NATIONAL CHEM-E CAR SAFETY RULES
Fall 2012

1.0 SCOPE
The safe preparation and operation of vehicles during all phases of the competition, including construction, testing and competition, is mandatory. Safety audits will be performed by an audit team of reviewers.

2.0 AUDITS
The safety audit of your vehicle will occur in two stages.

2.1 STAGE 1: PAPERWORK AUDIT
An audit of your system design and safety compliance will be determined from the documentation your team provides. By September 28, 2012 the following items must be uploaded to the competition website. Any delay in submission will result in exclusion from the competition. Please PDF your EDP into a single document for ease in reviewing.

2.1.1 An engineering documentation package for your Chem-E-Car that includes, in the following order as a minimum:

2.1.2.1 JSA
2.1.2.2 A description of your car and how it works, include a diagram or picture of the vehicle.
2.1.2.3 A complete list of every piece of equipment on the car in Table format, include in the list the manufacturer of the equipment. Include either the manufacturer's specification documents or specifications for custom-built components. Include operating limits for equipment, and ensure material compatibility where pertinent.
2.1.2.4 Standard operating procedures.
2.1.2.5 A description of the chemistry involved.
2.1.2.6 A quantitative design basis for pressure relieving load.
2.1.2.7 Sizing calculations for a pressure relief device.
2.1.2.8 Test procedure and results for a pressure relief.
2.1.2.9 Car experimentation area floor plan.
2.1.2.10 Management system for chemical use and disposal.
2.1.2.11 Management system for approval of changes in your vehicle.
2.1.2.12 A picture of your vehicle after construction has been completed. These pictures must be current. The entire car must be visible in the picture.
2.1.2.13 Material Safety Data Sheets for all chemicals.

2.1.3 Complete the Certification page.

2.1.3.1 Have the engineering documentation package reviewed by your faculty advisor to insure that you have identified the major hazards and have controlled them properly.

2.1.3.2 It is recommended that you also enlist the assistance of an outside safety expert or another faculty member with expertise in this area.

2.2 STAGE TWO: PHYSICAL AUDIT

During the poster competition, an audit team will inspect each vehicle to insure that all of the safety requirements have been completed and that the vehicle will operate without risk to the operators, contest staff and spectators. If the audit team deems the vehicle safe to operate, then the vehicle will be given permission to compete. This permission is not automatic and must be earned using the guidelines / procedures outlined below. If a car is deemed unsafe, then it will not be given permission to compete. Vehicles that are not given permission to compete at the Regional competition cannot compete in the National competition unless they can demonstrate they have corrected the problems from the Regional competition. The National safety audit team at the competition site has the final say in regard to permission to compete, regardless of whether a car was given permission to operate at the Regionals. On the day of the competition, the safety audit team will be checking for the following:

2.2.1 Disallowed Chemical Handling

2.2.1.1 Illegal Chemical Transport

No chemicals should be transported in private, university or rental vehicles to and from the competition site, even for short distances. The U.S. Department of Transportation (DOT) has severe penalties for unlicensed chemical transport. Chemicals may be shipped from your university to the competition site, but you will need to enlist the assistance of someone at your university who is trained and licensed to do this. Transport of chemicals in private, university or rental vehicles either to or from the competition is not allowed. The easiest way to do this is to order the chemicals directly from the supplier with shipping to the competition site. Please allow extra time for shipping since chemical shipping must be done by ground transportation.

2.2.1.2 Illegal Chemical Storage

Chemicals must not be stored in hotel rooms or other facilities not rated for chemical storage.

2.2.1.3 Illegal Testing of Vehicles

Testing of vehicles must only be done in a laboratory or other facility with chemical handling capability. Testing in hotel or dorm hallways, warehouses, or other facilities that are not designed for chemical handling is not allowed.

2.2.1.4 Illegal Disposal of Chemicals

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. Please minimize chemicals shipped to the competition site in order to reduce disposal costs. Failure to follow these rules on chemical handling will result in a multi-year suspension of your university.

2.2.2 Disallowed Vehicles

The following characteristics/observances will result in vehicles being disqualified:

2.2.2.1 Flames and/or smoke. All cars are restricted from having any open flames or emitting any smoke. Cars shall not have internal flames. The only exception to this rule is the use of a commercial internal combustion engine that uses an alternative fuel that is synthesized by students. Succinct safety procedures for the maintenance and operation of this engine must be demonstrated by the team. In addition, use of an internal combustion engine must show a demonstrable and significant student design component.

2.2.2.2 Liquid Discharge. Liquid may not be discharged under normal operating conditions. Liquid discharge is allowed during emergency relief situations to protect the equipment from rupture / explosion. This discharge must be collected in a containment vessel.

2.2.2.3 Open and/or Improperly Secured Containers. All containers on the vehicle containing chemicals with an NFPA rating of 2 or greater must be securely attached to the vehicle to prevent the container from tipping over during the competition. The lid to this container must also be securely attached to the container and must be capable to preventing escape of the chemical during any phase of the competition, including an accident involving tipping over of the vehicle.

2.2.2.4 No Open Containers or Chemical Pouring at the Starting Line. No open containers or pouring of chemicals with an NFPA rating of 2 or more is permitted at the starting line. For mixing chemicals to start a reaction, it is suggested that a small holding tank with a valve or a syringe be provided on your vehicle to add the chemical at the starting line. The chemical is added either by pushing on the syringe, or by gravity flow through the valve. All containers, syringes, packets, etc. brought to the starting line must be properly labeled.All containers must have a secure lid and must be properly managed to prevent spillage.

2.2.2.5 No Regulated Chemicals. A number of chemicals are listed by OSHA as a special hazard. The handling of these chemicals is outside the scope of the management systems available during the Chem-E-Car Competition. OSHA has a special regulation for each chemical. See www.osha.gov for details. Due to the hazards involved no chemical listed as regulated by OSHA will be allowed on any vehicle participating in the competition.

Regulated chemicals include: 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.

2.2.2.6 No Highly Reactive / Unstable Chemicals. Any chemical, raw material, intermediate or product with an NFPA reactivity / instability rating of 4 is not allowed. According to www.nfpa.org, this represents "those materials that, in themselves, are readily capable of detonation, explosive decomposition, or explosive reaction at normal temperatures and pressures." This includes: acetyl peroxide, 3-bromopropyne, cumene hydroperoxide, di-tert-butyl-peroxide, diethyl peroxide, diisopropyl peroxydicarbonate, 0-dinitrobenzene, divinyl acetylene, ethyl nitrite, nitroglycerin, nitromethane, paracetic acid, and some high explosives.

2.2.2.7 No Liquid Hydrogen Peroxide Concentrations Greater than 30%. Liquid hydrogen peroxide is very unstable and difficult to handle at concentrations greater than 30%.

2.2.3. Pressure Related Restrictions

Pressurized vessels and vehicle components represent a significant explosion hazard due to the substantial energy contained in the pressure. Student teams must demonstrate through appropriate pressure measurements that the pressures during normal operations do not exceed equipment specifications. Teams cannot just assume that the pressures are low. Appropriate documentation must be available for the safety auditors to examine during the poster competition. The student team must also demonstrate that the proper safety systems have been installed to prevent an explosion. The following restrictions apply to vehicles operating under pressure:

2.2.3.1 Maximum Operating Pressure. This is the highest pressure within the vessel during normal operation. For initial design purposes the maximum operating pressure can be estimated from the stoichiometry — but the actual pressure must still be measured once the car is operational. For example, a proposed reaction, when operating the car with its heaviest load (500 grams water) and longest distance (100 ft), can develop more than 200 psig, assuming complete reaction. If the MAWP is known for the vessel, the maximum operating pressure must always be below the MAWP. As a rule of thumb the maximum operating pressure should be no greater than 90% of the MAWP.

2.2.3.2 Pressure Requirements. If your vehicle has any pressures greater than 1 psig, then the requirements listed below must be met.

2.2.3.2.1 Pressure gauge. All vessels and equipment with pressures greater than 1 psig must have a pressure gauge that reads from 0 psig to 2 times the maximum operating pressure. For the example in 2.2.3.1, the appropriate pressure gauge range is 0 to 400 psig.

2.2.3.2.2 Emergency Relief Device. All vehicles with pressures greater than 1 psig must have an industry standard relief valve that is appropriately sized, and is set at no more than 1.1 times the maximum operating pressure, not the MAWP. The maximum operating pressure is typically defined as the pressure that would need to be generated to propel the vehicle 100 ft. and carry a load of 500 ml. For the example given in 2.2.3.1, the set pressure of the relief valve (the point when the relief valve begins to open) is a maximum of 220 psig. This valve must be tested and evidence must be provided in the safety documentation. Size the relief devices per Crowl and Louvar, "Chemical Process Safety", Prentice Hall PTR, Upper Saddle River, NJ, 2002, or equivalent (See also the SACHE module: *Emergency Relief system Design for Single and Two-Phase Flow*, 2nd Ed. by Ron Darby. This can be downloaded by SACHE members at http://www.sache.org. Ask your AIChE faculty advisor for this manual and Excel spreadsheets.) The design scenario for the emergency relief device must be clearly stated. For example, state the amount of reacting material assumed, the concentration of reacting material, the initial temperature, and any consideration of operating error such as overcharge, use of wrong material, or wrong concentration, and, if so, what is the "design case" error, etc? Also, the emergency relief system calculations must be included in the documentation and they must be reviewed and approved by a faculty representative.

2.2.3.2.3 Emergency Relief Device in Proper Location. The relief device must be properly located. For vessels, the relief valve must be located at the top of the vessel without any valves between the vessel and the relief. The piping connecting the relief to the vessel must be of appropriate size and must be as short as possible to prevent pressure drop during relief conditions. Consideration must also be provided for any entrained liquid or solids that might carry over from the vessel and prevent proper relief function.

2.2.3.2.4 Pressure Certification. All components, including vessels, piping and fittings, valves, gauges, filters, must be certified to operate at a pressure greater than the maximum operating pressure. For most components the pressure specifications can be obtained directly from the manufacturer. This information must be provided with your engineering documentation package. For vessels, the pressure certification might not be known. In this case you will need to either have someone test the vessel for you, or complete the pressure test yourself. See Appendix A on Pressure Vessel Test Protocol and Procedure.

2.2.3.2.5 Proper Management System to Prevent Over or Mis-Charging. Student teams must also be aware that the maximum operating pressure is dependent on the amount of reactant(s) charged. Students must demonstrate that proper management systems and controls are in place to insure that the proper quantity of reactant is charged to the vehicle. The following guidelines are recommended to insure proper charging of your vehicle: (1) The quantity to be charged should be agreed upon by all team members and must be supported by run data. (2)Measuring devices such as beakers and graduated cylinders should have the maximum permissible charge volume indicated. (3) At least one team member should observe both the measuring and charging operation to insure that it is done properly. (4)The car should be tagged once the charging is completed. This tag should remain until the run is finished.

2.2.3.2.6 PVC rules. No PVC, cPVC or polyethylene terephthalate (PETE or PET) vessels or piping used for pressurized gases. All of these three types of plastics have microscopic defects that result in hoop stress failure.

2.2.4 Chemical Containment Hazards This applies to any solvent, diluents, reactants, intermediate reaction species or product that is present on your vehicle during operation with a NFPA toxic hazard rating of 2 or more. Proper measures must be taken during chemical handling in the vehicle preparation area to prevent human exposure to these chemicals – see Appendix B on Chemical Handling and Disposal. If these chemicals are present on the vehicle then double containment must be provided on the vehicle to prevent spillage and to reduce human exposure.

2.2.4.1 Chemical Containment on Vehicle. The primary containment must be adequate to prevent leakage of any chemicals during normal transport of the vehicle to the starting line and during vehicle operation during the contest. The lid must be stout enough to provide no more than very limited release of chemicals during emergency conditions, such as a vehicle tip over or collision. All lids on containers containing chemicals must be securely attached to the container and should cover the entire container opening. Please insure that any holes in the lid or container are just big enough to accommodate the "through hole item" — seal if possible. **Saran™ wrap, Parafilm™, aluminum foil and other similar materials are not adequate as container covers.** The secondary containment on the vehicle must be of suitable durability and size to hold the contents of any spilled chemicals on the vehicle. Containment is required for flammable, and reactive chemicals.

2.2.5 Temperature Hazards. All exposed surfaces on your vehicle with temperatures greater than 150 deg. F or under 32 deg F must either be insulated or covered to prevent contact with human skin.

2.2.6 Electrical Hazards All wiring and exposed electrical components must be electrically insulated or covered to prevent the possibility of electrical shock or ignition of any component of a vehicle. Alligator clips and twisted wires represent both an electrical shock hazard and an ignition source for flammable vapors / liquids and are not allowed. Use more robust electrical connectors such as banana plugs or binding posts.

2.2.7 Mechanical Hazards Guards must be present for any moving parts and pinch points. This includes gears, belts, linkages, actuator arms and any other part that may present a pinch point.

2.2.8 Oxygen Hazards Oxygen rich gases present a potential explosion hazard for two reasons. First, the oxygen may react violently with any combustible material, including any hydrocarbon gas or liquid residue, paper, filters, valve packing or seat, regulator components, and O-rings. Secondly, small metal particles, always present in metal components, may be accelerated during gas flow, colliding with a surface and providing an ignition source for combustion of the metal particle. See the NASA document *Safety Standard for Oxygen and Oxygen Systems* (1996) for more information. This document can be found at http://www.hq.nasa.gov/office/codeq/doctree/canceled/1740151.pdf. The following requirements must be met for oxygen service:

> **2.2.8.1** All components in oxygen service must be rated by the manufacturer for oxygen service. This includes vessels, piping, filters, regulators and valves. Metallic components are preferred since nonmetals are more susceptible to oxygen ignition.
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> **2.2.8.2** All equipment in oxygen service must be thoroughly cleaned before being placed into oxygen service. Effective cleaning will: (1) remove particles, films, greases, oils, and other unwanted matter,(2) prevent loose scale, rust, dirt, mill scale, weld spatter, and weld flux deposited on moving and stationary parts from interfering with the component function and clogging flow passages, and (3) reduce the concentration of finely divided contaminants, which are more easily ignited than bulk material. Oxygen system cleaning must be done by disassembling all components to their individual components. The cleaning solutions used depend on the material to be cleaned. Stainless steels (300 series), Monel® alloys, Inconel® alloys, and Teflon® are usually cleaned in an alkaline solution and then in an acid solution. Carbon steel is cleaned by a rust and scale remover, if required, and then in an alkaline solution. In severe cases of rust or corrosion, carbon steel may be sand or glass-bead blasted. Copper and brass are cleaned in alkaline solution, then acid pickled. Aluminum and nonmetals are cleaned in liquid detergent. See the NASA document *Safety Standard for Oxygen and Oxygen Systems* (1996) for more information. This document can be found at http://www.hq.nasa.gov/office/codeq/doctree/canceled/1740151.pdf.
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> **2.2.8.3** The equipment must not have been used previously for another service. Previous service may contaminate the component with hydrocarbon liquid or gas residue. In particular, gas regulators used for hydrocarbon gas service are very likely to explode when placed into oxygen service.

2.2.9 Biohazards If any biological organisms are used during any phase of the design, development, operation, competition and preparation of your ChemE car, these biological hazards must be no more than biological hazard level 1 (also called biosafety level 1). This would include any bacterial, fungal, viral, or yeast organisms.

Additional details on biosafety can be found at:
http://www.cdc.gov/od/ohs/biosfty/bmbl4/bmbl4toc.htm

Biohazard level 1 is suitable for work involving well-characterized agents not known to consistently cause disease in healthy adult humans, and of minimal potential hazard to laboratory personnel and the environment. The laboratory is not necessarily separated from the general traffic patterns in the building. Work is generally conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is neither required nor generally used.

At biohazard level 1, standard microbiological practices include the use of mechanical pipetting devices, prohibiting eating, drinking and smoking in the lab, and requiring hand washing by all persons when they finish their work or when exiting the laboratory . Persons working in the lab should wear a lab coat to protect their street clothes. It is a recommended practice to wear gloves while manipulating these agents. Additional protective equipment includes eye protection and may also include working behind a splatter shield or face protection. All procedures must be performed carefully to minimize the creation of splashes or aerosols. Hand washing is one of the most important procedures that can be used to prevent removal of unwanted biological agents from the laboratory environment. Use of liquid soap is generally preferable to bar soap; twenty seconds of vigorous lathering will remove most of these materials very effectively.

All left over cultures, stocks, and other regulated wastes must be collected, packaged and decontaminated according to local, state and federal regulations.

3.0 ACCIDENTS / INCIDENTS

If there is a safety incident that occurs during the competition, then the AICHE student chapter advisor of that team will be informed that an incident analysis report must be submitted to the head of the Chem-E-Car Student Chapters Subcommittee, David Dixon (address and contact info above). This safety incident report must be approved by the Chem-E-Car Student Chapters Subcommittee before any team from that university can compete in Regional or National Chem-E-Car Competitions.

4.0 COMPETITION DAY RULES FOR THE PREP AREA

Each team must use appropriate safety procedures and equipment in the chemical preparation area to insure against chemical exposures, spills, and mis-identification or mixing of chemicals. The following rules apply:

4.1 Each team must provide the appropriate personal protective equipment for use in the chemical prep area, as identified in their JSA, and must use them properly. This includes lab coats, safety glasses, gloves, face shields, and hearing protection.

4.2 The personal protective equipment must be used appropriately by all team members depending upon the hazards encountered during the chemical preparation.

4.3 All containers with chemicals, including bottles, beakers, syringes and plastic bags must be properly labeled. This includes containers holding reactants, intermediates, products or mixtures. The label must minimally include the identity of the chemical(s), and the identity of the Chem-E-Car team, in clear English. Labels must be provided by the Chem-E-Car team.

4.4 All chemical pouring or mixing in the preparation area must be done with spill containment. A large tray, compatible with your chemicals, with a volume large enough to hold your chemical quantities, is required.

4.5 In order to facilitate the safe use of chemicals at the competition site, a designated area will be identified where teams must mix or prepare their chemicals (unless the material was shipped pre-mixed). All chemicals will be made available to the teams in the chemical preparation area at least 1 hour prior to the performance competition. Unfortunately, due to hotel/convention center safety regulations it is not possible to allow teams to do "trial runs". Teams that violate these safety rules jeopardize the continued operation of the Chem-E-Car Competition and may be disqualified by the judges.

4.6 Chemical waste disposal will be coordinated by the host school at the National Competition.

5.0 ASSISTANCE

There is no restriction on requesting assistance for vehicle safety. Teams may request safety assistance from their faculty advisor, other faculty members, other universities, and professional practitioners in industry and elsewhere.

5.1 Resources.

The primary method for characterizing the hazardous properties of chemicals for the Chem-E car competition is by the National Fire Protection Association (NFPA) method. This method assigns a numerical value to the degree of hazard based on three major hazard groups: toxicity, flammability and instability / reactivity. The numerical values range from 0 to 4, with 0 representing the lowest degree of hazard and 4 representing the highest. See www.nfpa.org for more details on this.

An excellent source of information on the hazardous properties of chemicals is the National Institute for Occupational Safety and Health (NIOSH), www.cdc.gov/niosh. In particular, they support a free, on-line guide to chemical hazards call the *NIOSH Pocket Guide to Chemical Hazards*. This is available at http://www.cdc.gov/niosh/npg/default.html.

5.2 Questions.

If there are any questions about these safety rules or on an issue of safety, contact the National Chem-E Car Safety Coordinator, Tara Henriksen, at vbritelite@hotmail.com

Appendix A: Pressure Vessel Test Protocol and Procedure

The **test pressure** is the target pressure specified for the hydrotest. This specification depends on whether the MAWP of the vessel is known or not. See the Pressure Vessel Test Protocol shown below.The manufacturer recommendations for the use of all pressurized components, **especially plastic components**, for a vehicle must be thoroughly researched and documented. This includes following manufacturer's recommendations for use of materials. **The use of PVC, cPVC or polyethylene terephthalate (PETE or PET) for pressurized gases is prohibited in this competition.** All of these three types of plastics have microscopic defects that result in hoop stress failure. If other types of plastic components are used for pressurized gases such as ABS (Acrylonitrile-Butadiene-Styrene), Nylon, or Teflon (PTFE), then the manufacturer's specifications should be consulted as well as evidence of proper/adequate hydraulic testing be conducted. [CAUTION: Some teams in the past have had soda bottles (PETE), or PVC vessels explode when pressurized with a reaction that creates a gas! Please note that PVC is only rated by ASTM D 1785 – 05 as schedule 40 for water at temperatures less than 73°F and is not recommended for use with pressurized gases.]

A.1 Pressure Vessel Test Protocol

There are three cases involving different protocols:

1. **You already know the MAWP of the vessel, and the vessel is less than 5 years old or has been retested within the last five years, and does not show any corrosion, wear or abuse**. In this case the vessel is already certified and all that is required is to obtain information related to this certification. There are two ways to get this information:

    i. The pressure vessel is already stamped with the MAWP or contains a plate indicating the MAWP. This indicates that it has been hydrostatically tested previously. Submit documentation that supports the MAWP rating, or a clear photograph of the name plate or the MAWP stamp and date of testing. See documentation requirements below.
    ii. The manufacturer of the vessel supplies the pressure rating of the vessel via technical specifications. In this case provide copies of this specification. The age of the vessel must also be certified. See documentation requirements below.

    The documentation is all that is required for the pressure certification for this case.

2. **You already know the MAWP of the vessel, and the vessel is more than 5 years old, or has not been retested within 5 years, or shows corrosion, wear or abuse.** There are two options available for this case:

    i. Use a commercial firm to recertify the MAWP via hydrotest. Provide documentation on this recertification with your JSA, including the name of the contractor and the date.
    ii. Recertify the vessel yourself using the hydrotesting procedure shown below. The test pressure in this case is 1.5 times the MAWP. See documentation requirements below.

3. **The MAWP is not known.** This case applies to unlabeled/undocumented vessels as well as custom-built pressure vessels. There are two options available for this case:

    i. Use a commercial firm to certify the MAWP of the vessel and perform the hydrotest. Provide documentation on this certification with your JSA, including the name of the contractor. See documentation requirements below.
    ii. Certify the vessel yourself using the hydrotesting procedure shown below. Use a test pressure of 2 times the maximum operating pressure. See documentation requirements below.

A.2 Hydrotesting Procedure

Hydrostatic testing (using water) is the standard for pressure vessel testing. Pneumatic tests using air, nitrogen, carbon dioxide or other gases is not permitted due to the explosive nature of rapidly expanding gases.

Pressure Gauge Requirements
The pressure gauge must have an indication range of not less than 1.5 and not more than 4 times the test pressure. The gauge must be able to be read to increments of at least 5 psig.

Measurement of Vessel Deformation
During pressure testing a gauge must be configured to measure any deformation of the vessel. This gauge must be visible to the operator applying pressure. Use a dial gauge accurate to at least 0.001 inch (0.0254 mm). Insure that the dial gauge is in good working condition and properly calibrated.
To confirm that plastic yielding (expansion) has not occurred during pressurization, the vessel must be measured along its centerline in three directions (x, y, z) both before and after hydrostatic testing. Measurements shall be taken using a caliper or mechanical gauge accurate to 0.001 inch or less.

Test Area
The test area should be restricted and barricaded. The vessel being pressure-tested should be oriented so that bolts, flanges, and other possible missiles point away from people and other equipment. All pressure tests must be conducted remotely. A barrier (sand bags, lumber) must be used to limit the potential from flying projectiles should the vessel fail the test. The barrier should be around all four sides of the vessel and should extend above the vessel.

Test Procedure

1. Provide a vent to allow air to leave the vessel while filling with water. You might consider providing a bottom drain to remove water when the testing is done.
2. Fill the vessel with water and remove the air. Make sure the vessel is completely filled with liquid prior to the test.
3. First, increase the pressure to a maximum of one-half of the test pressure. Then, raise the pressure in increments of 0.1 times the test pressure until the test pressure is reached. The final test pressure must be held for a minimum of 30 minutes. Pressure should hold

steady and not change significantly during the test. A change of 10% of the test pressure or 5 psig is significant. No water leaks or drips should be observed.

4. The pressure should then be lowered to the operating pressure of the vessel and held for a visual inspection of all joints and connections. No water leaks or drips should be observed.

5. Take appropriate vessel measurements, accurate to within 0.001inch (0.0254mm), both before and after testing to show that detectable plastic yielding has not occurred during pressurization.

Documentation of Test

Provide the following documentation in support of the hydrotest.

1. Identification of vessel(s) or system..
2. MAWP or test pressure of vessel(s) or system, if known.
3. Planned test pressure.
4. Supporting calculations.
5. Date and time that test started.
6. Date and time that test was completed or failed.
7. Maximum pressure attained.
8. Chart of test-pressure sequence (optional).
9. Test liquid.
10. External temperature of system.
11. Temperature of test liquid.
12. Organization conducting test.
13. Signature of Chem-E Car Advisor Certify the completion of the test.

Vessel Labeling

At the completion of the test a pressure test label must be affixed to the pressure vessel. Information on the label must include:

1. Identification of the Vessel (Car Name, Vessel Purpose)
2. MAWP or test pressure, and temperature
3. Working fluid
4. Test engineer
5. Test Date

Appendix B: Chemical Handling and Disposal

B.1 Introduction

All ChemE car students who handle chemicals either at their host institution or at a regional or national competition must understand the hazardous properties of these chemicals. Before using a specific chemical, safe handling methods must always be reviewed. Faculty advisers are responsible for ensuring that the equipment needed to work safely with chemicals is provided.

B.2 General Rules for Chemical Safety

A. Material Safety Data Sheets (MSDS) must be available in the laboratory for all chemicals, including those in storage in the laboratory.
B. When purchasing chemicals, purchase the smallest quantity necessary to complete the planned experiments. The cost of disposal of unused chemicals far exceeds the savings from quantity purchases.
C. Skin contact with chemicals must be generally avoided.
D. No more than 2-gallons of flammable solvent should be out in the laboratory at any one time. Store bulk flammable containers in a flammable storage cabinet.
E. All containers (including those in storage) must be labeled – see the section on labeling below. Any unlabeled container must be treated as a hazardous substance.
F. Wear compatible gloves and apron when handling strong acids and bases.
G. Use a grounding strap and/or dip leg when transferring flammable chemicals into a storage tank.
H. Transport <u>all</u> chemicals using a safety carrier. The chemical must be in a closed container.
I. Chemical containers must be kept away from high temperatures, the edge of the lab bench, and other areas where an incident might lead to loss of containment.
J. Mouth suction for pipetting or starting a siphon is not allowed.
K. Unknown substances must be treated as toxic and flammable.
L. Do not taste or smell any chemicals.
M. Operations involving chemicals should generally be done in a laboratory hood.

B.3 Chemical Storage

A. MSDS's must be available for all chemicals stored.
B. ALL chemicals stored must be properly labelled.
C. No chemicals shall be stored on the top of lab benches or out in the open. Chemicals must not be stored over eye level height to prevent accidents from dropping containers.
D. Flammable and volatile chemicals must be stored in a cabinet designated for flammable storage. See the discussion of flammable storage cabinets in the Safety Equipment section. Refrigerated storage of these chemicals requires a refrigerator rated for storing flammables.
E. Acids and bases should be stored separately.
F. Acid-resistant trays shall be placed under stored acid containers.
G. Acid-sensitive materials such as cyanides and sulfides must be separated from acids.

H. Oxidizable materials should be stored away from acids and bases.

I. Stored chemicals must be examined on a regular basis by the laboratory personnel (at least annually) to inspect for deterioration, container integrity, and expired dates. Chemicals which are not being used should be disposed of or returned to Chem Stores for recycling.

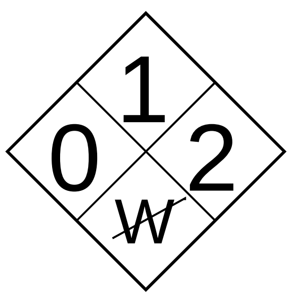
J. An inventory of stored chemicals must be maintained by the laboratory owner at all times. Unneeded items shall be properly discarded or returned to Chemical Stores. Store only what you are using.

B.4 Chemical Labeling

All chemicals must be labeled, even during temporary transport. This includes lab samples, temporary containers, etc. A proper chemical label must include:

- Identity of contents
- Date material was acquired
- Disposal date (for unstable chemicals)
- Responsible person
- Hazardous characteristics
- Other pertinent safety information

The hazardous characteristics are frequently denoted using an National Fire Protection Association (NFPA) diamond. A sample diamond is shown below:



The area with a “0" in the diamond denotes health hazard, the area with the “1" denotes fire hazard and the area with a “2" denotes reactivity hazards. The box at the bottom is used to denote special hazards, e.g. incompatible with water.

The hazards in the NFPA diamond are indicated by numbers 0 through 4. 0 means minimal hazard while 4 means extreme hazard.

B.5 Chemical Disposal

All chemicals must be disposed of in a safe and environmentally friendly manner. Any chemical substance which is corrosive, flammable, reactive, toxic, radioactive, infectious, phytotoxic, mutagenic, or acutely hazardous must be treated as hazardous waste. Do not dispose of chemicals by evaporation in a fume hood or in the sink! Do not hesitate if any questions occur about the hazards of a material.

Collect and store chemical waste in containers which are clearly labeled. Do not combine containers unless the contents in each container is known, is compatible, and it is certain that it is safe to do so. Combined wastes are much more difficult and costly to dispose of properly.

Ordinary waste such as paper, cardboard, etc., may be placed in the wastebasket. However, contaminated waste must be disposed of separately in a labeled container.

Empty chemical containers must also be disposed of in an acceptable fashion. They must first be cleaned and then either returned to Chemical Stores or disposed through normal trash.