

# Chem-E-Car Competition 2010



## **1. OBJECTIVE:**

The objective of this competition is to design and construct a car that uses a chemical reaction or reactions to power it and to control the distance it travels carrying a specified load. The goal of the competition is to have your car stop closest to a specified finish line (not being out of bounds) while carrying a specified load. The competition is about demonstrating ability to control a chemical reaction.

## **2. COMPETITIONS:**

During the early part of 2010 it is proposed to have competitions within Chemical Engineering Departments in Australia and New Zealand. The winners of these competitions will play off in a Grand Final at the CHEMECA Conference in Adelaide, Australia, 26th – 29th September 2010.

The ChemECar competition finals in Adelaide will be held in two Divisions:

- Division 1: Open to teams consisting of chemical engineering Undergraduate students from an Australian, New Zealand, or overseas University (by invitation).
- Division 2: Open to teams consisting of High School students from South Australia

There are two parts to each level of the Chem-E-Car Competition; a poster competition and a car performance competition.

## **3. RULES AND REQUIREMENTS:**

### ***3.1 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, weight of the complete car without the prescribed water load, and environmental and safety features in the design. Entries will also be judged on creativity. If obvious safety violations have occurred the judges have the discretion to disqualify the entry.

(b) The poster competition display 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) Winners of the poster competition will be announced at the start of the performance competition.

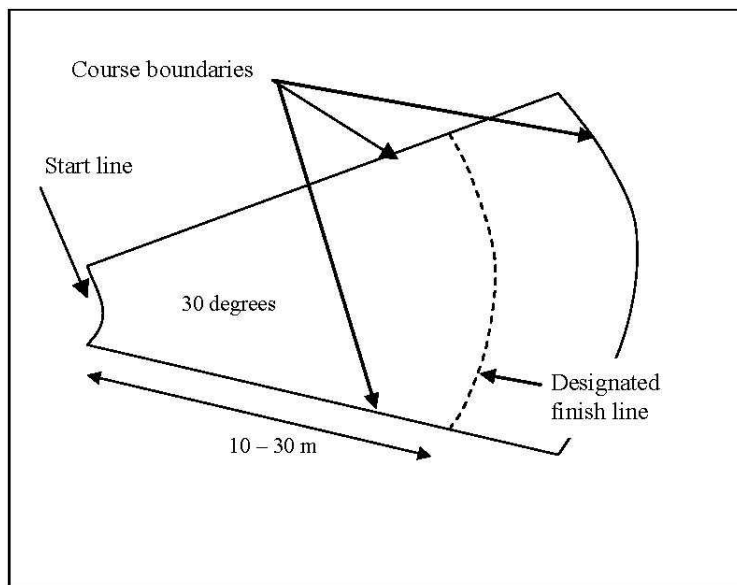
### **3.2 Chem-E-Car Performance Competition:**

#### 3.2.1 Team Formation and Ethical Conduct

- (a) Only undergraduate students enrolled in Chemical Engineering and related degree courses for 2010 are eligible for entry in Division 1. Only teams entered officially by a South Australian secondary school, and with the full support of their School, are eligible for entry in Division 2.
- (b) The competition will be conducted on the honor system. Academic staff, postgraduate students and school teachers can only act as sounding boards to the student queries. Non-team members cannot be idea generators for the project.
- (c) The students working on the project must also sign a statement saying they have abided by the rules.
- (d) This is a team competition. The minimum team size is 2 participants.

#### 3.2.2: Rules and requirements

- (a) Each car will be given two opportunities to traverse a specified distance carrying a certain additional load. The required load and distance will be announced to the teams one-hour prior to the start of the performance competition. The distance will be between 10 and 30 m  $\pm$  0.005 m and the load will be between 0 and 500 ml water. Teams may not add or remove any water (or other items) to adjust their vehicle weight once the poster session has concluded.
- (b) The car will start with its front end just touching the designated starting point. There will be a designated finish line. The distance will be measured with respect to the front end of the car. The goal of the competition is to have your car stop closest to the specified finish line (not being out of bounds) while carrying the specified load. When measuring the distance from the prescribed distance it does not matter if the car goes longer or shorter than the prescribed distance. The course will be wedge shaped with a starting point and the prescribed distance clearly marked in an arc of constant distance from the starting point (Figure 1). The physical site will dictate the exact course layout. A vehicle that goes outside the course will be disqualified from that round of competition.



**Figure 1: Chem-E-Car course layout**

- (c) The Chem-E-Car Competition judges will announce each team just prior to the start of their run. The team then has 2 minutes to get to the starting line, introduce their entry to the audience (team name and briefly mention your propulsion system) and start their car. Each car will have 2 attempts. The best score of these two attempts will be used in the judging. In the first round of attempts the order of the teams will be by random drawing. At the completion of the first round of attempts there will be a 5-minute break before the second round begins. The competition order in the second round of attempts will be determined by the 1st round standings, beginning with the entry that had the entry furthest from the prescribed distance and ending with the team that was closest.
- (d) 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. The distance travelled by the car must be controlled by a chemical reaction and no other means.
- (e) All components of the car must fit into a shoebox with dimensions equal to or smaller than 32 x 20 x 12 cm. The car may be disassembled to meet this requirement. If the judges are uncertain whether the car will fit inside the box when disassembled they may request that the team demonstrate they can do this.
- (f) The car must carry a container that holds up to 500 mL of water without spilling. An example container is a 500 ml Low-Density Polyethylene bottle (Selby Biolab catalogue number: NAL2003-0016 or equivalent). At the competition, only the water will be supplied, thus each car must already have its own container.
- (g) The cost of the contents of the "shoe box" and the chemicals must be less than AU\$500.
- (h) A car that uses a pressurized device must have evidence of proper design and

pressure testing.

- (i) Any car using or producing corrosive chemicals must have these chemicals contained to prevent leakage – even in the event of the car overturning.
- (j) Students are responsible for providing a hazard assessment on their cars, safety data and disposal information on the chemicals used. For the University Department Competitions provision of chemicals will be arranged by the Department Competition Coordinator and the Department Safety Officer or equivalent. (Other arrangements will be put in place for the Grand Final). High School teams (Division 2) must consult their supervising teacher in relation to the provision of chemicals and safety procedures. Hazardous chemical protocols must be followed and reported on the poster. If obvious safety violations have occurred the judges have the discretion to disqualify the entry. If there is an uncertainty on an issue of safety contact the Competition Coordinators: Matt Hardin ([math@mech.uwa.edu.au](mailto:math@mech.uwa.edu.au)) – Division 1 or Peter Ashman ([peter.ashman@adelaide.edu.au](mailto:peter.ashman@adelaide.edu.au)) – Division 2.
- (k) All cars must safely operate inside a building. If a car is deemed unsafe, then the judges may disqualify it. If there is an uncertainty on an issue of safety or other judging criteria contact Matt Hardin (Division 1) or Peter Ashman (Division 2).
- (l) Appropriate personal protection must be worn when handling chemicals and working with the car. Such protection must be provided by the entrants.
- (m) Chemicals must not be stored or used in hotel rooms.

### 3.2.3: Things that are specifically disallowed

- (a) The car must be an autonomous vehicle and must not be controlled remotely.
- (b) Pushing the car to start it is not allowed.
- (c) Starting the car using a mechanical device is not allowed.
- (d) Commercial batteries (for example, AA batteries) are not allowed at all on the car.
- (e) The car must be designed to avoid any liquid discharge. Any liquid on the car must be contained and not allowed to discharge from the car. Vehicles that intentionally spray liquids will be disqualified. (Given the general public's lack of understanding of general chemistry, anything that is visibly left behind by the car may well be construed as chemical pollution or even a hazardous material.)
- (f) A car which uses a naked flame or ignition source (e.g. spark) is not allowed.
- (g) A car which emits smoke is not allowed.
- (h) The use of anything resembling a fuse, either commercially available or home made, is not allowed. Simple "rocket" cars which discharge gas and liquid (acid and baking soda producing CO<sub>2</sub>, for example) as a means of propulsion are not allowed.

- (i) No mechanical force can be applied to the wheel or ground to slow or stop the car (e.g. no brakes).
- (j) There can be no mechanical or electronic device may be used to stop the chemical reaction or to stop the car.

If in doubt whether your idea is legal, consult the national coordinator Matt Hardin ([math@mech.uwa.edu.au](mailto:math@mech.uwa.edu.au)) – Division 1 or Peter Ashman ([peter.ashman@adelaide.edu.au](mailto:peter.ashman@adelaide.edu.au)) – Division 2.

#### **4: Prizes**

Winners of the Grand Final competition at CHEMECA will be recognised with the following prizes for each Division:

Poster Competition

1st 2nd and 3rd Places: Certificates

Performance Competition

1st Place: Trophy and certificates

2nd Place: Certificates

3rd Place: Certificates

#### **5. DESIGN TIPS**

Many cars in recent competitions have failed because of poor mechanical design.

So take particular care to:

- (a) Ensure that your car will travel in a straight line.
- (b) Ensure that your car is able to travel on different surfaces. We cannot guarantee that the surface for the Grand Final Competition is as level or as smooth as the one you used for the Department Competition or your test work.

#### **6. WHERE TO FROM HERE?**

##### **Division 1 (University Teams):**

(a) To enter the competition, make up a team and contact your Department Competition Coordinator.

(b) Before proceeding with any practical trials, each team must receive the go-ahead in writing from your Department Competition Coordinator.

(c) To obtain the go-ahead, each team must submit to the Department Competition Coordinator a written description of the concept for the car. This must include a risk assessment (see Safety section below) and details of chemicals to be used and their associated hazards.

## **Division 2 (High School Teams):**

(a) To enter the competition, contact your Science teacher or School Principal to register your school's interest with the local organiser, Peter Ashman (peter.ashman@adelaide.edu.au).

(b) Before proceeding with any practical trials, each team must receive the go-ahead in writing from your teacher or School Principal.

(c) To obtain the go-ahead, each team must submit to their teacher or School Principal a written description of the concept for the car. This must include a risk assessment (see Safety section below) and details of chemicals to be used and their associated hazards.

## **7. SAFETY**

Before commencing any practical trials, each team must receive the written approval to proceed from their Department Competition Coordinator or your School Teacher and/or Principal. The approval to proceed will be given in response to submission of a satisfactory and thorough written risk assessment. The risk assessment will have two components: (a) the handling and disposal of the chemicals involved and (b) the car design. The risk assessment must demonstrate how the risks involved in handling chemicals and in operating the car have been minimized to a low level through appropriate design features and operating and handling procedures.

The component of the risk assessment on the handling and disposal of the chemicals will include safe work instructions, which ensure that the risks involved are minimized. These instructions must include details of how the chemicals used, together with any reaction products, are safely disposed of.

As an example of the component of the risk assessment on the car design, in the case of a design where a gas is generated under pressure, the assessment would involve calculating the maximum pressure to be achieved in the vessel under normal operation, demonstrating by calculation that the vessel and associated piping is of sufficient strength to contain the pressure, identification of possible abnormal operation scenarios leading to overpressure and selection of a suitable relief valve to vent pressure.

School students participating in Division 2 should work closely with their School Teacher and the Division 2 Coordinator – Peter Ashman – to ensure that their car is safe.

## **8. DEPARTMENT COMPETITION DATE (Division 1 only):**

Your Department Competition should take place towards the end of semester one or in early semester two. The exact date will be announced by your Department Chem-E-Car Competition Coordinator.






To enter your Department competition, speak to your Department Chem-E-Car Competition Coordinator. Your Department Chem-E-Car Competition will generate a winning team to go forward to the Grand Final at CHEMECA in September. Competition

Coordinator, Matt Hardin will contact Department Coordinators in late July or early August to get details of each Department's entry and request safety assessments.

### **9. STUMPED FOR IDEAS?**

The Chem-E-Car Competition was run in 2001 for the first time in Australia, with the final held in Melbourne at the 6th World Congress of Chemical Engineering, September 2001. A few details of those cars that ran in the final may be found below together with details of cars from later competitions:

**Details of the cars in the Chem-E-Car Competition held in Melbourne at the 6th World Congress of Chemical Engineering, September 2001.**

Team	Chem-E-Car system
<p><b>National University of Singapore</b></p> 	<p><b>Reaction:</b> Catalytic decomposition of hydrogen peroxide, producing oxygen stored under pressure in reactor.</p> <p><b>Propulsion:</b> Gas generated is discharged through a valve at the rear of the car.</p> <p><b>Stopping:</b> Once the gas is discharged, the car stops due to natural friction in the wheels.</p> <p><b>Note:</b> This kind of "rocket" is now not allowed.</p>
<p><b>Sydney University</b></p> 	<p><b>Reaction:</b> Electrochemical cell (sulphuric acid and potassium dichromate solution with zinc electrodes).</p> <p><b>Propulsion:</b> Driven by an electric motor which was powered by the electrochemical cell.</p> <p><b>Stopping:</b> Depletion of reactants.</p>
<p><b>UNSW</b></p> 	<p><b>Reaction:</b> Electrochemical cell (zinc sulphate and copper sulphate solutions with zinc and copper electrodes.).</p> <p><b>Propulsion:</b> Powered by a 1.5-3V electric motor, running from the cell.</p> <p><b>Stopping:</b> Weight activated switch using subliming solid CO<sub>2</sub>.</p> <p>Strictly, this car is NOT legal because it uses a physical process rather than a chemical process to control the distance travelled.</p>
<p><b>Newcastle University Team One</b></p> 	<p><b>Reaction:</b> Electrochemical cell (zinc/copper copper sulphate battery, using 1M copper sulphate solution and 1M sulphuric acid.).</p> <p><b>Propulsion:</b> Driven by an 3.5 V, 1A electric motor which was powered by the electrochemical cell.</p> <p><b>Stopping:</b> Depletion of reactants.</p>
<p><b>Newcastle University Team Two</b></p> 	<p><b>Reaction:</b> Electrochemical cell (battery of four cells each producing 1.45V. The cell used was alkaline, very similar in chemistry to commercial batteries).</p> <p><b>Propulsion:</b> Driven by an 3V electric motor via a 6 speed gearbox, which was powered by the electrochemical cell.</p> <p><b>Stopping:</b> Children's sparkler used as a timing device, burning through a fusible circuit link.</p> <p><b>Note:</b> The sparkler is now not allowed.</p>

**Other clever ideas.....**

**Adelaide 2002 – Chemical reaction generating a gas under pressure.** Pressure released via an oscillating piston and cylinder driving a flywheel which became the driving wheel of the car. The pressure vessel, oscillating piston and cylinder and flywheel were “stolen” from a toy steam engine. Stopping control – depletion of reagents.

**Nagoya 2002 - Chemical reaction generating a gas under pressure.** Pressure released via a plastic piston engine driving a propeller, which pushed the car along. Stopping control – depletion of reagents.

**Monash 2003 – Power supply: homemade dry cells driving an electric motor.** In the circuit was a cell with platinum electrodes. One of the electrodes was previously plated with copper from solution. During running the copper goes back into solution. Once all the copper has been unplated, the resistance jumps up and the current to the motor drops to a level where the motor stops. Stopping control – quantity of copper plated on to the platinum electrode.

**Adelaide 2003 – Petrol engine driving a propeller which pulls the car along.** Stopping control – the quantity of air available for combustion was controlled by attaching a plastic bag to the engine air inlet. The bag was inflated to the required degree before each run.