The American Institute of Chemical Engineers

AIChE®

General Guidelines for *Chem-E-Car Competition* Organizers

Revised: February 2010

Includes information on regional safety compliance and host chapter safety responsibilities

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CONTENTS

Introduction

The American Institute of Chemical Engineers (AIChE) has prepared these guidelines for future Chem-E-Car Competition organizers, both in and outside AIChE's affiliate network:

- To establish context on the Competition – created by AIChE in the 1990's
- To offer a set of standards and recommendations for groups – within AIChE and internationally – that would like to conduct a competition
- To document basic rules and procedures for competition organizers and contestants
- To provide important safety guidelines and stimulate safety awareness among competing teams and competition organizers.

Background: History and objectives

In the late 1990's, leaders of the American Institute of Chemical Engineers sought to bring favorable public attention to chemical engineers and chemical engineering by creating a novel, high-profile annual event – in the style of egg drop competitions and cement canoe races conducted by engineers in other disciplines. The Institute challenged undergraduate student members to devise a competition concept that offered novelty and visual appeal, and that demonstrated chemical engineering principles to lay people.

The result of that competition was the creation of model autonomous vehicles – no larger than a shoe box – that teams of chemical engineering students would fuel to carry a load a designated distance, powered by a precisely controlled chemical reaction. Thus were the first AIChE "Chem-E-Cars" put into service.

Since 1999, AIChE's Chem-E-Car Competition has become a highlight of the Institute's annual activities for students, and its notoriety within AIChE and in the general public increases each year, and in each community where the competition is held.

Ten AIChE sponsored competitions are held each year. Nine regional competitions are held at chemical engineering schools across North American, in connection with AIChE's regional student conference series. The winners of these regional competitions become automatic qualifiers to compete in the national competition finals, held in connection with AIChE's Annual Meeting and National Student Conference in the fall of each year. At regional competitions, from three to fifteen or more cars may run in competition, depending on the size of the regional student population and the level of interest among those students. At the national final competition, 31 teams are eligible to compete, with a waiting list of teams prepared to accept coveted open slots.

The competition event consists of two components: 1) A performance competition, in which teams "race" their cars in solo heats, with the goal of having cars travel a precise distance (announced shortly before the performance competition), and 2) A poster session. The posters illustrate the construction and chemical reaction involved in each car's overall design, and demonstrate necessary safety considerations and compliance with competition rules. Prizes are presented in recognition of excellence in both performance and design.

A team of dedicated AIChE member volunteers – many of them among the group that devised the original competition – oversees the rules of these AIChE Competitions, and coordinates and judges the final competition.

By 2003, news media exposure and word of mouth led to AIChE's Chem-E-Car Competition capturing the interest of chemical engineers outside the U.S. Competitions were subsequently held by IChemE in the UK, among other groups. A first International Chem-E-Car Competition was held in Glasgow, Scotland in 2005, in connection with the IChemE-sponsored Seventh World Congress of Chemical Engineering.

The objectives of this competition are:

- To provide chemical engineering students with the opportunity to participate in a team-oriented hands-on design and construction of a small chemical energy powered model car – that will carry a specified load over a given distance and stop.
- To encourage students to become actively involved in their professional society - AIChE.
- To increase awareness of the chemical engineering discipline among the general public, industry leaders, educators and other students.

AIChE National Chem E Car Competition Winners
(Performance)

2009
1st: Northeastern University
2nd: University of Puerto Rico, Mayaguez
3rd: Louisiana State University

2008
First: Cornell University
Second: Louisiana State University
Third: Texas A&M University, College Station

2007
First: The Cooper Union
Second: Carnegie Mellon University
Third: University of Oklahoma

2006
First: University of Puerto Rico
Second: University of Dayton
Third: University of Maine

2005
First: Tennessee Tech
Second: Oklahoma State
Third: University of Puerto Rico

2004
First: University of Tulsa
Second: Tennessee Tech
Third: University of South Carolina

2003
First: University of Dayton
Second: Michigan Tech
Third: Florida Institute of Technology

2002
First: University of Kentucky, Paducah
Second: Colorado State University
Third: Mississippi State University

2001
First: Colorado State University
Second: New Mexico Institute of Technology
Third: University of Akron

2000
First: University of Akron
Second: Colorado State University
Third: University at Buffalo

1999
First: University of Michigan
Second: University of Nevada-Reno
Third: University of Iowa

How AIChE Competitions are Structured:

- **Regional and National Competitions and Prizes**
- **Rules Overview - Poster and Performance Components**

The American Institute of Chemical Engineers hosts two general competitions: regional and national. **Regional competitions** are held each spring at nine AIChE regional student conferences. In the fall, winners and non-winners of these regional competitions may compete in the **final competition**. The finals are held in conjunction with the National Student Conference, at the site of the AIChE Annual Meeting. A host AIChE student chapter, along with national AIChE staff and the Car Competition sub-committee from AIChE's Student Chapters Committee, provides support for the final competition.

Each competition features two components: a **poster presentation** and a distance or **performance competition**. These are discussed below and in more detail in rules. Each year the rules may be modified to address concerns that may have developed at past regional and annual competitions, or to incorporate improvements, new ideas and updated safety standards.

Competitions

Regional Conference Competitions

The host of each regional student competition is responsible for the scheduling, set up, execution, judging, and verification of the regional competition under their charge. National Car Competition organizers provide assistance in the form of basic guidelines, standard rules, and judging criteria – which apply in general to all competitions. The Student Chapters Committee of AIChE provides each regional conference host with a stipend of $300 to be used for prizes.

Regional conference hosts are required to report the results of their regional competition to AIChE (studentchapters@aiche.org), and these results are provided to the national competition organizers for later follow-up. While slots in the national competition are tentatively reserved for regional winners (according to a formula discussed below), regional conference hosts should consider it a duty to inform Car Competition competitors that it is each competing team's responsibility to apply for and confirm their own slot – usually before June 30. AIChE's Car Competition Subcommittee hosts a Website where this information can be submitted.

http://interact.sdsmt.edu/aiche/register.htm

In general, a regional host school can include any number of entries at its regional competition. However, the host school has the right to set a limit, should the need arise.

Complete rules for the competition are found later in these guidelines. The most up to date rules can always be found at: http://www.aiche.org/Students/Conferences/chemecar.aspx

The same competition rules apply to both the national and regional conference competitions.

Suggested Regional Conference awards

National AIChE provides each regional conference host with a prize money stipend of $300, to be allocated as shown below.

(Not all regions may have a sufficient number of entries or available resources to fulfill all the suggested prize categories.)

Poster Competition:

- Ribbons for 1st, 2nd, and 3rd place
- Ribbon for Most Creative Drive System: Selected by panel of judges at poster competition. Recognizes the team that has designed and installed the most creative propulsion system.
- Ribbon for Most Creative Vehicle Design

Performance Competition

- 1st place: $200 and Ribbon
- 2nd place: $100 and Ribbon
- 3rd place: Honorable mention and Ribbon
- Ribbons for 4th and 5th place finishers
- Ribbon for Spirit of Competition

National Competition

A total of 31 slots are available in AIChE's national competition – based on a formula that permits an equitable number of entries from the nine AIChE regional competitions. (Some regions incorporate many schools, others relatively few.)

The national competition is limited to one entry per student chapter, unless there are unfilled slots at competition time. Each student region may send at a minimum their first and second place winners. Mid-America, Northeast, Rocky Mountain and the Western regions may send their 1st, 2nd and 3rd place winners. The Mid-Atlantic, North Central, and the Southern Regions may send their top five winners.

It is the responsibility of each of the regional winning teams to apply for and confirm their slot for the National Competition, usually by June 30, and using the following Web resource: http://interact.sdsmt.edu/aiche/register.htm. After June 30, unclaimed slots are open to any AIChE student chapter team that wishes to enter. When all slots are full, a waiting list develops. As the final competition approaches, it is common for scheduled teams to drop out and for waiting list teams to acquire a slot.

AIChE's Car Competition Subcommittee supervises the scheduling, advance communication, onsite execution, and judging of the competition, with logistical assistance from the host school involved in general Student Conference arrangements and AIChE headquarters staff. A corporate sponsor supports the national prizes.

Prizes are announced at the conclusion of the competition. Prize money is sent to the winners at a later date.

National Competition prizes:

Poster Competition:

- Certificates for 1st, 2nd, and 3rd place
- Certificate for Most Creative Drive System: Selected by panel of judges at poster competition. Recognizes the team that has designed and installed the most creative propulsion system.
- Certificate for Most Creative Vehicle Design

Performance Competition

- 1st place: $2000 and a trophy
- 2nd place: $1000 and a trophy
- 3rd place: $500 and a trophy
- Society of Biological Engineers Award for Best Use of a Biological Reaction to Power a Car
- Most consistent performance: A certificate -- This award is based on the best average score for the two runs that the vehicle makes. Recognizes the team that has designed and most understands the reaction that powers the vehicle.
- Spirit of the Competition: A certificate -- This award is given to the team displaying the most team spirit as decided by a panel of judges.
- Golden Tire Award: A certificate - In 2002, Northeastern University team members created this award to recognize the team with the most creative vehicle design. The winning entry is selected by a ballot cast by each team entered in the competition.
- SACHE Chem-E-Car Safety Award

The Rules - Overview

Posters

The poster competition and judging occur prior to the Chem-E-Car performance competition. All team members should be present during judging to answer questions from the judges. Each team must also complete and make available to judges an Engineering Documentation Package **(See page 9)**

A poster board must be displayed along with the vehicle on the day of the competition. This poster should describe how the car is powered using the chemical reaction, the unique features of the car, and environmental and safety features in the design. Material Safety Data Sheets (MSDS) must be present for each chemical used in the entry.

A sample poster session judging form is included in the appendix. Safety and safe materials transportation procedures are very important considerations in this competition. If obvious safety violations have occurred, the judges can disqualify the entry. Entries are also judged on creativity in the propulsion system and the appearance of the vehicle.

Winners of the poster competition are announced at the end of the performance competition.

A team must achieve a minimum score of 70% in the poster competition to be able to advance to the Chem-E-Car Performance Competition. Posters will be judged according to the following criteria, with a maximum of 20 possible points (equal weighting):

- Description of the chemical reaction / power source
- Unique features of the vehicle
- Design creativity
- Environmental and safety features
- Quality of the poster and team member presentations

Vehicle safety inspections (see page 9 for more information)

AIChE's regional Chem-E-car safety coordinator helps to recruit safety inspectors for each regional competition. Often, regional hosts and the national safety coordinator are asked to assist with this recruitment effort.

Car inspections may take place concurrently with the poster competition — however, the car inspections are a separate activity with different objectives. Usually, it is practical to have different teams of judges/reviewers are needed for the general poster judging and car safety inspections.

The inspectors receive advance guidance from the national coordinator, and are provided with instructions including a review checklist — a sample of which appears in the appendix. See page 9 for more information about the safety network.

Performance Competition

Teams of students design and construct a vehicle that is powered with a chemical energy source that will carry a load to a given distance and stop. The vehicle will be judged based on the combination of completion of the defined task and a judging of the most creative design.

Contestants learn the prescribed distance that their competition vehicle must travel (not to exceed 30 meters) not more than one hour before the competition.

Competitors in the performance portion are allowed two separate "runs" of their vehicle. After two runs, the team that achieves the single best result (i.e whose car runs and stops closest to the goal) is deemed the winner. There is no penalty for exceeding the goal; the closest is the winner.

Because Chem-E Car-Competition rules are modified from year to year, participants and regional competition planners should look to the AIChE website for updated information. There, participants will find the current rules for competitors, judging criteria, poster session information, instructions for shipment of materials and chemicals, and more.

Official Regional and National Chem-E-Car Competition information:

http://www.aiche.org/Students/Conferences/chemecar.aspx

The Student Chapters Committee determines the criteria by which the panel of judges will score each participant. For more information, contact studentchapters@aiche.org.

Host Responsibilities & Competition Organization

Essential duties of competition organizers

(Safety compliance and guidance for participating teams)

There are several host chapter responsibilities that require full cooperation and collaboration with AIChE's national Chem-E-Car rules committee and the network of regional and national safety inspectors and safety compliance volunteers. These responsibilities are of such importance that if a chapter feels it cannot carry out the duties **to the letter**, it should not host the regional conference.

Review the Competition Rules

Latest version at: http://www.aiche.org/Students/Conferences/chemecar.aspx

Regional conference hosts should familiarize themselves with the Competition rules. The rules are revised annually, and include several sections that pertain specifically to competition management and organization. In addition to design instructions, the rules address many facets of competition organization.

A note on Competition eligibility

In order to qualify to compete in regional Car Competitions, teams must regularly send new student team leaders to an AIChE-sponsored safety training workshop. Additionally, the team faculty advisor (including newly assigned team advisors) must each participate in this safety training at least once. These workshops are held annually at AIChE's National Student Conference. AIChE also has online safety training available at http://www.aiche.org/Students/Conferences/regcarsafety.aspx#Safety_Training_Requirements. Access this site for more detailed qualification information.

The national Chem-E-Car organizers maintain a list of schools and their safety training status. Only teams with satisfactory status are permitted to compete in a given year. The list of eligible teams is provided to regional conference hosts in advance of the spring competitions. No exceptions to the list of approved teams will be allowed. Contact chem-e-car@aiche.org if any questions arise.

Identify a faculty member to act as safety coordinator

Beginning with the 2009 Regional Chem-E-Car Competitions, the National Chem-E-Car Committee requires that each regional conference host school identify a non-student faculty member or other professional to serve as Chem-E-Car safety coordinator for your regional student conference. This person may be the student chapter advisor, a ChE department faculty member, a department/university safety coordinator already assisting with regional conference planning, etc. The person must be committed to doing some advance planning for the regional Chem-E-Car Competition, and must be available onsite at the conference to supervise Chem-E-Car safety and other Car Competition activities.
In the weeks leading up to your conference, the Chem-E-Car Committee will be communicating by phone and e-mail with your designated faculty safety representative to provide detailed instructions and advice about competition set-up, car preparation area management, safe handling of chemicals, and more.

Engineering Documentation Package (EDP)

AIChE requires an Engineering Documentation Package (which includes the JSA) be submitted for each Chem-E-Car team. This package must be made available for inspection by the national reviewers in advance of each competition, as well as by the poster judges and car inspectors during the pre-performance poster session and inspections.

Collection and review of the EDP is not the responsibility of the regional conference hosts. The reviewers are recruited and coordinated by AIChE's national safety coordinator. In some cases, regional conference hosts may be asked to help recruit regional EDP reviewers and onsite safety inspectors.

The use of the EDP is intended to prompt all Car Competition students and advisors to keep safety procedures, planning, and awareness foremost in mind when entering into the Competition. The package allows contestants to document the chemical reaction they are using, the safety equipment to be employed, and the safe handling and participation practices they intend to follow in the Competition.

The components of the EDP with submission instructions and related safety documents can be downloaded at: http://www.aiche.org/Students/Conferences/regcarsafety.aspx

Teams wishing to compete in regional Car Competitions must submit EDP to AIChE's national administrator, according to instructions to be posted on the website and promoted in e-mail messages. Deadlines for EDP submission are usually two to three weeks in advance of each Competition.

AIChE will provide regional conference hosts with instructions pertaining to these EDPs and are expected to promote these messages to schools in the region. Only in unusual cases will regional hosts be asked to help AIChE with EDP collection.

Competing teams must also bring a copy of the EDP to the competition, and make it available to judges during the pre-competition poster session.

Collaboration with the regional safety inspector network

National AIChE – with the cooperation of the regional safety coordinator — will assist in assembling teams of safety inspectors for each regional Car Competition.

Safety inspectors typically work in teams of two, so a minimum of two qualified inspectors is needed at the smallest competitions. Larger competitions may benefit from at least two or three teams of inspectors. Whenever possible, the safety inspectors are drawn from industrial practice. **Regional conference hosts are encouraged to help recruit qualified inspectors** from local companies and professional AIChE sections. AIChE will provide guidance.

Onsite, the safety inspectors will examine each vehicle, using a checklist of safety criteria and the Car Competition rules as guidelines. (See the appendix for a sample.) Vehicles that do not meet safety and design standards will be disqualified. The checklists and competition rules will be provided in advance to regional hosts and safety inspectors – and are also available by contacting chem-e-car@aiche.org.

Inspectors will also examine Engineering Documentation Packages (EDP) up to two weeks in advance of each competition, with the cooperation of national administrator and the regional host chapter, as needed.

Identification of the safety inspectors usually takes place during the month before each regional conference.

Safety waivers

All people involved in Chem-E-Car Competitions must take responsibility for their own participation. Each participating team member, judge, safety inspectors, onsite organizers, etc., must read and sign a waiver – attesting to their understanding of safety and risk factors involved in the competition, and assuming personal responsibility for their own conduct, well being, and personal safety at an AIChE-organized Chem-E-Car Competition. **A sample of this waiver is included in the appendix.**

In most cases, a national AIChE representative will be attending your regional conference, and will take responsibility for collecting signed safety wavers from all participating teams and competition personnel. When a national representative is not available, the host chapter will be required to fulfill this duty. In those cases, national AIChE will provide the documents to the host, with instructions on how to distribute the form to participating teams and how to instruct contestants to comply with the waiver.

In those cases, regional conference hosts must then mail the original signed waivers to AIChE headquarters within one week following the competition.

Each valid waiver must carry the signatures of all teammates present at the Car Competition. A team's failure to complete and submit the waiver to the designated regional compliance representative prior to the team's performance run will disqualify the team from entering their car in competition.

At the national competition, signatures are collected beginning during the preliminary poster session and continued up until the competition start.

Supervise collection and removal of waste chemicals

The Car Competition generates both acidic and base wastes that must be supervised and removed from the venue for disposal. The amount of waste generated during the competition may be only a few liters – but regardless of the quantity, the proper handling, documenting, and removal of waste chemicals is a critical responsibility of the competition organizer.

The host chapter must provide appropriate labeled containers to accommodate waste chemicals, and will take responsibility for removal and proper disposal of the waste chemicals after the competition, according to rules established by campus and department safety officials, the venue, the EPA, and other authorities.

It is recommended that a single person be assigned to supervise this collection of waste materials. **Separate labeled containers WITH LIDS for acids and bases should be acquired before the competition and supervised by the designated waste materials handler.** Lists should be maintained of the waste chemicals deposited into each container. At the conclusion of the competition, the supervisor(s) should personally oversee the removal of waste containers for disposal at a predetermined waste disposal location.

Additional basins, containers or trash bins should be obtained and used to dispose of any non-hazardous wastes.

Organizers should check with their campus, chemical engineering department, the EPA or other safety authorities so that they can comply with official recommendations and instructions for final disposal of these wastes **well before the start of the competition**.

Left-over chemicals should become the property of the host school, for future use or disposal.

A FINAL RESPONSIBILITY:
Instruct regional winners to apply for National Competition slots

Immediately after the competition, and in any follow-up messages to top teams – remind the eligible winners that it is their own responsibility to confirm their intention to compete in the national competition by applying for their slot online. The online application opens May 1, and is found at:

http://interact.sdsmt.edu/aiche/register.htm

The deadline for this activity is June 30, 2010. Eligible winning teams that do not request their slot by this date will lose it, and may then join a waiting list.

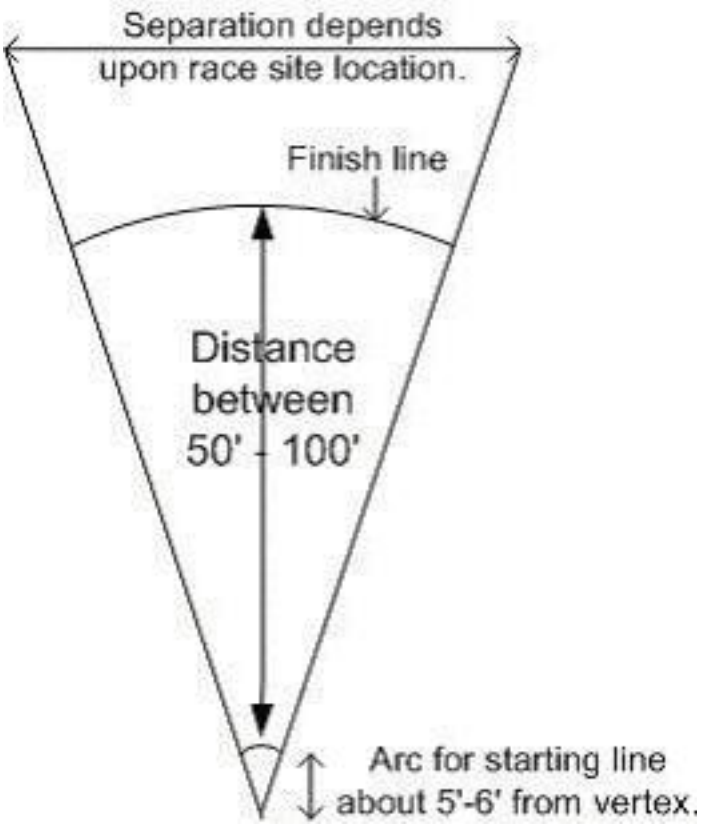
General responsibilities & competition management

Select the venue

Car Competitions have been held in a variety of spaces – from public courtyards to campus field houses to ballroom floors. The location will vary depending upon space availability and considerations of access, safety and utility.

Venues with an unbroken concrete surface works best. The surface should have an unobstructed straightaway. The length of the track may vary between 15 and 30 meters, according to the competition judges' decision for a given competition, so a straightaway of not less than 30 meters is recommended.

Here is a diagram of a typical course:



In addition to the racetrack, consider the following when selecting a venue (described in more detail below):

- Car preparation area /safety area – location and access – directly adjacent to starting line (discussed below)
- Judges station – with work table/equipment (if appropriate)

- Audience location, flow space and crowd control
- Ability to arrange for and maintain a restricted area – accessible to competitors, judges and competition organizers only. (Described on page 13)
- Safety exits for competitors and viewers
- Secure location for use of chemicals and hydrogen tank

When selecting a venue, it is important for Chem-E-Car Competition organizers to discuss the nature of the event with the site managers or representatives, so that issues related to safety can be addressed in advance.

Provide contestants with a shipping address for delivery of shipped cars and chemicals

In AIChE's regional conference series, it may be practical for students to drive to the conference site, and carry their Chem-E-Car materials with them. Schools traveling a long distance to attend a Car Competition are usually instructed to ship necessary materials and chemicals (and possibly their cars) to an address designated by the host chapter organizers, to be held in storage until the Competition. (Note: Contestants should not attempt to bring their cars or chemicals aboard airplanes.)

Regional hosts should provide a shipping address to which teams will be required to ship chemicals (as well as cars), including deadline dates for the arrival of these shipments. Chemicals for the competition will be handles exclusively by the host chapter up until the competition. Chemicals cannot be stored in teams' hotel rooms, personal vehicles, etc.

In all cases, Department of Transportation (DOT) rules must be followed. Teams should not attempt to bring chemicals or Chem-E-Cars on board airplanes. Also, it is best to avoid carrying chemicals to the competition in motor vehicles. This activity may be illegal in some states.

Any chemicals being shipped to the competition should be shipped directly from the chemical vendor rather than from the student contestants. Depending on the chemical stockroom at a particular university, some schools may be able to package and ship chemicals to the conference site – in accordance with DOT and other regulations. Teams should ship the minimum amount of material to the competition. For example, ship no more material than what is required for 5 runs. Chemicals must only be shipped to the designated holding facility specified by the host chapter, and by the deadline date announced by the host.

Left-over chemicals should become the property of the host school, for future use or disposal – unless a participating school has made pre-arrangements to have the chemicals properly shipped back to the point of origin, in accordance with DOT regulations. In those latter cases, the school would need to pay for the return shipment and arrange for pick up of the shipment by the return delivery service.

Delivery of shipments to race venue: The organizers will deliver the received chemical and cars to the Chem-E-Car venue before the competition – at a time contingent upon the venue's instructions.

Inform contestants of deadlines and responsibilities

Among contestants' responsibilities – participants should be advised in advance to bring practical or personal safety items not provided at the contest site – including proper clothing, footwear, safety goggles, gloves, etc.

Advise contestants of two important safety requirements:

Engineering Documentation Package (EDP)

AIChE Safety Waiver

See instructions on page 9 & 10.

Provide basic chemicals for general use

Regional hosts can help to minimize the quantities of shipped chemicals by providing basic chemicals that are widely used by competing teams. Hosts can identify these chemicals in advance of the competition by contacting the competing teams to learn about their needs, and by reviewing information contained in teams' Engineering Documentation Packages.

With a few exceptions, hosts are not required to supply these chemicals — but it will be important to let teams in your region know one way or the other what will be provided on site.

The major exception to the options is a hydrogen cylinder, which must be provided by the host in regions where any team needs one — which will be most regions. If items like hydrogen or HCl are not being used by teams, then of course there is no need to make them available.

Sodium bicarbonate is another staple of many competitions, and is also useful to help clean-up spills — which proper safety procedures should prevent from occurring in the first place.

Chemicals supplied by some hosts (quantities based on national competition, which accommodates 30 teams):

- **Hydrogen tank, K size (required, where needed)**
- Sodium hydroxide pellets, 2.5 kg
- Hydrochloric Acid (Muriatic acid), 2.5 L
- Sulfuric Acid, 90-98%, 2.5 L
- Sodium Bicarbonate, 10 kg (also useful for spill clean-up)
- Glacial Acetic Acid, 2.5 L
- Dry Ice, 35 lb. /Ice Chest
- Liquid Nitrogen, 25 L dewar
- Hydrogen Peroxide – 1 gallon
- Crushed Ice, several bags – Ice Chest #2

Hydrogen cylinder: Hydrogen is a commonly used element in Car Competitions, and in cases where several contestants plan to use hydrogen it is best to provide a single source onsite. The competition organizer must take responsibility for ordering, receiving on-site, and supervising use of / security, and return to vendor of hydrogen tank. The organizer should collaborate with the venue to contact the gas supplier and arrange for delivery of the tank.

- The hydrogen tank should be a standard pressurized gas cylinder.
- Research grade hydrogen is sufficient
- A relatively small tank (2-3 ft. tall) should be sufficient. A 1A tank would be much more than necessary.
- A regulator and a selection of wrenches will be required. Contestants should be advised in advance of the type of regulator fitting to be used on the tank, so that they can prepare their cars accordingly.
- If the hydrogen is coming from a commercial vendor it will need to be delivered then stored on-site. Securing the tank will likely require a tank mount that can be attached to tables, counters, or another secure feature. School labs may have these mounts readily available.

Provide laboratory and safety equipment

It is helpful for the host to provide some basic laboratory equipment for use by contestants in the car preparation area – including scale(s), a selection of measuring cylinders, plastic basins, etc. **(See the "car preparation area" entry below for a discussion of safety equipment – which must include labeled containers for collection and removal of waster material.)** Hosts should also bring plastic sheeting to cover all worktables and the floor space in the preparation area.

Following is a list of lab and safety equipment that should be available in the chemical preparation and handling area. Quantities should be adjusted so that they are appropriate for the number of participants.

- Minimum of **1–2 balance** to read as low as 0.001g (should be sufficient for most regional conferences with 10 or fewer competing teams)
- **1 Balance** to read as high as 600g., 0.1 resolution (for measurement of distilled water used as variable load carried by all vehicles.)
- Minimum **1 or 2 hot plates/Magnetic Stirrers** plus Stirring magnets
- **Plastic weigh boats** for weighing chemicals
- **Graduated cylinders** (1 each): 10ml, 50ml, 100ml, 250ml, 500ml
- **Beakers** (2–3 each): 100ml, 250ml, 500ml
- **Gloves:** a few boxes, enough for approx. five students per team, plus host volunteers assisting in chemical area; Large and XLarge
- **Rubber Gloves for Acids** etc.: 2 pairs
- **Spare Lab Coats:** (Lab Coats for host Volunteers ~4-5)
- **Safety Glasses for host Volunteers:** enough for all volunteers
- **Wrenches for Hydrogen Cylinder**
- **Rolling Tank Dolly, Chain, & Lock --** for securing hydrogen cylinder
- **Hydrogen Regulator System** (regulator +arrestor + valve)
- **Spill Kits** – acid/base – 12 each, small
- **Plastic Bins** – assorted sizes

- **2 Fire extinguisher** – one in chemical distribution area, one at starting line
- **Eye Wash Kits** – several
- **First Aid Kit**
- **Plastic sheeting** – sufficient to cover work floor area, work tables, etc.
- **Labeled containers with lids for waste** (acids, bases, etc.) (may be provided by waste disposal company, when applicable)
- **Note sheets to record wastes** being deposited into labeled waste containers (may be provided by waste disposal company)
- **Trash bin+Trash bags (NOT TO BE USED FOR CHEMICAL WASTE DISPOSAL)**
- **Dewars for Liquid Nitrogen** – 5Liter + several 665 mL dewars
- **Insulated gloves for Liquid nitrogen** (if applicable)
- **Distilled/Deionized Water** – Min. 1–2 large containers – approx. 12 gal/each (1 container should be sufficient for regions with 10 teams or less)
- **Blue Painters tape** (to lay out track)
- **Paper towels/Rags**
- **PowerStrips**
- **Extension cords**
- **Box cutters/scissors**
- **Broom/Dustpans**

Recruit judges for the poster session & performance competition

These judges may include professors, alumni, representatives from local companies and AIChE professional sections, or young AIChE members.

A key responsibility of judges at both the poster session and the performance competition will be to examine the safety in design of the vehicles, according to the rules. Cars that do not meet safety criteria should be disqualified from the competition.

Recruit and deploy onsite volunteers

In addition to the onsite judges and conductors, several people may be needed to help set up the race venue and car preparation area prior to the event, as well as to assist during and after the race.

Obtain and set-up audiovisual equipment (Some competitions)

Judges at large events like AIChE's national final competition employ microphones, laptop computers, lcd (or overhead) projectors, and a screen, on which the running order of the teams and the standings are projected.

Should audiovisual equipment or a sound system be required, make arrangements with the in advance to access electric lines.

Supervise on-site execution and judges work area

At larger competition, it may be useful to provide the presiding judges with a worktable chairs, a microphone and PA system.

Teams will need to know the running order, and how much time they have before their run. At AIChE's national competition, the judges project this information on a screen – and also display the current competitions standings. The national judges use a laptop computer to track (and display) results.

At the very least, the starting order should be posted in writing prior to the competition, so that competitors can be prepared to proceed to the preparation area in the proper order.

Set up and equip the car preparation area – including safety equipment

Near the starting line, a safe work area should be reserved where contestants can prepare their vehicles for the race. This area should be accessible to contestants and Car Competition personnel only, and safety equipment and precautions must be a foremost consideration. Ideally, this area should be strictly off limits to public access.

Depending on the size of the competition, the preparation area should include three to six worktables – enough for several teams to work on their cars simultaneously. Tables should be covered in sheet plastic, as should the floor in the staging area.

Use of chemicals and pressurized gases (hydrogen) must be confined to this area. At the national competition, a hydrogen cylinder is locked down on a loading platform outside the race venue and adjacent to the car preparation area.

Safety equipment: should be delivered to the car preparation area in advance of the competition – and it is the responsibility of the host to provide such items as:

- Fire extinguisher
- Eye wash kits
- First aid kit
- Chemical spill kit
- Plastic sheeting
- Labeled containers with lids for acetic and basic waste **(See waste removal discussion below.)**
- Note sheets to record acidic and basic wastes disposed in waste containers
- Sturdy trash bin (NOT for disposal of chemical waste)

See page 15 above for a more complete list of equipment

All contestants should use proper protective clothing, footwear, safety goggles, and other gear. The Job Safety Analysis form outlines these items, and contestants should be instructed to bring their own goggles, gloves, etc.

Restricted area – for authorized participants only

Car Competition organizers must arrange for and maintain a restricted zone - accessible only to authorized competitors, judges and competition organizers. This restricted area will consist of the marked car track axis along with a clearance of three (3) meters along the perimeter on both sides of the track, and the entire car preparation area and areas adjacent to and encompassing the start line.

Only car competition organizers, judges, rules coordinators, and competitors will be allowed in this area for the duration of the competition (including set-up and clean up time), and will be allowed there only after reading and signing the waiver of liability form(s) provided onsite at the Competition (described above). This waiver constitutes authorization to enter the restricted area.

Car Competition judges, rules coordinators, and competition organizers must police the restricted area, and have the duty and authority to enforce a no-admittance policy to unauthorized persons. An announcement should be made and reinforced before and during the competition, stating that unauthorized persons will not be allowed to enter the restricted area for the duration of the competition (except in the event of an emergency).

It is recommended that the restricted area be visually delineated from the viewing and public areas and, if possible, be physically separated by the use of stanchions, cordons, cones, etc., around the track perimeter at a distance of three (3) meters from the track axis.

Supervise collection and removal of waste chemicals

The Car Competition generates both acidic and base wastes that must be closely supervised and removed from the venue for disposal after the Competition. The amount of waste generated during the competition may be only a few liters – but regardless of the quantity, the proper handling, documenting, and removal of waste chemicals is a critical responsibility of the competition organizer.

The host chapter must provide appropriate labeled containers to accommodate waste chemicals, and will take responsibility for removal and proper disposal of the waste chemicals after the competition, according to rules established by the venue, the EPA, and other local authorities.

It is recommended that a single person be assigned to supervise this collection of waste materials. **Separate labeled containers WITH LIDS for acids and bases should be acquired before the competition and supervised by the designated waste materials handler.** Lists should be maintained of the waste chemicals deposited into each container. At the conclusion of the competition, the supervisor(s) should personally oversee the remove the waste containers for disposal at a predetermined waste disposal location.

Addition basins, containers or trash bins should be obtained and used to dispose of any non-hazardous wastes.

Organizers should check with their campus, chemical engineering department, the EPA or other safety authorities so that they can comply with official recommendations and instructions for final disposal of these wastes **well before the start of the competition**.

After the Competition

AIChE regional competition organizers are responsible for reporting the results of each Chem-E Car Competition to the national coordinator of AIChE student programs as soon as possible after the Competition – using a report form provided to regional hosts in advance of the competition. Contact studentchapters@aiche.org.

Organizers of each regional competition should explain to regional contestants and winners how to apply for a slot in the national competition. (A discussion of regional qualification for the national finals appears **on page 5.**

In summary, top-finishing teams at AIChE's regional competitions automatically receive "dibs" on one of the 31 slots in the national final competition. However, those teams must confirm their desire to participate in the national competition by June 30 (most years) – using an online application process found at: http://interact.hpcnet.org/sdsmtforms/aiche/register-online.htm

Winning teams that do not claim their slot by the deadline date lose their automatic eligibility, and remaining slots are open to all teams – first come, first served. Winning teams that miss the deadline can apply after the deadline, but may find themselves on a waiting list. Should teams drop out of the national competition (several teams cancel each year), teams on the waiting list will receive those slots in the order in which they applied.

Summary -- Context on chemicals and safety:

When competition organizers "shop" for a venue, the venue representative will be interested in the types of chemicals to be used on site. Competition planners might provide the following notes:

- The hydrogen tank is a standard pressurized cylinder, perhaps two or three feet in height. This would be delivered to the site and secured under the supervised by the event organizer or a knowledgeable representative. The cylinder should be located in a "safe" area that is still easily accessible to the Car Competition venue – particularly the planned car preparation area near the starting line. The tank will be used by knowledgeable people, under the supervision of other knowledgeable and experienced professional engineers.
- The chemicals used in the competition include hydrogen, acids (generally acetic, vinegar, or hydrochloric), bases (e.g. baking soda), and water. The total amount of waste produced in the staging area is typically not more than a few liters, and the competition conductors will be equipped with labeled containers to supervise the collection and removal of any waste from the premises.
- According to contest rules, cars must be designed so that they do not emit liquid, steam or smoke.

AIChE Chem-E-Car Competition

2010 National Competition

Updated – January 22, 2010

2010 Chem-E-Car Competition Timeline

Timeline	Date	Item
1		For regional competitions: Plan Chem-E-Car vehicle using approved safety procedures. An Engineering Documentation Package (EDP) including the JSA form must be filled out and appropriate approvals obtained. Instructions will be provided.
2		Design, build & test car following approved safety procedures specified at each university and the national Chem-E-Car competition.
3	various dates	Regional Competitions **Regional qualifiers must submit their entry on the website and send their $150 entry fee to AIChE National (Attn: Nina Scatton) PRIOR to June 30, 2010, to secure their slot in the National Competition** The National Competition application submission website is open exclusively to **QUALIFIED REGIONAL WINNERS** until May 1, 2010. http://interact.hpcnet.org/sdsmtforms/aiche/register.htm
4		Revise and modify cars following approved safety procedures specified at each university and the national Chem-E-Car Competition.
5	May 1, 2010	Website opens for application submission **for any open slot**, and is open until June 30, 2010. No applications for open slots will be accepted prior to 1 May 2010 (12:00 AM Eastern Time) http://interact.hpcnet.org/sdsmtforms/aiche/register.htm
6	June 30, 2010	Eligible team's Student Chapter Annual Report must be completed via web submission http://www.aiche-xtranet.org/aichereport/default.asp?CatID=2
7	June 30, 2010	Closing date for regional qualifier submissions and any applications for open slots for the National Competition. Decision on number of open positions will be made and open-slot teams notified within 30 days.
8	June 30, 2010	$150 entry fee due from teams selected for any open slots for the National Competition.
9	October 1, 2010	Deadline to submit Engineering Documentation Package (including JSA) to Chem-E-Car SharePoint site.
10	TBD	All chemicals must be received by close of business at designated receiving location.
11	November 7, 2010	National Chem-E-Car Competition Salt Lake City, Utah

Sponsored by Chevron

The objective of this competition is:

- To provide chemical engineering students with the opportunity to participate in a team-oriented hands-on design and construction of a small chemical powered model car.
- To design and construct a car that is powered with a chemical energy source that will carry a specified load over a given distance and stop.
- To encourage students to become actively involved in their professional society.
- To increase awareness of the chemical engineering discipline among the general public, industry leaders, educators and other students.

There are two general competitions. The first is held at spring regional conferences and the second is held at the AIChE Annual Meeting. Each year the annual competition is held in conjunction with the Annual Student Conference at the site of the AIChE Annual Meeting. A host AIChE chapter, along with the national AIChE staff and the competition sub-committee from the Student Chapters Committee, and SACHE, provides support for the annual competition.

There is a poster session and a distance or performance session at each competition, as detailed below. Each year the rules may be modified to address concerns that have developed at the past regional and annual competitions. The rules listed below have been significantly modified, so be sure to read all of them carefully.

Competitions

Regional Conference Competitions

1. In general, a school can have any number of entries at the Regional Conference. However, the Host School has the right to set a limit, should the need arise.
2. The rules listed under the National Conference Competition shall apply for the regional conference competition.
3. Regional conference host school organizers should contact the National Chem-E-Car Rules Committee (see below, at end of item 10) with questions or for clarification on the competition rules.

Regional Conference awards:

Poster Competition:

- Ribbons for 1st, 2nd, and 3rd place
- Ribbon for Most Creative Drive System
- Ribbon for Most Creative Vehicle Design

Performance Competition:

- 1st place: $200 and Ribbon

- 2nd place: $100 and Ribbon
- 3rd place: Honorable mention and Ribbon
- Ribbons for 4th and 5th place finishers
- Ribbon for Spirit of Competition

National Conference Competition
There will be a maximum of 31 car entries at the 2010 National Conference. The list of national entries is drawn from regional winners, based on the size of each region. Each Student Chapter Region may send their first and second place winners at the minimum. Mid-America, Northeast, Rocky Mountain and the Western regions may send their 1st, 2nd and 3rd place winners. The Mid-Atlantic, North Central, and the Southern Regions may send their top five winners. While multiple entries from a single school may be permitted at the regional competitions only one entry per school, via this qualifying procedure, is allowed at the national competition. Multiple entries per school may be allowed following the open entry procedure outlined in the following paragraph.

Submit your application online: The eligible teams from the Regional Conference Competitions (as described above) *must submit* an application to compete in the national competition at the 2010 AIChE Annual Student Conference in Salt Lake City, Utah.
Applications should be made by Web application starting immediately after their regional conference concludes and ending on June 30, 2010. If an eligible chapter does not submit their application by the above deadline their competition slot will be opened up to any Chem-E-Car team from any region that wishes to compete according to the following procedure. **Interested teams who do not qualify at a regional competition** should submit their application to the website given above beginning on May 1, 2010, but at least by June 30, 2010. On July 1, 2010, any open entry slots will be allocated on a "first come" basis; however, preference will be given so that there will be only one team entry per student chapter. For this year's national competition a $150 entrance fee will be charged for each competing team. This entry fee was added to cover the cost of the disposal of chemicals at the competition site. This entry fee must be paid to AIChE as given below:

Web application to Compete in Nationals (submit by June 30, 2010)
Applications should be made by **Web application** to compete in nationals--
http://interact.hpcnet.org/sdsmtforms/aiche/register.htm -- and should include:

- Student Chapter Name
- Point of contact for the team (name, phone number, email address)
- List of team members
- Title of entry
- General description of chemical reaction(s) / drive system (at least 1 or 2 paragraphs so the judges can understand any potential safety issues involved.)
- Regional Conference (and place) where the team competed
- Place earned in the regional performance competition, or indicate applying for open-slot
- National Competition Fee of $150. (See web for details)

Web Application: Engineering Documentation Package (Deadline: October 1, 2010)

- Please see Chem-E-Car Safety Checklist for all documents required for this package: http://www.aiche.org/Students/Conferences/carsafety.aspx
- Includes completed 2010 Job Safety Analysis form (JSA)

Questions about the application process should be sent to:

Professor David Dixon
Dept. Chemical and Biological Engineering
South Dakota School of Mines and Technology
501 E. St. Joseph Street
Rapid City, SD 57701
Work Phone: (605) 394-1235, FAX (605) 394-1232
Email: david.dixon@sdsmt.edu

There are two sessions of the National Chem-E-Car Competition: a poster competition and a car performance competition.

Poster Competition

a. A poster board must be displayed with the autonomous vehicle on the day of the competition. This poster should describe how the car is powered using the chemical reaction, the unique features of the car, and environmental and safety features in the design. Appropriate documentation on the design and testing of your vehicle must be available for inspection by the judges at the poster competition. This documentation must include:

- vehicle design description, drawings and testing results
- Complete Engineering Design Documentation package described in the Safety rules.
- Material Safety Data Sheets (MSDS) for each chemical used by the entry
- calculation of relief valve size and evidence of hydraulic pressure testing if required, see below
- procedures for transportation of vehicle and related accessories
- letter from student chapter advisor or department chair stating that to the best of his/her knowledge that the students abided by the rules.
- Entries will also be judged on creativity in the propulsion system and the appearance of the vehicle.

b. The poster competition and judging will occur prior to the Chem-E-Car Performance Competition. Team members should be present during judging to answer questions from the judges.

c. A team must achieve a minimum score of 70% in the poster competition to be able to advance to the Chem-E-Car Performance Competition. Posters will be judged according to the following criteria:

- Description of the chemical reaction / power source (20%)
- Design creativity and unique features of the vehicle (20%)
- Environmental and safety features (40%)
- Quality of the poster and team member presentations (20%)

d. Winners of the poster competition will be announced at the end of the performance competition:

- 1st, 2nd and 3rd place plaques will be awarded.
- A plaque will be awarded for Most Creative Drive System
- A Golden Tire plaque will be awarded for the Most Creative Vehicle Design
- Society of Biological Engineers Award for Best Use of a Biological Reaction to Power a Car
- SAChE Safety Award for the best application of the principles of chemical process safety to the Chem-E-Car competition.

Chem-E-Car Performance Competition:

1. Load and Distance:

Each car will be given two opportunities to traverse a specified distance carrying a certain additional load. The required load and distance will be given to each team one hour prior to the start of the performance competition. The distance will be between 15 and 30 m ± 0.0127 m (50 - 100 ft ± 0.5 in.) and the load will be between 0 and 500 ml of water. A judge from the student host chapter will measure out the prescribed water for each team. Teams may not add or remove any "load" (or other inert items) to adjust their vehicle weight once the poster session has concluded. Teams are allowed to adjust "fuel" or reactants used in the car's chemical reaction.

2. Course Layout and Distance Measurement:

The car will start with its front end just touching the designated starting line. There will be a designated finish line. The distance will be measured with respect to the front most point of the car. The goal of the competition is to have your car stop closest to the specified finish line (in bounds) while carrying the specified load. The course should be wedge-shaped with a starting line and the prescribed distance clearly marked in an arc of constant distance from the starting point. The physical site will dictate the exact course layout. See Figure 1 for an example of the course layout. A vehicle that goes outside the course will have its distance measured to where it went out of bounds, and a penalty of 3.048 m (10 feet) will be added to the measured distance. “Outside the course” is defined as having the entire vehicle outside the side tape boundaries of the course. The tape is considered as part of the course. When measuring the distance from the finish line it does not matter if the car goes longer or shorter than the prescribed distance.

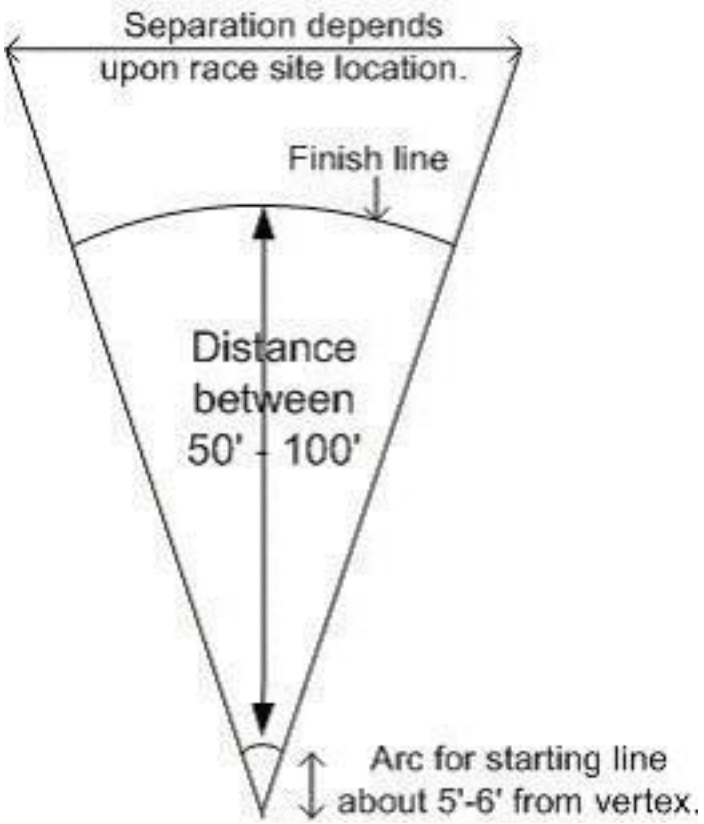


Figure 1. Sketch of typical performance course layout

3. Race Logistics:
A Chem-E-Car Competition judge (or MC) will announce each team just prior to the start of their run. Each team will be asked to introduce its entry to the audience, giving the school name and briefly mentioning the propulsion system. Each car will have two (2) attempts to complete the course, each attempt lasting no more than two (2) minutes. The best score of these two attempts will be used in the judging. In the event a team fails to show up on the starting line, or the vehicle fails to start, the next team in the order of the competition will be announced and requested to proceed to the starting line. The order of the teams in the first round of competition will be determined by random drawing. There will be a short break at the completion of the first round before the second round begins. The competition order in the second round will be determined by the 1st round standings, beginning with the team that is farthest from the prescribed distance and ending with the team that was closest.

4. Starting Procedure:
Each car is guaranteed a maximum competition time of two (2) minutes. The car must start moving, traverse the distance, and come to a stop within this time interval. If the car goes out of bounds, the next team must be ready to start its run as soon as the MC invites the team to the

starting line. Since the run time of cars that go out of bounds or do not start may be less than two minutes, the next car in the order of the competition must always be ready to run at a moment's notice. If a car does not stop within the 2-minute period, then it is disqualified from that round of the competition.

5. Competition Order Logistics:
The purpose of the time restrictions is to allow 31 cars to compete at the national competition within the period allotted for the event.

5.1. Team start order is determined during the poster competition.

5.2. The order for the first round may change because of disqualifications. If a car is disqualified that was scheduled to start before your car, then you will move-up one position in the start order earlier than was originally scheduled.

5.3. The load and distance are announced one hour before the competition starts.

5.4. Five (5) minutes before the start of the competition, the first three (3) teams are called to the start. The first team will be at the start line, the second team at ready, and the third team at the water load check station.

5.5. The first team is given a one-minute warning before the competition starts.

5.6. The competition starts when the MC signals the timing to begin. The first team is given 2 minutes for the car to start moving, traverse the distance and stop. When the car stops, the timer is reset for the next competitor. The timing will also stop if the car travels out of bounds. If the car does not stop within the 2-minute period, then it is disqualified from that round of the competition.

5.7. After the car for team 1 stops, the distance traveled is measured. During the distance measurement, team 4 is called and each team moves up one position. Team 1 should take their car directly to the chemical disposal station to dispose of their spent chemicals. This disposal process is repeated for each car upon completion of its run.

5.8. After the measurement is completed, team 2 is told to start their car, and has 2 minutes to complete the run. When the car stops, the timer is reset for the next competitor. The timing will also stop of the car travels out of bounds. If the car does not stop within the 2-minute period, then it is disqualified from that round of the competition.

5.9. During the distance measurement of team 2, team 5 is called and each team moves up one position. The process is continued until all qualified cars have competed once in the competition.

Note that if every car took two minutes to complete the course, then the competition for 31 cars would take a minimum of 124 minutes, which is more than the two hours allotted for the competition. To enable the competition to proceed in a timely fashion, it is recommended that the next team to compete should be ready and at the staging area at least five (5) minutes before their anticipated run time. Upon the completion of the run of the previous team, the next car should be ready to start.

6. Vehicle Drive System:
An objective of this contest is a demonstration of the ability to control a chemical reaction. The only energy source for the propulsion of the car is a chemical reaction.

6.1. Vehicles entered into the competition must have a significant and demonstrable student design component, particularly with respect to the vehicle drive system, and the starting and stopping mechanisms. Any vehicle that is purchased from a vendor without major modifications to its operation will be disqualified. For example a team could not purchase a fuel cell car and race this car without any modifications. (e.g. Thames and Kosmos - Fuel Cell Kit -- http://www.thamesandkosmos.com/products/fc/fc2.html).

6.2. Commercial batteries: No commercial batteries (for example, AA batteries) are allowed as the power source. Commercial batteries are allowed for specialized instrumentation (e.g. detectors, sensors)

6.3. Autonomous vehicle: The car must be an autonomous vehicle and cannot be controlled remotely. Pushing to start the vehicle or using a mechanical starting device is not allowed. Check with the Rule Coordinators (see below, after item 12) if you have a specific question concerning your vehicle.

6.4. No brakes: No mechanical force can be applied to the wheel or ground to slow or stop the car (e.g. no brakes).

6.5. Mechanical or electronic timing devices: There can be no mechanical or electronic timing device(s) to stop the chemical reaction or stop the car. In addition, a timing device cannot utilize what is normally considered as an instantaneous reaction. For example, a constant, or draining, liquid feed to a sensing cell that employs an instantaneous reaction (acid-base or precipitation) would not be allowed. Another example would be a liquid draining out of a vessel to serve as a stop switch would be considered a mechanical timing device, and would not be allowed.

7. Size of Car:
All components of the car must fit into a shoebox of dimensions no larger than 40 cm x 30 cm x 18 cm. The car may be disassembled to meet this requirement. If the judges are uncertain whether the car will fit inside the box when dissembled, they may request that the team demonstrate that they can do this.

8. Water Load Container:
The car must carry a container that holds up to 500 mL of water without spilling. An example container is a Nalgene Low-Density Polyethylene Narrow-Mouth Bottles (500 mL) Nalge No. 38-430 20039016 or Fisher Cat. No 02-923-11G. At the competition, only the water will be supplied, thus each car must already have its own container.

9. Capital Cost of Vehicle:
The cost of the contents of the "shoe box" and the chemicals must not exceed $2000. The vehicle cost of the car includes the donated cost of any equipment. The time donated by university machine shops and other personnel will not be included in the total price of the car. It is expected that every university has equal access to these resources. The cost of pressure testing is also not included in the capital cost of the car. The method used to estimate the donated cost of the equipment must be shown. It is expected that standard financial procedures will be used to estimate this cost. **The same car cannot be reused from year to year**. Substantial changes should be made and indicated in the poster presentation.

10. Team Member Status and Conduct:

10.1. All team members attending the National Competition must be National AIChE members.

10.2. The competition will be conducted on the honor system. Faculty and graduate students can only act as sounding boards to the student queries. The faculty cannot be idea generators for the project. There is no restriction on requesting assistance on vehicle safety – teams may request safety assistance from their faculty advisor, other faculty members, other universities, and professional practitioners in industry and elsewhere.

10.3. The students working on the project must sign a statement saying they have read, understand, and abided by the rules. This statement must be included (or be available) at the poster competition.

10.4. This is a team competition and must have students from at least two chemical engineering classes. The percentage of students from any one class must not be greater than 80% of the total number of students on the team. Multi-disciplinary teams are also encouraged.

10.5. The minimum team size is five (5) participants. All team members do not have to be present at the National Chem-E-Car Competition; however, all are encouraged to attend, if possible.

10.6. Each Chem-E-Car team must have a faculty member and student team member that has undergone AIChE approved safety training.

10.7 All Chem-E-Car team members must have received appropriate safety training by the university.

10.8 All student chapters that are competing in the national competition must have submitted a Student Chapters Annual Report online to AIChE following the standard timelines given by AIChE.

If there is any uncertainty on an issue of safety or other judging criteria, please contact:

Rules Coordinators: (Contact these folks first if you have questions on the rules.)

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jesmith@che.uah.edu

11. Declaration of the Winning Team:

The winning team is the car that stops closest to the finish line. This is defined as the absolute value of the distance between the front most part of the car and the finish line. In case of ties, the team with the best average from the two runs will be declared the winner. Winners of the National Chem-E-Car Performance Competition will be recognized immediately following the performance competition. Chevron sponsors the National Chem-E-Car Competition.
The National awards are:

- 1st place: $2000 and a trophy
- 2nd place: $1000 and a trophy
- 3rd place: $500 and a trophy

In addition to the top three performance awards, other awards will be given as described below:

- **Best Use of a Biological Reaction to Power a Car - $1,000 Prize:** Sponsored by the Society for Biological Engineering
- **SAChE Safety Award** for the best application of the principles of chemical process safety to the Chem-E-Car competition.
- **Most Consistent Performance** - This award is based on the best average score for the two runs that the vehicle makes. It has been created to recognize the team

that has designed and most understands the performance of the reaction that powers the vehicle. Award consists of a plaque.

- **Spirit of the Competition** - This award is given to the team displaying the most team spirit as decided by a panel of judges. Award consists of a plaque.
- **Most Creative Drive System** - Recognition is awarded to the team that has designed and installed the most creative propulsion system. The winner is decided by a panel of judges during the poster competition. Award consists of a plaque.
- **Golden Tire Award** - In 2002, Northeastern University team members created this award to recognize the team with the most creative vehicle design. The national committee has adopted this as an annual award. The winning entry is decided by a ballot cast by each team entered in the competition. Award consists of a plaque.

For more information on this competition, contact AIChE at (646) 495-1331, studentchapters@aiche.org, or by fax at (646) 495-1503.

NATIONAL CHEM-E-CAR SAFETY RULES
Spring 2010

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. The following items must be uploaded to the competition website. Any delay in submission will result in exclusion from the competition.

2.1.1 A completed Job Safety Analysis (JSA) form.

2.1.2 An engineering documentation package for your Chem-E-Car that includes, as a minimum:

2.1.2.1 A description of your car and how it works, include a diagram or picture of the vehicle.

2.1.2.2 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.

2.1.2.3 Standard operating procedures.

2.1.2.4 A description of the chemistry involved.

2.1.2.5 A quantitative design basis for pressure relieving load.

2.1.2.6 Sizing calculations for a pressure relief device.

2.1.2.7 Test procedure and results for a pressure relief.

2.1.2.8 Car experimentation area floor plan.

2.1.2.9 Management system for chemical use and disposal.

2.1.2.10 Management system for approval of changes in your vehicle.

2.1.2.11 Material Safety Data Sheets for all chemicals.

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.

2.1.3 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.

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.

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 misidentification 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 labeled.
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.

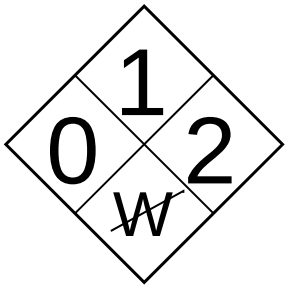
J. An inventory of stored chemicals must be maintained by the laboratory owner at all times. Unneeded items shall be properly discarded or returned to Chemical Stores. Store only what you are using.

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 are known, are 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.

APPENDIX:

- **Sample Safety Waiver**
- **Poster judges' sheet**
- **Car inspection checklist**

AIChE®

November 2009

TO: All teams competing at the AIChE National Chem-E-Car Competition on November 8, 2009 – Nashville, Tennessee

FROM: The American Institute of Chemical Engineers

RE: **Chem-E-Car safety information and mandatory waiver**

The Chem-E-Car competition is a favorite event at the AIChE Annual Student Conference and the unofficial start to the professional AIChE Annual Meeting.

AIChE, its Student Chapters Committee, and the Chem-E-Car Subcommittee execute the Competition with utmost attention to detail and safety. As participants and collaborators in the Chem-E-Car Competition, each team and team member must also do their part by adhering strictly to formal safety protocol – as presented in the competition rules and instructions to competitors.

All teams were asked to complete a Engineering Documentation Package and make it available for inspection by judges prior to the Chem-E-Car Poster Session – preceding the performance competition. This item makes certain that teams are aware of potential risks—and how to mitigate them prior to the competition. It is based on the assessment a professional chemical engineer would complete in their day-to-day responsibilities.

Even with this awareness, there remains a risk of injury or property damage through participation in the Chem-E-Car Competition. AIChE's insurer has stated that all parties must take full responsibility for their own participation. AIChE therefore asks each competitor to **read and sign the waiver below**. This waiver is modeled after the Society of Automotive Engineers' waiver for a contest where students also build and race cars.

In order to ensure that safety is kept foremost in the minds of team members, a signature must be provided by each student participating in the AIChE National Chem-E-Car competition. Missing signatures will result in **disqualification** of the team from the 2009 National Chem-E-Car competition.

All waivers must be returned to Car Competition officials before 2:00PM on Sunday, November 8, the start of the Chem-E-Car Performance Competition. Only those people signing the forms will be permitted to compete or to enter the areas designated for Car Competition participants.

Competition officials will be available at the Student Conference on Saturday, November 7, between 4:00 PM and 7:00 PM (during car inspections, poster judging and the mandatory team safety meeting) and at the Competition site on Sunday to collect late waivers and enforce this policy.

Chem-E-Car Waiver

IN CONSIDERATION of being permitted to compete, officiate, observe from a RESTRICTED AREA, work for or participate in any way in the EVENT(S) or being permitted to enter for any purpose any RESTRICTED AREA, EACH OF THE UNDERSIGNED, for himself, his personal representatives, heirs, and next of kin:

1. HEREBY AGREES TO INDEMNIFY AND SAVE AND HOLD HARMLESS the promoters, participants, association, sanctioning organizations or any subdivision thereof, space owners, officials, car owners, team members, emergency personal, any persons in the RESTRICTED AREA, sponsors, advertisers, owners and lessees of premises used to conduct the EVENT(S) and event inspectors, surveyors, underwriters, consultant and others who give recommendations, directions, or instructions or engage in risk evaluation or loss control activities regarding the premises or EVENT(S) and each of them, their directors, officers, agents and employees all for the purpose herein referred to as "Releasees" and each of them FROM ANY LOSS, LIABILITY, DAMAGE, OR COST the may incur arising out of or relate to the EVENT(S) WHETHER CAUSED BY THE NEGLIENCE OF THE RELEASEES OR OTHERWISE.

2. HEREBY ASSUMES FULL RESPONSIBILITY FOR ANY RISK OF BODILY INJURY, DEATH OR PROPERTY DAMAGE arising out of or related to the EVENT(S) whether caused by the NEGLIGENCE OF RELEASEES or otherwise.

I HAVE READ THIS RELEASE AND WAIVER OF LIABILITY, ASSUMPTION OF RISK AND INDEMNITY AGREEMETN, FULLY UNDERSTAND ITS TERMS, UNDERSTAND THAT I HAVE GIVEN UP SUBSTANTIAL RIGHTS BY SIGNING IT, AND HAVE SIGNED IT FREELY AND VOLUNTARILY WITHOUT ANY INCUDEMENT, ASSURANCE OR GUARANTEE BEING MADE TO ME AND INTEND MY SIGNATURE TO BE A COMPLETE AND UNCONDITIONAL RELEASE OF ALL LIABILITY TO THE GREATEST EXTENT ALLOWED BY LAW

All Sections must be completed. If more room is needed, please add another sheet.

School Name

Competitor Information

Print Name Here	Sign Name Here	Duties	Date

Witness: Print Name	Print Title	Signature

Address	Date

2009 Chem-E-Car Competition
(Poster Session – Sunday, November 8)

Entrant _____

Criteria	Score	Comments
Description of power Source	/20	
Unique features	/20	
Creativity	/20	
Environmental/safety factors	/20	
Quality of poster/presentation	/20	
Total	/100	

Most creative of the entries you evaluated ☐ Yes ☐ No

2009 National Chem-E-Car Safety Inspector's Checklist **November 7, 2009**

University:

Inspector(s):

1. **Disallowed Vehicles:** All of the items listed below are not allowed. Please check any box that you believe may exist in the design of the car.

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.

2. Safety Management: All items listed below must be available and in satisfactory form.

Item	Availability	Status
☐ (a) JSA:	☐ Present ☐ Absent	☐ Satisfactory ☐ Unsatisfactory
☐ (b) Complete Engineering Documentation package:	☐ Present ☐ Absent	☐ Satisfactory ☐ Unsatisfactory
☐ (c) MSDS:	☐ Present ☐ Absent	☐ Satisfactory ☐ Unsatisfactory
☐ (d) Personal Protective Equipment:	☐ Present ☐ Absent	☐ Suitable ☐ Unsuitable

3. 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:** ☐ Pressure gauge (must read to 2x max. operating pressure) ☐ Emergency relief device set to 1.1 times max. operating pressure. Sizing calculations must be provided. ☐ Pressure certification, either from equip. vender or by hydrotest at 1.5 to 2x max. operating pressure using liquid. **Must have measurements or calculations to prove maximum operating pressure.**
☐ (b) Toxic	Any chemicals with an NFPA toxicity of 2 or greater? ☐ Properly contained and handled. ☐ Double containment for acids or bases, such as a drip tray.
☐ (c) Flammable	Any chemicals with an NFPA flammability rating of 2 or higher? ☐ Properly contained and handled.
☐ (d) Reactive	Any chemicals with an NFPA instability / reactivity rating of 2 or 3? **Chemicals with a 4 rating are not allowed.** ☐ Properly contained and handled.
☐ (e) Temperature	Any exposed surface greater than 150 deg. F or under 32 deg F? ☐ 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. ☐ Proper electrical insulation and connections provided.
☐ (g) Mechanical	Any fast moving parts (meshing gears, belts or chains) that are pinch hazards? ☐ Guards present and adequate.

4. Operating Experience: Team must have at least ten hours of operating experience. This is verified by the Certification document signed by the faculty advisor. Please ensure this form is signed by advisor, and that advisor has attended safety training.

☐ **Satisfactory** ☐ **Unsatisfactory**

5. Engineering Documentation Package: The engineering documentation package must contain the following items. In some instances, where pressure is not used above 1 psig in the car's design, pressure sizing calculations and testing of pressure relief devices are not required.

a. Description of the car and how it works. ☐ **Satisfactory** ☐ **Unsatisfactory**
(May be contained in JSA)

b. Complete list of every piece of equipment on the car in Table format, this list should include the manufacturer of the equipment, or indicate that it was custom built.
☐ **Satisfactory** ☐ **Unsatisfactory**

c. Manufacturer's spec sheets or specs for custom built equipment.
☐ **Satisfactory** ☐ **Unsatisfactory**

d. Standard Operating Procedure (May be contained in JSA) ☐ **Satisfactory** ☐ **Unsatisfactory**

e. Have the students explain the chemistry. Rate their understanding of any chemical hazards present. ☐ **Satisfactory** ☐ **Unsatisfactory**

f. Check the design basis for pressure relieving load.
☐ **Satisfactory** ☐ **Unsatisfactory**

g. Check the sizing calculations for a pressure relief device against the manufacturer's spec sheet. ☐ **Satisfactory** ☐ **Unsatisfactory**

h. Check the student's test procedure and results for a pressure relief.
☐ **Satisfactory** ☐ **Unsatisfactory**

i. Ensure they have a diagram of the laboratory floor plan in the documentation package. ☐ **Satisfactory** ☐ **Unsatisfactory**

j. Ask about the management system for chemical use and disposal during the competition. ☐ **Satisfactory** ☐ **Unsatisfactory**

k. Ensure there are MSDS sheets for each chemical in use during the competition.
☐ **Satisfactory** ☐ **Unsatisfactory**

l. Ensure the pictures of the car in the documentation package match the actual car in front of you. If there are changes, ask to see the MOC document documenting the changes. ☐ **Satisfactory** ☐ **Unsatisfactory**

m. Check the comments from the paperwork audit and ensure that all comments made by the first reviewer have been properly addressed.
☐ **Satisfactory** ☐ **Unsatisfactory**

FINAL INSPECTION STATUS: ☐ **PASSED** ☐ **FAILED**

INSPECTOR'S SIGNATURES: _____

Provide any additional supporting comments below. List any additional hazards not covered in Table 2 (Biohazards, lasers, ionizing radiation, etc) that might affect the safety of the vehicle. State whether the control is satisfactory.