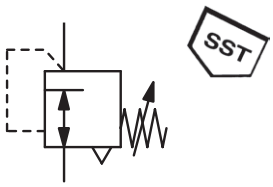


# Stainless Steel Pressure Regulator R364-S / R10-S

| | |
|---|---|
| **Description** | Compact stainless steel pressure regulator with diaphragm. |
| **Media** | compressed air, gases or liquids |
| **Supply pressure** | max. 21 bar |
| **Adjustment** | by plastic knob with snap-lock at R364 and R10, by hexagonal spindle at R354 |
| **Relieving function** | relieving, optionally non-relieving |
| **Gauge port** | G¼ on both sides of the body, screw plugs supplied |
| **Mounting position** | any |
| **Temperature range** | 0 °C to 65 °C / 32 °F to 149 °F, for appropriately conditioned compressed air down to -30 °C / -22 °F<br>0 °C to 80 °C / 32 °F to 176 °F for spring cage made of fiberglass or stainless steel |
| **Material** | Body: stainless steel 316<br>Spring cage: glass fibre-reinforced plastic at R364 and R10, stainless steel 316 at R354, optionally fibreglass at R364<br>Elastomer: FKM<br>Inner valve: stainless steel 316 |




**G¼ and G½ gases or liquids**

| Dimensions A mm | B mm | C mm | Description | $K_v$ value (m³/h) | Flow rate m³/h*1 | l/min*1 | Connection thread G | Pressure range bar | Order number |
|---|---|---|---|---|---|---|---|---|---|
| **Stainless steel pressure regulator** supply pressure max. 21 bar | | | | | | | | | **R364-S** |
| 40 | 75 | 13 | relieving for compressed air | 0.4 | 27 | 450 | G¼ | 0.2…1.8 | **R364-02AS** |
| | | | | | | | | 0.2…4.0 | **R364-02BS** |
| | | | | | | | | 0.3…9.0 | **R364-02CS** |
| 40 | 75 | 13 | non-relieving for liquids | 0.4 | 0.4 | 6 | G¼ | 0.2…1.8 | **R364-02ASK** |
| | | | | | | | | 0.2…4.0 | **R364-02BSK** |
| | | | | | | | | 0.3…9.0 | **R364-02CSK** |
| **Stainless steel pressure regulator** supply pressure max. 21 bar, without constant bleed | | | | | | | | | **R10-S** |
| 60 | 124 | 35 | relieving for compressed air | 2.6 | 180 | 3000 | G½ | 0.2…4.0 | **R10-04BS** |
| | | | | | | | | 0.3…9.0 | **R10-04CS** |
| | | | | | | | | 0.5…17 | **R10-04DS** |
| 60 | 124 | 35 | non-relieving for liquids | 2.6 | 2.6 | 43 | G½ | 0.2…4.0 | **R10-04BSK** |
| | | | | | | | | 0.3…9.0 | **R10-04CSK** |
| | | | | | | | | 0.5…17 | **R10-04DSK** |


R354-S R364-S

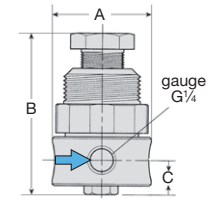

R10-S

## Special options, add the appropriate letter

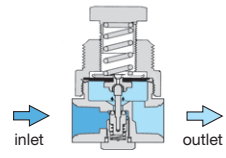
| | | |
|---|---|---|
| **NPT** | connection thread | R.. -0...**N** |
| **free of grease and oil** | specially cleaned | R3.4-0...**L** |
| **stainless steel spring cage** | including stainless steel adjusting screw, total height 60 mm | R354-02.. |
| **fibreglass spring cage** | max. 80 °C / 176 °F | R364-02..**X57** |

## Accessories, enclosed

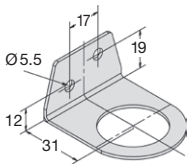
| | | | |
|---|---|---|---|
| **pressure gauge** | Ø 40 mm, 0…*2 bar, G¼ | for R364 | **MS4002-..*2** |
| **pressure gauge** | Ø 50 mm, 0…*2 bar, G¼ | for R10 | **MS5002-..*2** |
| **mounting bracket** | | for R364 | **BW30-04S** |
| **mounting nut** | | for R364 | **M30x1,5S** |
| **mounting bracket** | | for R10 | **BW45-03S** |
| **mounting nut** | | for R10 | **M45X1,5S** |



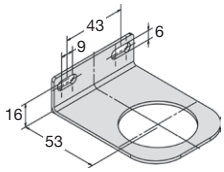

R354-S



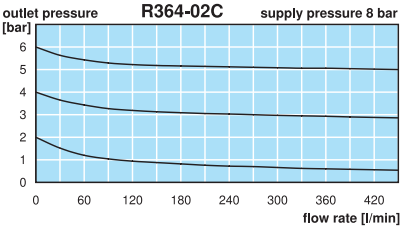

cross section R354-S

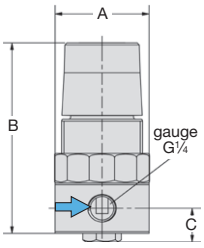



BW30-04S

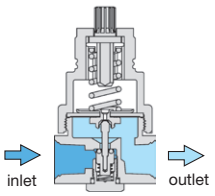



BW45-03S

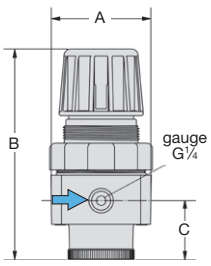


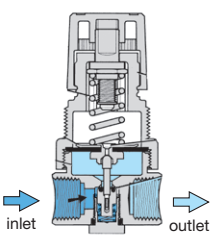

R364-S



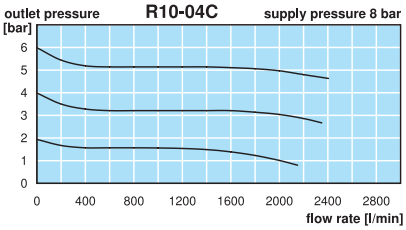

cross section R364-S




R10-S




cross section R10-S




*1 at 8 bar supply pressure, 6 bar outlet pressure and 1 bar pressure drop
*2 **02** = 0…2.5 bar, **04** = 0…4 bar, **10** = 0…10 bar, **16** = 0…16 bar, **25** = 0…25 bar

**Gauges: see chapter for measuring devices**

PDF CAD
www.aircom.net

**Order example: R364-02AS**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# Golden Highope Industrial Inc.

EVERBEST

**Select** ☑ **to :** Inquire Now Add to Basket

## Products : Stainless And Carbon Steel Ball Valves

**Select to inquiry :** ☑

**Model No:** CHA-2F

**Factory Location:** Taiwan

**Sample Request (Y/N):** N

**Target Markets:** Worldwide.

5. 15% reinforced glass fibrous teflon seats.
6. Blow-out proof stem s/s 316, adjustable stem packing.
7. 100% tested air-under water at 100 psi(6 bars) open & close position.

**Specification :**

1. Size: 1/4"-3"full bore.
2. Thread end: BSPT, NPT, DIN259, DIN 2999.
3. Materials: astm a351-cf8m (din 1.4408) stainless steel.
4. Astm a351-cf8(din 1.4308) stainless steel.
5. Astm a216-wcb (din 1.0619) carbon steel.

## Contact Us


Company Name: Golden Highope Industrial Inc.

Contact Person: Mr. Winston Chiu Inquire Now

Address: P.O. Box 1065, Taichung 402, Taiwan

Telephone: +886-4-23726536

Fax: +886-4-23726216

Web Site: http://www.valve-fitting.com.tw/

## Stainless Steel Pipe Specs

From this web site:

http://www.engineeringtoolbox.com/stainless-steel-pipes-pressure-ratings-d_346.html

Ratings for standard seamless stainless steel pipes, temperatures from 100°F to 750°F. All ratings in psig based on ANSI/ASME B 31.1.

| Pressure Rating *(psig)* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pipe Size *(inches)* | Pipe Schedule | Temperature *(°F)* | | | | | | | | |
| | | 100 | 200 | 300 | 400 | 500 | 600 | 650 | 700 | 750 |
| 1" | 40 | 3048 | 2629 | 2362 | 2171 | 2019 | 1924 | 1867 | 1824 | 1810 |
| 1" | 80 | 4213 | 3634 | 3265 | 3002 | 2791 | 2659 | 2580 | 2528 | 2501 |
| 1" | 160 | 6140 | 5296 | 4759 | 4375 | 4068 | 3876 | 3761 | 3684 | 3646 |
| 1.5" | 40 | 2257 | 1947 | 1750 | 1608 | 1496 | 1425 | 1383 | 1354 | 1340 |
| 1.5" | 80 | 3182 | 2744 | 2466 | 2267 | 2108 | 2009 | 1949 | 1909 | 1889 |
| 1.5" | 160 | 4619 | 3984 | 3580 | 3291 | 3060 | 2916 | 2829 | 2772 | 2743 |
| 2" | 40 | 1902 | 1640 | 1474 | 1355 | 1260 | 1201 | 1165 | 1141 | 1129 |
| 2" | 80 | 2747 | 2369 | 2129 | 1957 | 1820 | 1734 | 1682 | 1648 | 1631 |
| 2" | 160 | 4499 | 3880 | 3486 | 3205 | 2980 | 2840 | 2755 | 2699 | 2671 |
| 3" | 40 | 1806 | 1558 | 1400 | 1287 | 1196 | 1140 | 1106 | 1084 | 1072 |
| 3" | 80 | 2553 | 2202 | 1979 | 1819 | 1691 | 1612 | 1564 | 1532 | 1516 |
| 3" | 160 | 3840 | 3312 | 2976 | 2736 | 2544 | 2424 | 2352 | 2304 | 2280 |
| 4" | 40 | 1531 | 1321 | 1187 | 1091 | 1014 | 967 | 938 | 919 | 909 |

# Non-lubricated Air Motors

*up to .18 hp, speeds from 1000 to 4,000 rpm, maximum pressure 80 psi (5,6 bar)*

MODEL

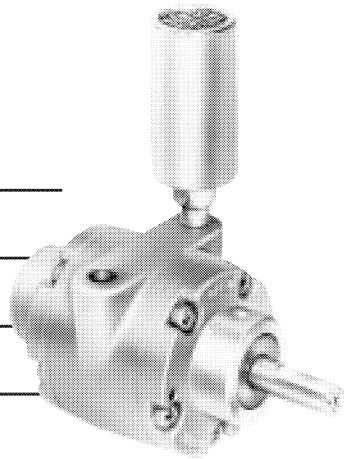
**NL22-NCC-1**
(4 Vanes, CCW Rotation)

**NL22-NCW-2**
(4 Vanes, CW Rotation)

**NL22-FCC-3**
(4 Vanes, CCW Rotation)

**NL22-FCW-4**
(4 Vanes, CW Rotation)

Net wt. 3 lbs. (1,4 kg)



Hub mounting model shown with muffler attached

FEATURES

- Hub or foot mounting
- Treated body, rotor, and end plates for corrosion resistance
- No lubrication necessary - no contaminated air in the work area
- Any plane operation
- Muffler AF350

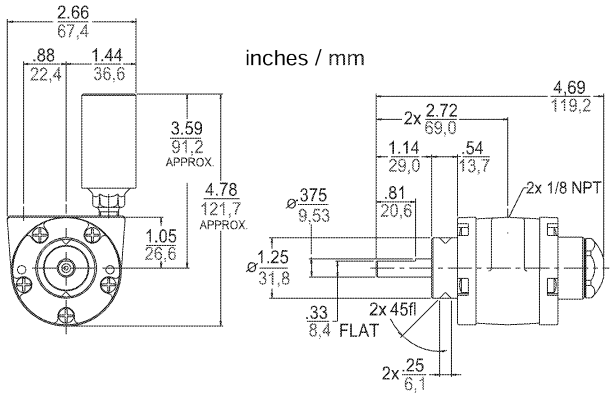
RECOMMENDED

- Filter AH100F
- Regulator AH101R
- Gauge AA807
- Repair kit K285A

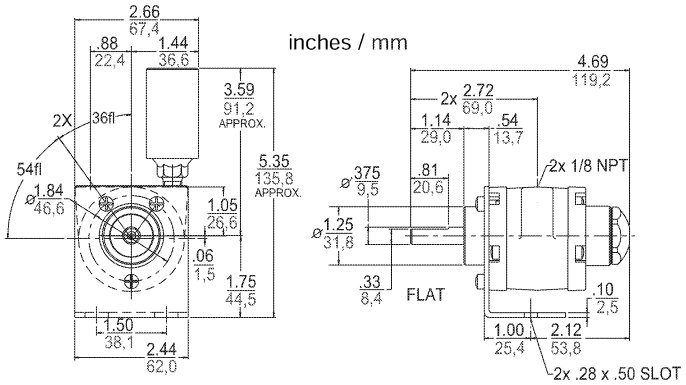
OPTIONAL

- Muffler AL444 (for additional noise reduction)

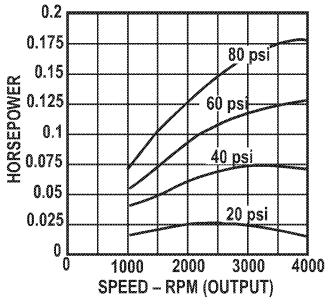
***Hub mounting (NL22-NCC-1, NL22-NCW-2)***

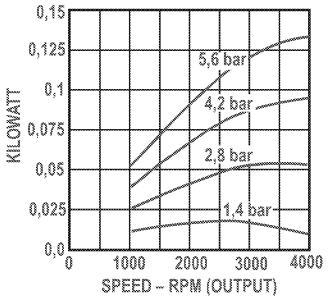



***Foot mounting (NL22-FCC-3, NL22-FCW-4)***

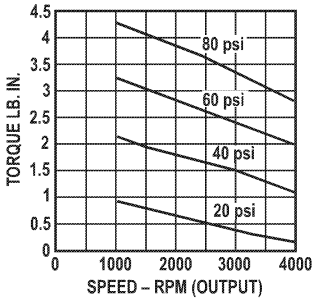


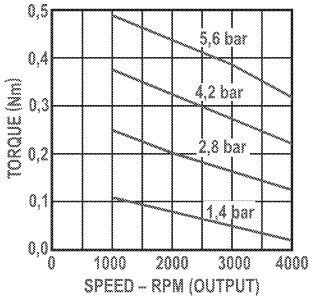

## Output Power vs. Speed



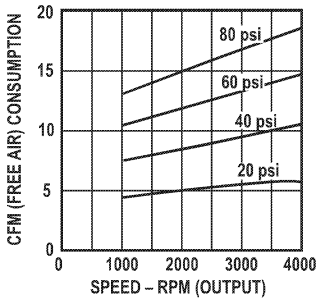



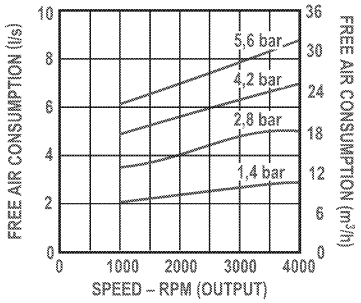

## Torque vs. Speed




## Air Consumption vs. Speed



# 6. Pressure Certification of Vessel

**Documentation of Pressure Test**

| | |
|---|---|
| Identification of vessel or system: | Louise PV |
| Location of vessel or system: | 870 S 500 W Salt Lake City, UT |
| MAWP or test pressure of vessel or system: | MAWP unknown (custom vessel)<br>Max operating pressure: 280 psig<br>Test Pressure: 560 psig (2x operating pressure) |
| Planned test Pressure: | 560 psig |

Supporting Calculations:

Pressure vessel volume: 3.08 liters

Overall reaction: $NaHCO_3(s) + CH_3COOH(l) \rightarrow NaCH_3COO(s) + CO_2(g) + H_2O(l)$

Molecular weight of $CH_3COOH$: 60.05 g/mol

137 ml (144 g) $CH_3COOH$ (maximum amount of limiting reactant) = 2.40 mol $CH_3COOH$

2.40 mol CH3COOH will produce 2.40 mol $CO_2$

$P_{max} = nRT/V$

$= (2.40 \text{ mol } CO_2)(0.08206 \text{ L·atm/mol·K})(298 \text{ K})/(3.08 \text{ L})$

$= 19.0 \text{ atm}$

$= 280 \text{ psi}$

**Maximum operating pressure: 280 psig**

| | |
|---|---|
| Date and time that test started: | 10-15-08 13:11 |
| Date and time that test was completed or failed: | Completed 10-15-08 13:41 |
| Maximum Pressure attained: | 560 psig |
| Test Liquid: | Water |
| External temperature of system: | 70 F |
| Temperature of test liquid: | 75 F |
| Organization conducting test: | University of Utah AIChE ChemE Car Team |
| People witnessing the test and their organization: | Aaron Woolsey, John Peckham |

Signature of Chem-E Car Advisor to Certify the completion of the test: 

## 7. Test Data

**This is preliminary data - more data will be available at the competition.**

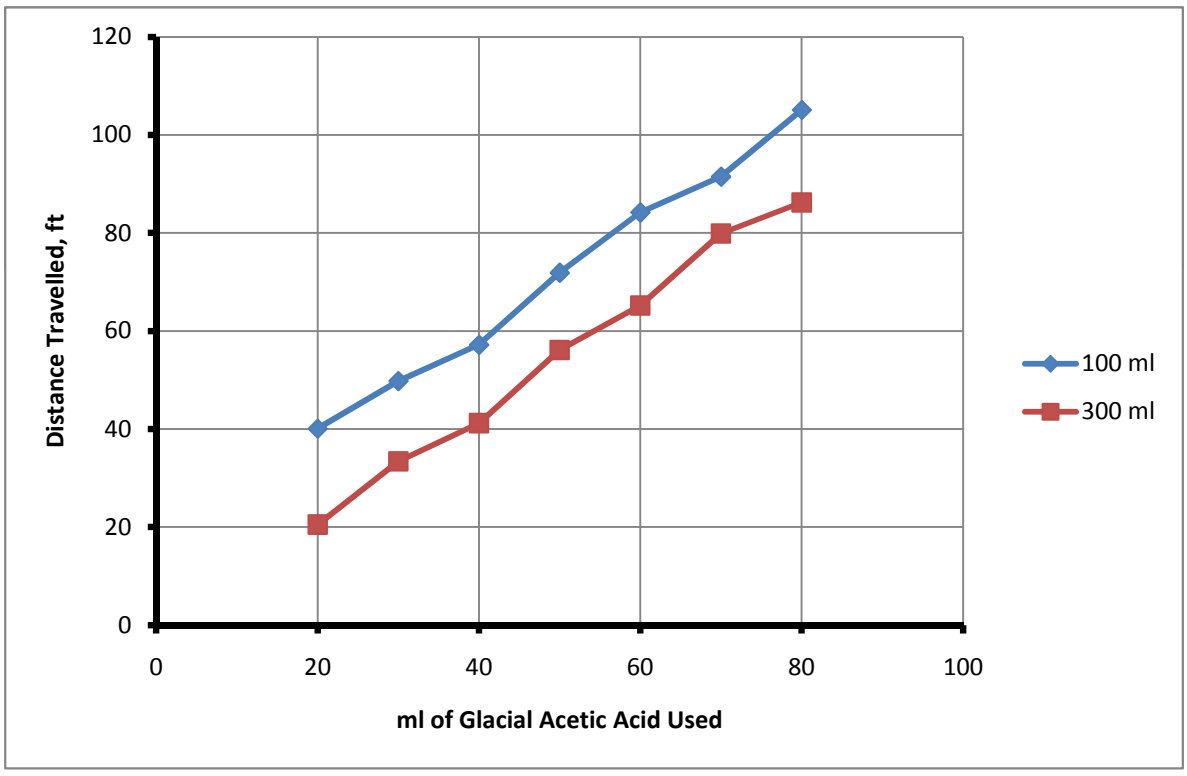
Test Data - Limited at this time

Load = 100 ml of water

| Glacial Acetic Acid, ml | Max. Pressure, psig | Distance Travelled ft |
|---|---|---|
| 20 | 39.5 | 40.1 |
| 30 | 63.1 | 49.8 |
| 40 | 80.5 | 57.2 |
| 50 | 103.7 | 71.9 |
| 60 | 121.5 | 84.2 |
| 70 | 141.2 | 91.5 |
| 80 | 162.8 | 105.1 |

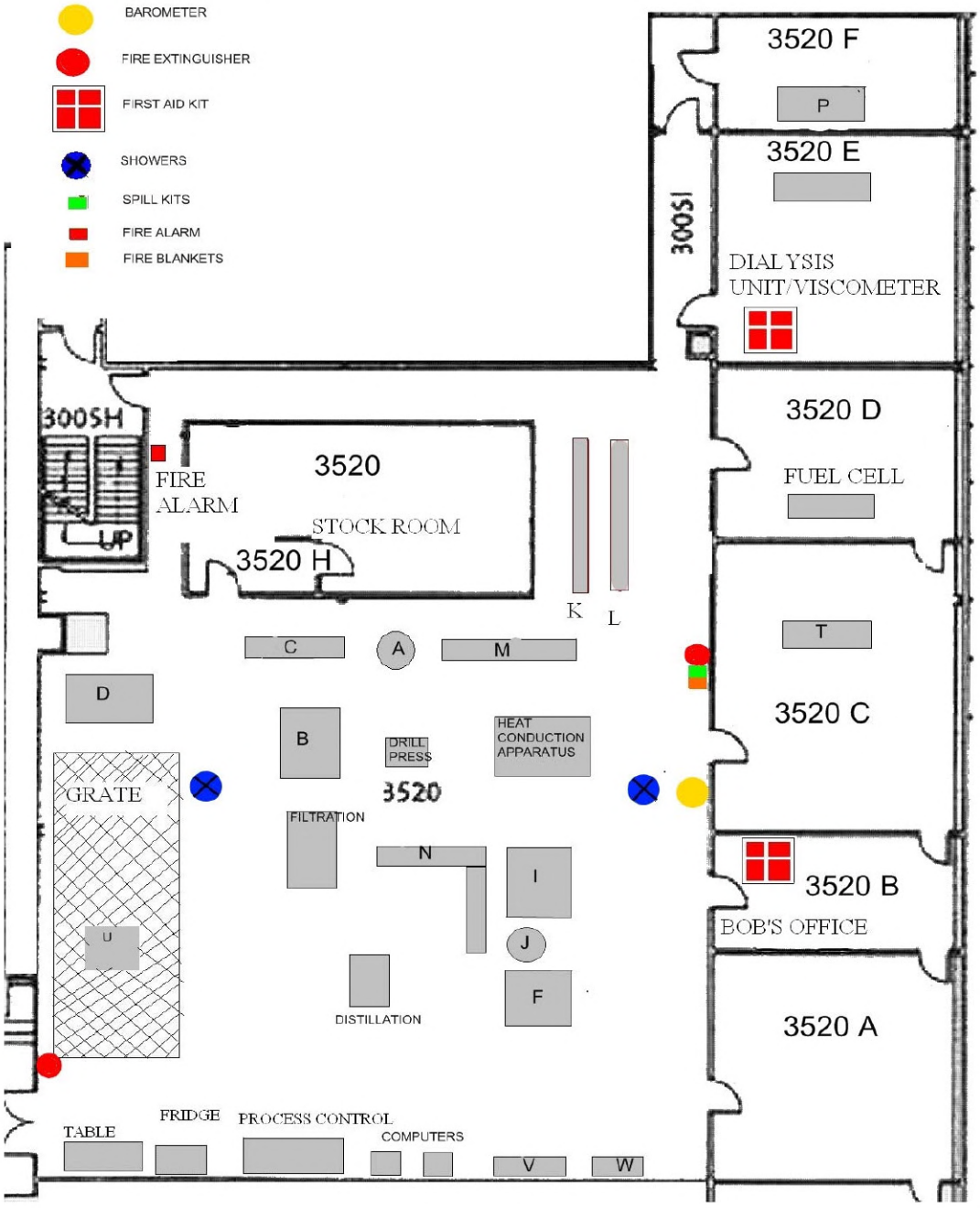
Load = 300 ml of water

| Glacial Acetic Acid, ml | Max. Pressure, psig | Distance Travelled ft |
|---|---|---|
| 20 | 39.5 | 20.5 |
| 30 | 63.1 | 33.4 |
| 40 | 80.5 | 41.2 |
| 50 | 103.7 | 56.1 |
| 60 | 121.5 | 65.2 |
| 70 | 141.2 | 79.9 |
| 80 | 162.8 | 86.2 |



## 8. Car Experimentation Area Floor Plan

| | | | |
|---|---|---|---|
| A | Long-tube vertical evaporator | K | Double-pipe heat exchanger |
| B | Bubble-plate distillation column | L | Shell and tube heat exchanger |
| C | Extruder | M | Gas flow Circuit |
| D | Gas absorber columns | N | Liquid flow circuit |
| E | Liquid-liquid extraction columns | P | CSTR / Tubular reactor |
| F | high pressure glass lined reactor | T | Fermentor/Bioreactor |
| G | Vacuum tray drier | U | Air de-humidifier |
| H | Spray drier | V | Heat Control Experiment |
| I | Fluidized bed apparatus | W | Liquid level flow control (Valtec) |
| J | Pressure/Flow rate cart | | |

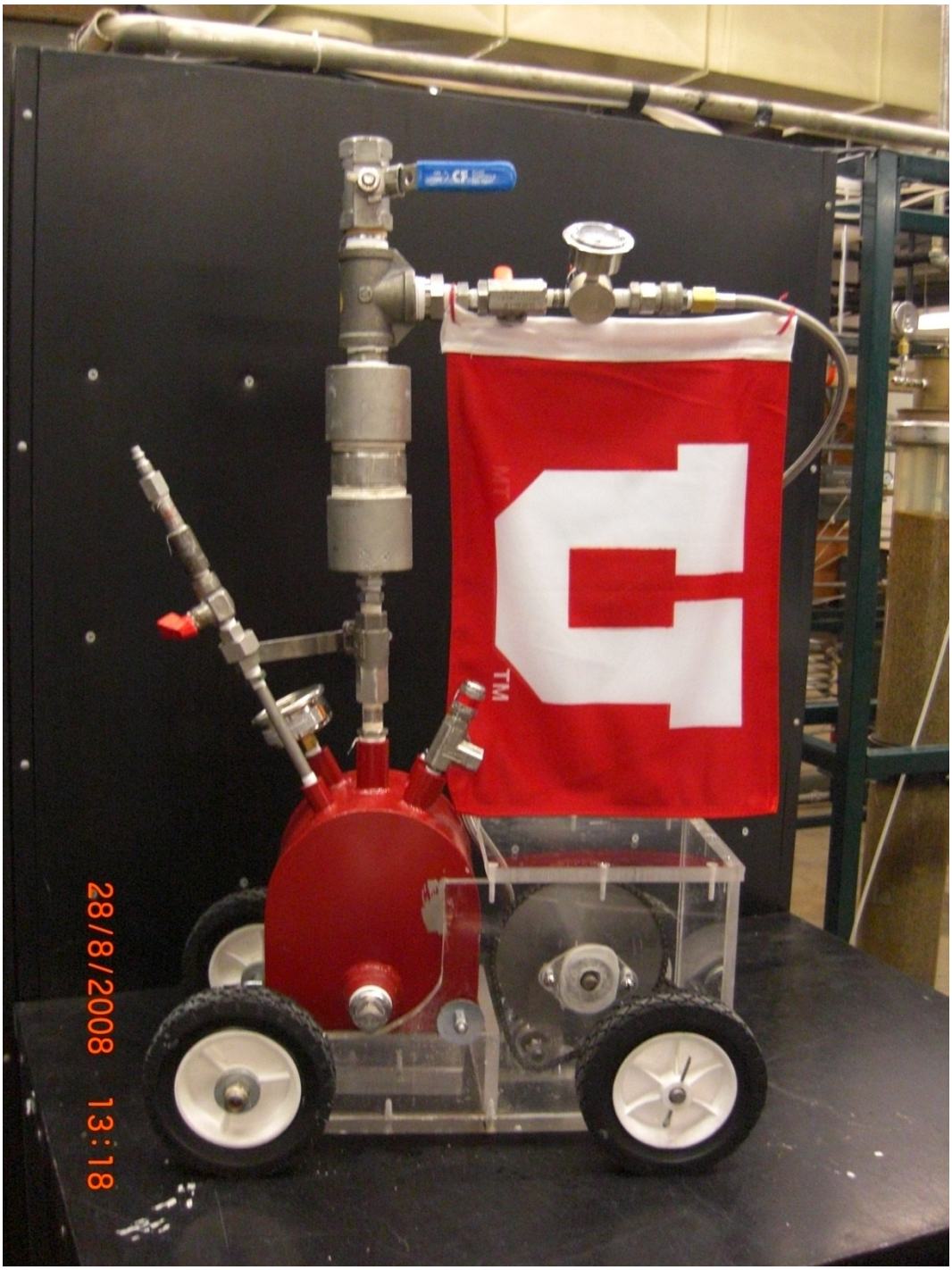


## 9. Management System for Vehicle Modifications

All modifications to the vehicle after the initial design will be done to insure safety. All changes will be approved by the entire team prior to implementation. If the changes are major, then a complete safety review will be required, including participation by the faculty advisor. This would include any changes to the pressure vessel, relief system, maximum operating pressure, replacement of major equipment pieces, and reactant concentrations or quantities. If the changes are smaller in scope, the team itself can decide on the safety.

The team will keep a log book of changes and will update the documentation to insure that the design package is current.

**10. Pictures of Vehicle**
**As it would appear on the starting line.**



# 11. Material Safety Data Sheets

MSDS Number: **A0326** * * * * * *Effective Date:* ***05/06/05*** * * * * * *Supercedes:* ***07/02/02***

**MSDS** **Material Safety Data Sheet**

*From:* **Mallinckrodt Baker, Inc.**
**222 Red School Lane**
**Phillipsburg, NJ 08865**

Mallinckrodt CHEMICALS J.T.Baker

**24 Hour Emergency Telephone: 908-859-2151**
**CHEMTREC: 1-800-424-9300**

**National Response in Canada**
**CANUTEC: 613-996-6666**

**Outside U.S. and Canada**
**Chemtrec: 703-527-3887**

**NOTE:** CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

# ACETIC ACID GLACIAL

## 1. Product Identification

**Synonyms:** Acetic acid, methane carboxylic acid; ethanoic acid
**CAS No.:** 64-19-7
**Molecular Weight:** 60.05
**Chemical Formula:** CH3COOH
**Product Codes:**
J.T. Baker: 5355, 5579, 5844, 6903, 9500, 9501, 9503, 9505, 9507, 9508, 9511, 9513, 9515, 9522, 9524, 9526
Mallinckrodt: 10127, 1302, 2501, 2504, 3121, 5586, 7711, 8817, H979, V155, V193, V194, V625

## 2. Composition/Information on Ingredients

| Ingredient | CAS No | Percent | Hazardous |
|---|---|---|---|
| Acetic Acid | 64-19-7 | 99.5 - 100% | Yes |

## 3. Hazards Identification

**Emergency Overview**

**POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG AND TOOTH DAMAGE. FLAMMABLE LIQUID AND VAPOR.**

**SAF-T-DATA(tm)** Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Poison)
Flammability Rating: 2 - Moderate
Reactivity Rating: 2 - Moderate
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER

Storage Color Code: Red (Flammable)

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**Potential Health Effects**

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**Inhalation:**
Inhalation of concentrated vapors may cause serious damage to the lining of the nose, throat, and lungs. Breathing difficulties may occur. Neither odor nor degree of irritation are adequate to indicate vapor concentration.
**Ingestion:**
Swallowing can cause severe injury leading to death. Symptoms include sore throat, vomiting, and diarrhea. Ingestion of as little as 1.0 ml has resulted in perforation of the esophagus.
**Skin Contact:**
Contact with concentrated solution may cause serious damage to the skin. Effects may include redness, pain, skin burns. High vapor concentrations may cause skin sensitization.
**Eye Contact:**
Eye contact with concentrated solutions may cause severe eye damage followed by loss of sight. Exposure to vapor may cause intense watering and irritation to eyes.
**Chronic Exposure:**
Repeated or prolonged exposures may cause darkening of the skin, erosion of exposed front teeth, and chronic inflammation of the nose, throat, and bronchial tubes.
**Aggravation of Pre-existing Conditions:**
Persons with pre-existing skin disorders or eye problems, or impaired respiratory function may be more susceptible to the effects of the substance.

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## 4. First Aid Measures

**Inhalation:**
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
**Ingestion:**
DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.
**Skin Contact:**
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Call a physician.
**Eye Contact:**
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

---

## 5. Fire Fighting Measures

**Fire:**
Flash point: 40C (104F) CC
Autoignition temperature: 427C (801F)
Flammable limits in air % by volume:
lel: 4.0; uel: 16.0
Flammable Liquid and Vapor!
**Explosion:**
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Vapors can flow along surfaces to distant ignition source and flash back. Contact with strong oxidizers may cause fire. Reacts with most metals to produce hydrogen gas, which can form an explosive mixture with air.
**Fire Extinguishing Media:**
Water, dry chemical, foam or carbon dioxide. Water spray may be used to keep fire exposed containers cool.

**Special Information:**
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Water may be used to flush spills away from exposures and to dilute spills to non-flammable mixtures. Water diluted acid can react with metals to form hydrogen gas.

---

## 6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Use water spray to dilute spill to a nonflammable mixture. Contain and recover liquid when possible. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Use non-sparking tools and equipment. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRASORB® or TEAM® 'Low Na+' acid neutralizers are recommended for spills of this product.

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## 7. Handling and Storage

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Protect from freezing. Store above 17C (63F). Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

---

## 8. Exposure Controls/Personal Protection

**Airborne Exposure Limits:**
-OSHA Permissible Exposure Limit (PEL):
10 ppm (TWA).
-ACGIH Threshold Limit Value (TLV):
10 ppm (TWA); 15 ppm (STEL).
**Ventilation System:**
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
**Personal Respirators (NIOSH Approved):**
If the exposure limit is exceeded, a full facepiece respirator with organic vapor cartridge may be worn up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres.
**Skin Protection:**
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.
**Eye Protection:**
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain

and quick-drench facilities in work area.

## 9. Physical and Chemical Properties

**Appearance:**
Clear, colorless liquid.
**Odor:**
Strong, vinegar-like.
**Solubility:**
Infinitely soluble.
**Density:**
1.05
**pH:**
2.4 (1.0M solution)
**% Volatiles by volume @ 21C (70F):**
100
**Boiling Point:**
118C (244F)
**Melting Point:**
16.6C (63F)
**Vapor Density (Air=1):**
2.1
**Vapor Pressure (mm Hg):**
11 @ 20C (68F)
**Evaporation Rate (BuAc=1):**
0.97

## 10. Stability and Reactivity

**Stability:**
Stable under ordinary conditions of use and storage. Heat and sunlight can contribute to instability. Releases heat and toxic, irritating vapors when mixed with water. Acetic acid contracts slightly upon freezing which may cause the container to burst.
**Hazardous Decomposition Products:**
Carbon dioxide and carbon monoxide may form when heated to decomposition. May also release toxic and irritating vapors.
**Hazardous Polymerization:**
Will not occur.
**Incompatibilities:**
Acetic Acid is incompatible with chromic acid, nitric acid, ethylene glycol, perchloric acid, phosphorous trichloride, oxidizers, sodium peroxide, strong caustics, most metals (except aluminum), carbonates, hydroxides, oxides, and phosphates.
**Conditions to Avoid:**
Heat, flame, ignition sources, freezing, incompatibles

## 11. Toxicological Information

Oral rat LD50: 3310 mg/kg; skin rabbit LD50: 1.06 g/kg; inhalation mouse LC50: 5620ppm/1-hr; investigated as a mutagen, reproductive effector.

--------\Cancer Lists\----------

| Ingredient | ---NTP Carcinogen--- Known | Anticipated | IARC Category |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Acetic Acid (64-19-7) | No | No | None |

## 12. Ecological Information

**Environmental Fate:**
When released into the air, this material may be moderately degraded by reaction with photochemically produced hydroxyl radicals. When released into air, this material is expected to have a half-life between 10 and 30 days. When released into water, this material is expected to readily biodegrade. When released into the water, this material is expected to have a half-life between 1 and 10 days. Standard dilution BOD5/TOD = 58% When released into the soil, this material is expected to readily biodegrade. This material is not expected to significantly bioaccumulate. This material has an estimated bioconcentration factor (BCF) of less than 100.
**Environmental Toxicity:**
This material is expected to be slightly toxic to aquatic life. The LC50/96-hour values for fish are between 10 and 100 mg/l.

For glacial acetic acid:
EC50 (wheat fumigation) = 23.3 mg/m3/2-hr, effect: leaf injury
LC50 (shrimp) = 100 - 300 mg/l/48-hr
LC50 (fathead minnow) = 88 mg/l/96-hr
This material may be toxic to aquatic life.

## 13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

## 14. Transport Information

**Domestic (Land, D.O.T.)**

**Proper Shipping Name:** ACETIC ACID, GLACIAL (WITH MORE THAN 80% ACID, BY MASS)
**Hazard Class:** 8, 3
**UN/NA:** UN2789
Packing Group: II
**Information reported for product/size:** 450LB

**International (Water, I.M.O.)**

**Proper Shipping Name:** ACETIC ACID, GLACIAL (WITH MORE THAN 80% ACID, BY MASS)
**Hazard Class:** 8, 3
**UN/NA:** UN2789
Packing Group: II
**Information reported for product/size:** 450LB

## 15. Regulatory Information

| Ingredient | TSCA | EC | Japan | Australia |
|---|---|---|---|---|

| Acetic Acid (64-19-7) | Yes | Yes | Yes | Yes |
|---|---|---|---|---|

\--------\Chemical Inventory Status - Part 2\----------

| Ingredient | Korea | --Canada-- DSL | NDSL | Phil. |
|---|---|---|---|---|
| Acetic Acid (64-19-7) | Yes | Yes | No | Yes |

\--------\Federal, State & International Regulations - Part 1\----------

| Ingredient | -SARA 302- RQ | TPQ | ------SARA 313------ List | Chemical Catg. |
|---|---|---|---|---|
| Acetic Acid (64-19-7) | No | No | No | No |

\--------\Federal, State & International Regulations - Part 2\----------

| Ingredient | CERCLA | -RCRA- 261.33 | -TSCA- 8(d) |
|---|---|---|---|
| Acetic Acid (64-19-7) | 5000 | No | No |

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: Yes Fire: Yes Pressure: No
Reactivity: Yes (Pure / Liquid)

**Australian Hazchem Code:** 2P
**Poison Schedule:** S6
**WHMIS:**
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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# 16. Other Information

**NFPA Ratings:** Health: **3** Flammability: **2** Reactivity: **0**
**Label Hazard Warning:**
POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG AND TOOTH DAMAGE. FLAMMABLE LIQUID AND VAPOR.
**Label Precautions:**
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor or mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Keep away from heat, sparks and flame.
**Label First Aid:**
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention immediately.
**Product Use:**
Laboratory Reagent.
**Revision Information:**
No Changes.
**Disclaimer:**
**********

**Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product.**

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**********

**Prepared by:** Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

MSDS Number: **S2954** * * * * * *Effective Date:* ***05/23/06*** * * * * * *Supercedes:* ***09/12/03***

**MSDS** **Material Safety Data Sheet**

*From:* **Mallinckrodt Baker, Inc.**
**222 Red School Lane**
**Phillipsburg, NJ 08865**

Mallinckrodt CHEMICALS J.T.Baker

**24 Hour Emergency Telephone: 908-859-2151**
**CHEMTREC: 1-800-424-9300**

**National Response in Canada**
**CANUTEC: 613-996-6666**

**Outside U.S. and Canada**
**Chemtrec: 703-527-3887**

**NOTE:** CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

# SODIUM BICARBONATE

## 1. Product Identification

**Synonyms:** Sodium hydrogen carbonate; sodium acid carbonate; baking soda; bicarbonate of soda
**CAS No.:** 144-55-8
**Molecular Weight:** 84.01
**Chemical Formula:** NaHCO3
**Product Codes:**
J.T. Baker: 3506, 3508, 3509, 3510
Mallinckrodt: 7285, 7396, 7397, 7412, 7749, 7903

## 2. Composition/Information on Ingredients

| Ingredient | CAS No | Percent | Hazardous |
|---|---|---|---|
| Sodium Bicarbonate | 144-55-8 | 99 - 100% | No |

## 3. Hazards Identification

**Emergency Overview**

**As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the chemical substance and ensure prompt removal from skin, eyes and clothing.**

**SAF-T-DATA(tm)** Ratings (Provided here for your convenience)

Health Rating: 1 - Slight
Flammability Rating: 1 - Slight
Reactivity Rating: 1 - Slight
Contact Rating: 1 - Slight
Lab Protective Equip: GOGGLES; LAB COAT
Storage Color Code: Green (General Storage)

**Potential Health Effects**

---

**Inhalation:**
High concentrations of dust may cause coughing and sneezing.
**Ingestion:**
Extremely large oral doses may cause gastrointestinal disturbances.
**Skin Contact:**
No adverse effects expected.
**Eye Contact:**
Contact may cause mild irritation, redness, and pain.
**Chronic Exposure:**
No information found.
**Aggravation of Pre-existing Conditions:**
No information found.

## 4. First Aid Measures

**Inhalation:**
Remove to fresh air. Get medical attention for any breathing difficulty.
**Ingestion:**
Give several glasses of water to drink to dilute. If large amounts were swallowed, get medical advice.
**Skin Contact:**
Not expected to require first aid measures.
**Eye Contact:**
Wash thoroughly with running water. Get medical advice if irritation develops.

## 5. Fire Fighting Measures

**Fire:**
Not considered to be a fire hazard.
**Explosion:**
Not considered to be an explosion hazard.
**Fire Extinguishing Media:**
Use any means suitable for extinguishing surrounding fire.
**Special Information:**
Use protective clothing and breathing equipment appropriate for the surrounding fire.

## 6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Sweep up and containerize for reclamation or disposal. Vacuuming or wet sweeping may be used to avoid dust dispersal. Small amounts of residue may be flushed to sewer with plenty of water.

## 7. Handling and Storage

Keep in a well closed container stored under cold to warm conditions, 2 to 40 C, (36 to 104F). Protect against physical damage. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

## 8. Exposure Controls/Personal Protection

**Airborne Exposure Limits:**
None established.
**Ventilation System:**
In general, dilution ventilation is a satisfactory health hazard control for this substance. However, if conditions of use create discomfort to the worker, a local exhaust system should be considered.
**Personal Respirators (NIOSH Approved):**
For conditions of use where exposure to dust or mist is apparent and engineering controls are not feasible, a particulate respirator (NIOSH type N95 or better filters) may be worn. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
**Skin Protection:**
Wear protective gloves and clean body-covering clothing.
**Eye Protection:**
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

## 9. Physical and Chemical Properties

**Appearance:**
White crystalline powder.
**Odor:**
Odorless.
**Solubility:**
7.8g/100g water @ 18C (64F).
**Density:**
2.2
**pH:**
8.3 (0.1 molar @ 25C (77F))
**% Volatiles by volume @ 21C (70F):**
0
**Boiling Point:**
Not applicable.
**Melting Point:**
60C (140F)
**Vapor Density (Air=1):**
No information found.
**Vapor Pressure (mm Hg):**
No information found.
**Evaporation Rate (BuAc=1):**
No information found.

## 10. Stability and Reactivity

**Stability:**
Stable under ordinary conditions of use and storage.
**Hazardous Decomposition Products:**
Gaseous carbon dioxide.
**Hazardous Polymerization:**
Will not occur.
**Incompatibilities:**
Reacts with acids to form carbon dioxide. Dangerous reaction with monoammonium phosphate or a

sodium-potassium alloy.
**Conditions to Avoid:**
Heat, moisture, incompatibles.

## 11. Toxicological Information

Investigated as a mutagen, reproductive effector. Oral rat LD50: 4220 mg/kg. Irritation data: human,skin, 30mg/3D-I mild, rabbit,eye, 100 mg/30 S, mild.

--------\Cancer Lists\----------

| Ingredient | ---NTP Carcinogen--- Known | Anticipated | IARC Category |
|---|---|---|---|
| Sodium Bicarbonate (144-55-8) | No | No | None |

## 12. Ecological Information

**Environmental Fate:**
No information found.
**Environmental Toxicity:**
No information found.

## 13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

## 14. Transport Information

Not regulated.

## 15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

| Ingredient | TSCA | EC | Japan | Australia |
|---|---|---|---|---|
| Sodium Bicarbonate (144-55-8) | Yes | Yes | Yes | Yes |

--------\Chemical Inventory Status - Part 2\----------

| Ingredient | Korea | --Canada-- DSL | NDSL | Phil. |
|---|---|---|---|---|
| Sodium Bicarbonate (144-55-8) | Yes | Yes | No | Yes |

--------\Federal, State & International Regulations - Part 1\----------

| Ingredient | -SARA 302- RQ | TPQ | ------SARA 313------ List | Chemical Catg. |
|---|---|---|---|---|
| Sodium Bicarbonate (144-55-8) | No | No | No | No |

--------\Federal, State & International Regulations - Part 2\----------

| Ingredient | CERCLA | -RCRA- 261.33 | -TSCA- 8(d) |
|---|---|---|---|
| Sodium Bicarbonate (144-55-8) | No | No | No |

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: No Chronic: No Fire: No Pressure: No
Reactivity: No (Pure / Solid)

**Australian Hazchem Code:** None allocated.
**Poison Schedule:** None allocated.
**WHMIS:**
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

---

## 16. Other Information

**NFPA Ratings:** Health: **1** Flammability: **0** Reactivity: **0**
**Label Hazard Warning:**
As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the chemical substance and ensure prompt removal from skin, eyes and clothing.
**Label Precautions:**
None.
**Label First Aid:**
Not applicable.
**Product Use:**
Laboratory Reagent.
**Revision Information:**
No Changes.
**Disclaimer:**
**********

**Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. MALLINCKRODT BAKER, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, MALLINCKRODT BAKER, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.**
**********

**Prepared by:** Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

MSDS Number: **S2666** * * * * * *Effective Date:* ***03/16/06*** * * * * * *Supercedes:* ***02/16/06***

***MSDS*** ***Material Safety Data Sheet***

*From:* **Mallinckrodt Baker, Inc.**
**222 Red School Lane**
**Phillipsburg, NJ 08865**

Mallinckrodt CHEMICALS | J.T.Baker

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**National Response in Canada**
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**NOTE:** CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

# SODIUM ACETATE

## 1. Product Identification

**Synonyms:** Sodium acetate trihydrate; Acetic acid, sodium salt trihydrate
**CAS No.:** 127-09-3 (Anhydrous); 6131-90-4 (Trihydrate)
**Molecular Weight:** 136.08
**Chemical Formula:** CH3COONa 3H2O
**Product Codes:**
J.T. Baker: 3460, 3461, 3462, 4009
Mallinckrodt: 7356, 7364, 7690, 7768

# 2. Composition/Information on Ingredients

| Ingredient | CAS No | Percent | Hazardous |
|---|---|---|---|
| Sodium Acetate | 127-09-3 | 99 - 100% | Yes |

---

# 3. Hazards Identification

**Emergency Overview**

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**CAUTION! MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT.**

**SAF-T-DATA(tm)** Ratings (Provided here for your convenience)

---

Health Rating: 1 - Slight
Flammability Rating: 1 - Slight
Reactivity Rating: 1 - Slight
Contact Rating: 1 - Slight
Lab Protective Equip: GOGGLES; LAB COAT; VENT HOOD; PROPER GLOVES
Storage Color Code: Green (General Storage)

---

**Potential Health Effects**

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**Inhalation:**
May cause irritation to the respiratory tract. Symptoms may include coughing, sore throat, labored breathing, and chest pain.
**Ingestion:**
Large doses may produce abdominal pain, nausea, and vomiting.

**Skin Contact:**
May cause irritation with redness and pain.
**Eye Contact:**
Contact may cause irritation, redness, and pain.
**Chronic Exposure:**
No information found.
**Aggravation of Pre-existing Conditions:**
No information found.

---

# 4. First Aid Measures

**Inhalation:**
Remove to fresh air. Get medical attention for any breathing difficulty.
**Ingestion:**
Give several glasses of water to drink to dilute. If large amounts were swallowed, get medical advice.
**Skin Contact:**
Immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops.
**Eye Contact:**
Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

---

# 5. Fire Fighting Measures

**Fire:**
Autoignition temperature: 611C (1132F)
As with most organic solids, fire is possible at elevated temperatures or by contact with an ignition source. Listed fire data is for the Anhydrous Material.
**Explosion:**
Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

**Fire Extinguishing Media:**
Water spray, dry chemical, alcohol foam, or carbon dioxide.
**Special Information:**
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

---

## 6. Accidental Release Measures

Remove all sources of ignition. Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Clean up spills in a manner that does not disperse dust into the air. Use non-sparking tools and equipment. Reduce airborne dust and prevent scattering by moistening with water. Pick up spill for recovery or disposal and place in a closed container. Small amounts of residue may be flushed to sewer with plenty of water.

---

## 7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from any source of heat or ignition. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

---

## 8. Exposure Controls/Personal Protection

**Airborne Exposure Limits:**
None established.
**Ventilation System:**
A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

**Personal Respirators (NIOSH Approved):**
For conditions of use where exposure to dust or mist is apparent and engineering controls are not feasible, a particulate respirator (NIOSH type N95 or better filters) may be worn. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
**Skin Protection:**
Wear protective gloves and clean body-covering clothing.
**Eye Protection:**
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

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# 9. Physical and Chemical Properties

**Appearance:**
Colorless crystals.
**Odor:**
Slight acetic acid odor.
**Solubility:**
76 gm/100mls water @ 0C
**Density:**
1.45
**pH:**
8.9
**% Volatiles by volume @ 21C (70F):**
0
**Boiling Point:**
Not applicable.
**Melting Point:**
Loses water @ 120C (248F); decomposes @ 324C (615.2F)
**Vapor Density (Air=1):**
No information found.
**Vapor Pressure (mm Hg):**
No information found.

**Evaporation Rate (BuAc=1):**
No information found.

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# 10. Stability and Reactivity

**Stability:**
Stable under ordinary conditions of use and storage.
**Hazardous Decomposition Products:**
Emits fumes of acetic acid upon heating and on contact with strong acids.
**Hazardous Polymerization:**
Will not occur.
**Incompatibilities:**
Nitric acid, fluoride, potassium nitrate, strong oxidizers and diketene.
**Conditions to Avoid:**
Incompatibles.

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# 11. Toxicological Information

Hydrate: Investigated as a mutagen. Anhydrous: Oral rat LD50: 3530 mg/kg; inhalation rat LC50: > 30 gm/m3; skin rabbit LD50: > 10 mg/kg; Irritation Data, standard Draize: Skin rabbit 500 mg/24H, mild; standard Draize, Eye rabbit 10 mg, mild. Investigated as a mutagen.

--------\Cancer Lists\----------

| Ingredient | ---NTP Carcinogen--- Known | Anticipated | IARC Category |
|---|---|---|---|
| Sodium Acetate (127-09-3) | No | No | None |

---

# 12. Ecological Information

**Environmental Fate:**
No information found.
**Environmental Toxicity:**
Freshwater Fish Species Data: 24 Hr LC50 Lepomis macrochirus: 5000 mg/L
Microtox Data: 18 Hr EC50 Pseudomonas putida: 7200 mg/L
Water Flea Data: 48 Hr EC50 water flea: 5800 mg/L

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## 13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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## 14. Transport Information

Not regulated.

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## 15. Regulatory Information

--------\Chemical Inventory Status - Part 1\---------------------------------

| Ingredient | TSCA | EC | Japan | Australia |
|---|---|---|---|---|
| Sodium Acetate (127-09-3) | Yes | Yes | Yes | Yes |

--------\Chemical Inventory Status - Part 2\---------------------------------

| | | --Canada-- | | |
|---|---|---|---|---|
| Ingredient | Korea | DSL | NDSL | Phil. |
| Sodium Acetate (127-09-3) | Yes | Yes | No | Yes |

--------\Federal, State & International Regulations - Part 1\----------------

| Ingredient | -SARA 302- RQ | TPQ | ------SARA 313------ List | Chemical Catg. |
|---|---|---|---|---|
| Sodium Acetate (127-09-3) | No | No | No | No |

| Ingredient | CERCLA | -RCRA- 261.33 | -TSCA- 8(d) |
|---|---|---|---|
| Sodium Acetate (127-09-3) | No | No | No |

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: No Fire: No Pressure: No
Reactivity: No (Pure / Solid)

**Australian Hazchem Code:** None allocated.
**Poison Schedule:** None allocated.
**WHMIS:**
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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# 16. Other Information

**NFPA Ratings:** Health: **1** Flammability: **1** Reactivity: **0**
**Label Hazard Warning:**
CAUTION! MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT.
**Label Precautions:**
Avoid contact with eyes, skin and clothing.
Avoid breathing dust.
Use with adequate ventilation.
Wash thoroughly after handling.
Keep container closed.
**Label First Aid:**

If inhaled, remove to fresh air. Get medical attention for any breathing difficulty. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Get medical attention if irritation develops or persists.

**Product Use:**

Laboratory Reagent.

**Revision Information:**

MSDS Section(s) changed since last revision of document include: 3, 12.

**Disclaimer:**

**********

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**Prepared by:** Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

BOC GASES

***MATERIAL SAFETY DATA SHEET***

PRODUCT NAME: CARBON DIOXIDE, GAS

## 1. Chemical Product and Company Identification

**BOC Gases,**
**Division of**
**The BOC Group, Inc.**
**575 Mountain Avenue**
**Murray Hill, NJ 07974**

**TELEPHONE NUMBER:** (908) 464-8100
**24-HOUR EMERGENCY TELEPHONE NUMBER:**
CHEMTREC (800) 424-9300

**BOC Gases**
**Division of**
**BOC Canada Limited**
**5975 Falbourne Street, Unit 2**
**Mississauga, Ontario L5R 3W6**

**TELEPHONE NUMBER:** (905) 501-1700
**24-HOUR EMERGENCY TELEPHONE NUMBER:**
(905) 501-0802
**EMERGENCY RESPONSE PLAN NO:** 20101

**PRODUCT NAME:** CARBON DIOXIDE, GAS
**CHEMICAL NAME:** Carbon Dioxide
**COMMON NAMES/SYNONYMS:** Carbonic Anhydride
**TDG (Canada) CLASSIFICATION:** 2.2
**WHMIS CLASSIFICATION:** A

**PREPARED BY:** Loss Control (908)464-8100/(905)501-1700
**PREPARATION DATE:** 6/1/95
**REVIEW DATES:** 6/7/96

## 2. Composition, Information on Ingredients

| INGREDIENT | % VOLUME | PEL-OSHA[1] | TLV-ACGIH[2] | $LD_{50}$ or $LC_{50}$ Route/Species |
|---|---|---|---|---|
| Carbon Dioxide<br>FORMULA: $CO_2$<br>CAS: 124-38-9<br>RTECS #: FF6400000 | 99.8 TO 99.999 | 5000 ppm TWA | 5000 ppm TWA<br>30,000 ppm STEL | Not Available |

[1] As stated in 29 CFR 1910, Subpart Z (revised July 1, 1993)

[2] As stated in the ACGIH 1994-95 Threshold Limit Values for Chemical Substances and Physical Agents

## 3. Hazards Identification

EMERGENCY OVERVIEW

Oxygen levels below 19.5% may cause asphyxia. Carbon dioxide exposure can cause nausea and respiratory problems. High concentrations may cause vasodilation leading to circulatory collapse.

**ROUTE OF ENTRY:**

| Skin Contact | Skin Absorption | Eye Contact | Inhalation | Ingestion |
|---|---|---|---|---|
| Yes | No | Yes | Yes | Yes |

**HEALTH EFFECTS:**

| Exposure Limits | Irritant | Sensitization |
|---|---|---|
| Yes | No | No |
| Teratogen | Reproductive Hazard | Mutagen |
| No | No | No |
| Synergistic Effects<br>None reported | | |

Carcinogenicity: -- NTP: No IARC: No OSHA: No

**EYE EFFECTS:**
No adverse effects anticipated.

**SKIN EFFECTS:**
No adverse effects anticipated.

**INGESTION EFFECTS:**
No adverse effects anticipated.

**INHALATION EFFECTS:**
Carbon dioxide is the most powerful cerebral vasodilator known. Inhaling large concentrations causes rapid circulatory insufficiency leading to coma and death. Asphyxiation is likely to occur before the effects of carbon dioxide overexposure. Chronic, harmful effects are not known from repeated inhalation of low concentrations. Low concentrations of carbon dioxide cause increased respiration and headache.

Effects of oxygen deficiency resulting from simple asphyxiants may include: rapid breathing, diminished mental alertness, impaired muscular coordination, faulty judgement, depression of all sensations, emotional instability, and fatigue. As asphyxiation progresses, nausea, vomiting, prostration, and loss of consciousness may result, eventually leading to convulsions, coma, and death.

Oxygen deficiency during pregnancy has produced developmental abnormalities in humans and experimental animals.

| **NFPA HAZARD CODES** | **HMIS HAZARD CODES** | **RATINGS SYSTEM** |
|---|---|---|
| Health: 1 | Health: 1 | 0 = No Hazard |
| Flammability: 0 | Flammability: 0 | 1 = Slight Hazard |
| Reactivity: 0 | Reactivity: 0 | 2 = Moderate Hazard |
| | | 3 = Serious Hazard |
| | | 4 = Severe Hazard |

## 4. First Aid Measures

**EYES:**
Never introduce oil or ointment into the eyes without medical advice! If pain is present, refer the victim to an ophthalmologist for further treatment and follow up.

**SKIN:**
No adverse effects anticipated.

**INGESTION:**
Not anticipated.

**INHALATION:**
PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO CARBON DIOXIDE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS. Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Further treatment should be symptomatic and supportive.

## 5. Fire Fighting Measures

| | | |
|---|---|---|
| Conditions of Flammability: Nonflammable | | |
| Flash point:<br>None | Method:<br>Not Applicable | Autoignition<br>Temperature: None |
| LEL(%): None | UEL(%): None | |
| Hazardous combustion products: None | | |
| Sensitivity to mechanical shock: None | | |
| Sensitivity to static discharge: None | | |

**FIRE AND EXPLOSION HAZARDS:**
None. Nonflammable

## 6. Accidental Release Measures

Evacuate all personnel from affected area. Use appropriate protective equipment. If leak is in user's equipment, be certain to purge piping with inert gas prior to attempting repairs. If leak is in container or container valve, contact the appropriate emergency telephone number listed in Section 1 or call your closest BOC location.

## 7. Handling and Storage

**Electrical Classification:**
Non-Hazardous

Dry carbon dioxide can be handled in most common structural materials. Moist carbon dioxide is generally corrosive by its formation of carbonic acid. For applications with moist Carbon Dioxide, 316, 309 and 310 stainless steels may be used as well as Hastelloy ® A, B, & C, and Monel ®. Ferrous Nickel alloys are slightly susceptible to corrosion. At normal temperatures carbon dioxide is compatible with most plastics and elastomers.

Use only in well-ventilated areas. Carbon dioxide vapor is heavier than air and will accumulate in low areas. Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the system.

Protect cylinders from physical damage. Store in cool, dry, well-ventilated area away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 125°F (52°C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders being stored for excessive periods of time.

For additional storage recommendations, consult Compressed Gas Association's Pamphlet P-1.

Never carry a compressed gas cylinder or a container of a gas in cryogenic liquid form in an enclosed space such as a car trunk, van or station wagon. A leak can result in a fire, explosion, asphyxiation or a toxic exposure.

Maximum use for potable water 100 mg/l.

## 8. Exposure Controls, Personal Protection

**EXPOSURE LIMITS[1]:**

| INGREDIENT | % VOLUME | PEL-OSHA[2] | TLV-ACGIH[3] | $LD_{50}$ or $LC_{50}$ Route/Species |
|---|---|---|---|---|
| Carbon Dioxide<br>FORMULA: $CO_2$<br>CAS: 124-38-9<br>RTECS #: FF6400000 | 99.8 TO 99.999 | 5000 ppm TWA | 5000 ppm TWA<br>30,000 ppm STEL | Not Available |

[1] Refer to individual state of provincial regulations, as applicable, for limits which may be more stringent than those listed here.
[2] As stated in 29 CFR 1910, Subpart Z (revised July 1, 1993)
[3] As stated in the ACGIH 1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents.

IDLH (Carbon Dioxide): 50,000 ppm

**ENGINEERING CONTROLS:**
Use local exhaust to prevent accumulation of high concentrations so as to reduce the oxygen level in the air to less than 19.5% and the carbon dioxide concentration below the exposure limit.

**EYE/FACE PROTECTION:**
Safety goggles or glasses as appropriate for the job.

**SKIN PROTECTION:**
Protective gloves of any material appropriate for the job.

**RESPIRATORY PROTECTION:**

Positive pressure air line with full-face mask and escape bottle or self-contained breathing apparatus should be available for emergency use.

**OTHER/GENERAL PROTECTION:**
Safety shoes.

## 9. Physical and Chemical Properties

| PARAMETER | VALUE | UNITS |
|---|---|---|
| Physical state (gas, liquid, solid) | : Gas | |
| Vapor pressure at 70 $^{o}$F | : 856 | psia |
| Vapor density at 70 $^{o}$F, 1 atm (Air = 1) | : 1.53 | |
| Evaporation point | : Not Available | |
| Boiling point (CO2 Sublimes) | : -109.3 | $^{o}$F |
| | : -78.5 | $^{o}$C |
| Freezing point | : -69.8 | $^{o}$F |
| | : -56.6 | $^{o}$C |
| pH | : Not Available | |
| Specific gravity | : Not Available | |
| Oil/water partition coefficient | : Not Available | |
| Solubility (H20) | : Very soluble | |
| Odor threshold | : Not Applicable | |
| Odor and appearance | : A colorless, odorless gas. | |

## 10. Stability and Reactivity

**STABILITY:**
Stable

**INCOMPATIBLE MATERIALS:**
Certain reactive metals, hydrides, moist cesium monoxide, or lithium acetylene carbide diammino may ignite. Passing carbon dioxide over a mixture of sodium peroxide and aluminum or magnesium may explode.

**HAZARDOUS DECOMPOSITION PRODUCTS:**
Carbon monoxide and oxygen when heated above 3092 $^{o}$F (1700$^{o}$C). Carbonic acid is formed in the presence of moisture.

**HAZARDOUS POLYMERIZATION:**
Will not occur.

## 11. Toxicological Information

**REPRODUCTIVE:**
Oxygen deficiency during pregnancy has produced developmental abnormalities in humans and experimental animals.

Exposure of female rats to 60,000 ppm carbon dioxide for 24 hours has produced toxic effects to the embryo and fetus in pregnant rats. Toxic effects to the reproductive system have been observed in other mammalian species at similar concentrations.

**OTHER:**

Carbon dioxide is the most powerful cerebral vasodilator known. Inhaling large concentrations causes rapid circulatory insufficiency leading to coma and death. Chronic, harmful effects are not known from repeated inhalation of low (3 to 5 molar %) concentrations.

## 12. Ecological Information

No data given.

## 13. Disposal Considerations

Do not attempt to dispose of residual waste or unused quantities. Return in the shipping container PROPERLY LABELED, WITH ANY VALVE OUTLET PLUGS OR CAPS SECURED AND VALVE PROTECTION CAP IN PLACE to BOC Gases or authorized distributor for proper disposal.

## 14. Transport Information

| PARAMETER | United States DOT | Canada TDG |
|---|---|---|
| **PROPER SHIPPING NAME:** | Carbon Dioxide | Carbon Dioxide |
| **HAZARD CLASS:** | 2.2 | 2.2 |
| **IDENTIFICATION NUMBER:** | UN 1013 | UN 1013 |
| **SHIPPING LABEL:** | NONFLAMMABLE GAS | NONFLAMMABLE GAS |

## 15. Regulatory Information

**SARA TITLE III NOTIFICATIONS AND INFORMATION**

**SARA TITLE III HAZARD CLASSES:**
Acute Health Hazard
Sudden Release of Pressure Hazard

## 16. Other Information

Compressed gas cylinders shall not be refilled without the express written permission of the owner. Shipment of a compressed gas cylinder which has not been filled by the owner or with his/her (written) consent is a violation of transportation regulations.

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