

## ChemE Car Safety Workshop Part 1

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## History of the ChemE Car Competition

- Began in 1999 as a means to bring more student involvement into AICHE.
- Contains a lot of opened ended design content.
- Contains a chemical reaction component.
- The competition has been very popular and the final competition has attracted a very large audience of students and professionals.

## Difficulties with Original Concept

Safety was not a part of the original concept.

- Some original cars used rocket motors, or ejected liquid into the competition area.
- Students transported chemicals themselves to the competition.
- Students stored and mixed chemicals in hotel room and tested cars in hallways of hotel
- Students disposed of chemicals in easiest way.

## Difficulties with Original Concept

From 1999 to 2005 a number of serious accidents occurred, both at the students home institution and the regional and national competitions. Some involved medical treatment and/or hospitalization of the students. These accidents involved:

1. Explosions, projecting chemicals and car parts into competitors and spectators.
2. Fires, requiring the use of a fire extinguisher.
3. Spilling of acids and bases and other chemicals on floor.
4. Improper waste disposal.
5. Improper chemical transportation and use.

## National Competition November 2005

Two major accidents during competition:

1. Major explosion of a pressurized pop bottle, with a very loud bang and projection of car debris into audience.
2. A fire, requiring the use of a fire extinguisher.

Fortunately, no one was injured.

**RESULT:** AICHE Board of Directors suspended the competition until a safety program could be developed to prevent such incidents.

## Essential Problem!

We are holding a competition with lots of spectators, using toxic, flammable and reactive chemicals, in an exhibit hall in a major hotel!



## Safety Program

- Developed with the assistance of a number of people, in conjunction with the ChemE car committee.

Four parts to the program:

1. New rules / guidelines to prevent accidents.
2. Mandatory training of all teams prior to competition.
3. Completion of an Engineering Documentation package.
4. Independent inspection and audit by industrial / academic practitioners in safety.

## Safety Program

For both regional and National competitions:

1. Engineering Documentation Package (EDP) must be submitted well in advance of the competition.
2. The EDPs are reviewed by experienced safety folks and feedback is provided to the teams.
3. A final inspection of the vehicle is done just before the competition.

Teams must earn the right to compete by demonstrating that they have a safe vehicle.

## Definitions

**Hazard:** A chemical or physical condition that has potential to cause an accident.

**Primary hazards in Chem-E-car:** flammability, toxicity, reactivity, pressure, temperature, electrical, mechanical, others.

**Risk:** A combination of probability and consequence.

## ChemE Car Safety

You may enlist outside assistance with respect to your car safety and preparation of the EDP.

This includes your faculty advisor, other faculty, industrial folks, university safety person, others.

The ChemE car rules and EDP requirements are revised regularly - please check AICHE web site prior to regional or national meetings.

## Engineering Documentation Package (EDP)

1. Job Safety Analysis (JSA)
2. Flow diagram of car
3. Design basis for maximum operating pressure
4. Design basis for estimating relieving mass flow rate
5. Equipment specifications summary table and equipment specification data
6. Pressure certification of vessel
7. Standard operating procedures
8. Test Data
9. Car experimentation area floor plan
10. Management system for vehicle modifications
11. Management system for chemical use and disposal
12. Pictures of vehicle, as it would appear on starting line
13. Material Safety Data Sheets (MSDS)

## Job Safety Assessment (JSA)

- A management system used to determine hazards associated with a particular experiment / procedure and to control the hazards.
- This works best during the initial conceptual design and construction phase of your car.

### JSA – Page 1: Identification

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

University:	Vehicle Name:
JSA Author Contact Name:	Author Email:
Faculty Supervisor:	Supervisor Email:
Revision #:	Revision Date:

Used to identify location of experiment.

### JSA – Page 1: Purpose of Experiment

Describe your car's design:
Power source:
Stopping mechanism:
Hazards inherent in design:
Safety measures:

Provide a brief, few sentence description for each item in this table.

### JSA – Page 1: Expected Operating T&P

Expected Operating Conditions:

Temperature		Pressure	
Normal:		Normal:	
Minimum:		Minimum:	
Maximum:		Maximum:	

List the expected normal, minimum and maximum values for the temperature and pressure.

### JSA – Page 2: Personal Protective Equip.

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

<input type="checkbox"/> Long Pants	<input type="checkbox"/> Safety Glasses	<input type="checkbox"/> Hard Hat	<input type="checkbox"/> Apron
<input type="checkbox"/> Long Sleeves	<input type="checkbox"/> Splash Goggles	<input type="checkbox"/> Insulated Gloves	<input type="checkbox"/> Ear Protection
<input type="checkbox"/> Non-porous Shoes	<input type="checkbox"/> Face Shield	<input type="checkbox"/> Chemical Gloves	<input type="checkbox"/> Other

This should summarize all the personal protective equipment required normally in the laboratory and PPE required for this particular experiment. Equipment that is required all the time (such as safety glasses) does not need to be listed on each step of the JSA procedure section.

### JSA – Page 2: Spill Response

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

Item	Location
Spill Kit:	
Floor-Dri:	
Spill Dikes:	
Sodium Bicarbonate:	
Drain Plugs:	
Spill Pillows:	
Mercury Spill Kit:	
Other:	
Other:	

Spill response supplies in the event of a chemical spill – at home institution.

### JSA – Page 2: Available Safety Equip.

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

Item	Location
Fire Extinguisher:	
Eyewash:	
Safety Shower:	
Telephone:	
First Aid Kit:	
Spill Containment	
Other:	

Available safety equipment at home institution where vehicle will be tested.

### JSA – Page 3: Disallowed Activities

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

**Item**

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

### JSA Page 3: Disallowed Vehicles

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

Item	Explanation
(a) Flames and/or smoke	Both inside and outside the vehicle, except for commercial internal combustion engines. See ChemE car rules for using commercial internal combustion engines.
(b) Liquid Discharge	Liquid may not be discharged under normal operating conditions.
(c) Open and/or improperly secured containers	Containing chemicals having an NFPA rating of 2 or greater. No open containers allowed at the starting line or during the operation of your vehicle. 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 <a href="http://www.osha.gov">www.osha.gov</a> 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.
(h) Biohazards	Biological organisms with a biohazard level greater than 1.

### JSA Page 3: Disallowed Vehicles



#### Flames and/or Smoke

Both inside and outside the vehicle, except for internal combustion engines.

### JSA Page 3: Disallowed Vehicles



#### Liquid Discharge

Liquid may not be discharged under normal operating conditions.

### JSA Page 3: Disallowed Vehicles



#### Open and/or improperly secured containers

Containing chemicals having an NFPA rating of 2 or greater. All containers with these chemicals must be secured to the vehicle. All containers brought to the starting line must have lids and be properly labeled.

### NFPA Diamond

Ratings: 0-4

0 : no hazard

4: max. haz.

Used for firefighters

#### HEALTH HAZARD

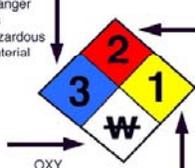
- 4 - Deadly
- 3 - Extreme danger
- 2 - Hazardous
- 1 - Slightly hazardous
- 0 - Normal material

#### FIRE HAZARD

- Flash Point
- 4 - Below 73° F
- 3 - Below 100° F
- 2 - Below 200° F
- 1 - Above 200° F
- 0 - Will not burn

#### SPECIFIC HAZARD

- Oxidizer OXY
- Acid ACID
- Alkali ALK
- Corrosive COR
- Use NO WATER
- Radiation Hazard



#### REACTIVITY

- 4 - May detonate
- 3 - Shock and heat may detonate
- 2 - Violent Chemical change
- 1 - Unstable if heated
- 0 - Stable

**JSA Page 3: Disallowed Vehicles**

 **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.

**JSA Page 3: Disallowed Vehicles**

 **Regulated Chemicals**

A number of chemicals are listed by OSHA as a special hazard. OSHA has a special regulation of each chemical. See list provided.

**JSA – Page 3**

**Some Regulated chemicals:** asbestos, methyl chloromethyl ether, bis-chloromethyl ether, benzidine, ethyleneimine, vinyl chloride, inorganic arsenic, benzene, acrylonitrile, ethylene oxide, formaldehyde, 4,4'-Methylenedianiline, 1,3-butadiene, methylene chloride.

**JSA Page 3: Disallowed Vehicles**

 **Highly Reactive / Unstable Chemicals**

Any chemical, raw material, intermediate or product with an NFPA reactivity / instability rating of 4.

**JSA Page 3: Disallowed Vehicles**

 **Hydrogen Peroxide greater than 30% concentration**

Hydrogen peroxide at greater than 30% is unstable and difficult to store and handle.

**JSA Page 3: Disallowed Vehicles**

 **No biological organisms with a biohazard level greater than 1.**

Biohazard levels greater than 1 require special laboratory equipment and procedures that we are unable to provide during the competition.

## JSA – Page 4

**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
<input type="checkbox"/> (a) Pressure	Anything greater than 1 psig? Must meet all requirements below: <input type="checkbox"/> Pressure gauge (must read to 2x max. operating pressure) <input type="checkbox"/> Emergency relief device set to no more than 1.1 times max. operating pressure. Relief sizing calculations must be provided. <input type="checkbox"/> Emergency relief device in proper location. <input type="checkbox"/> Pressure certification – see Pressure Vessel Testing Protocol <input type="checkbox"/> Proper management system to prevent over or mis-charging. <input type="checkbox"/> All car components exposed to pressure must be certified to operate at that pressure. Provide manufacturer's pressure specifications. <input type="checkbox"/> No PVC, cPVC or polyethylene terephthalate (PETE or PET) plastics in pressure service Must have measurements or calculations to prove maximum operating pressure. See ChemE car rules for more details on these requirements.

## Pressure Hazards

Anything greater than 1 psig?

**Must have measurements to prove max. pressure - even if below 1 psig.**

**Must meet all requirements below:**

**Pressure Gauge – must read 2x max. operating pressure.**

## Pressure Hazards

**Emergency relief device set to no more than 1.1 times max. operating pressure. Sizing calculations must also be provided.**

**Emergency relief device properly located.**

**Pressure certification.** Either from equipment manufacturer or by hydrotest at 2x operating pressure.

See model Engineering Documentation Package for examples of this.

## Pressure Hazards

**Management system to prevent over or mischarging.**

**We have had several accidents caused by mischarging reactants!**

- Have several people involved in the calculations, measuring and pouring operations.
- Put maximum lines on measuring containers.
- Tag vehicle when it has been charged.

## Pressure Hazards

**All car components exposed to pressure must be certified to operate at that pressure. Provide manufacturer's pressure specifications.**



## Pressure Hazards

**No PVC, cPVC or polyethylene terephthalate (PETE or PET) plastics in pressure service.**



### Toxic Hazards

Any chemical with an NFPA toxicity rating of 2 or higher?

→ Must be properly contained and handled



### Flammable Hazards

Any chemicals with an NFPA flammability rating of 2 or higher.

→ Must be properly contained and handled



### Reactive Hazards

Any chemicals with an NFPA instability / reactivity rating of 2 or 3.

**Chemicals with 4 rating not allowed!**

→ Must be properly contained and handled.



### Temperature Hazards

Any exposed surfaces greater than 150 deg. F. or under 32 deg. F?

→ Insulation or barriers to prevent contact.



### Electrical Hazards

Exposed wiring and electrically energized components are ignition, electrocution, and a shorting / fire hazard.

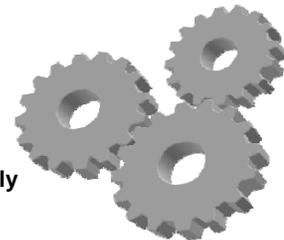
→ Must be properly insulated.

Alligator clips and twisted wire connections are not allowed – use binding posts or banana plugs for more secure connections.

### Mechanical Hazards

Any fast moving parts (meshing gears, belts or chains) that are pinch hazards?

→ Must be properly guarded.



## Oxygen

All components exposed to oxygen must:

1. Certified for oxygen service. Consult manufacturer's specs.
2. Thoroughly cleaned to remove any hydrocarbon residue / contaminants.
3. Not previously used in other service.

## Biological Hazards

Does your vehicle involve any live organisms such as bacteria, yeast, viruses, fungus, or other living organisms?

This could include any phase of your cars operation, including design, construction, preparation or competition.

If these organisms are used, then they must belong to the lowest biohazard level 1 (also called biosafety level). See detailed rules for more information on this.



## Overall Hazards

**Must convince inspectors that these hazards have been properly identified, managed and controlled!**

This completes **Part 1** of the ChemE Car Safety Training.

**Part 2** will complete the discussion of the Job Safety Assessment (JSA) Form, and will provide final details on the Engineering Documentation Package (EDP).

