A Chemical Engineering Competition for Middle and High School Students

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There are engineering competitions hosted around the country by groups of engineering societies, but these competitions rarely include a chemical engineering event. This lack is a missed chance at interesting students in careers in chemical engineering. The authors have developed and implemented a chemical engineering competition for middle and high school students. This contest is inspired by the chemical stop switches used by many teams in AIChE's Chem-E-Car Competition.

The Chemical Switch Competition was introduced at the Tulsa Engineering Challenge (TECh) [1] this spring. The goal of the competition is to use a chemical reaction to break an electrical circuit 20 seconds after setup. Breaking the circuit before 20 seconds disqualifies the run. Entries that don't break the circuit within 5 minutes are given a second chance, and ties are broken by the judges determining which team had the most fun during the competition. Prizes this year were $50, $30, and $20 for 1st, 2nd, and 3rd places, respectively, with middle school and high school students competing in separate divisions. Prizes in TECh are split 50/50 between the students and their classroom. The Tulsa local section of AIChE provided the prize money. These prizes are slightly lower than the prizes in the other competitions at TECh and probably should be raised for the next year. The students may compete either individually or as a team, with no upper limit on the size of the team.

The test circuit was designed and built by two electrical engineering students as a project for one of their classes. Their circuit diagram is given in Figure 1, and a picture of the unit is given in Figure 2. The test circuit has an on/off switch and a green LED that indicates that the unit is on. Students attach their equipment to the circuit with alligator clips. The test circuit contains a blue LED that is on when the circuit through the contest entry is complete and is off when the circuit is broken, providing a visual cue to stop timing. Power for the LEDs is provided by a 9-volt battery. The materials for this test circuit can be purchased for less than $25.

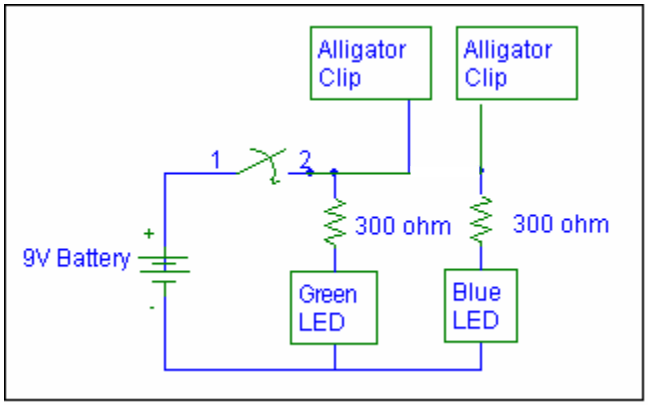

Figure 1. Circuit diagram of the testing unit.

Safety is an important consideration with this type of project. The contest rules included the following restrictions and instructions for safety:

- The design must operate safely indoors: Open flames, smoke, and sprays are not allowed.
- Dilutions must be done before bringing chemicals to the site, since we had no fume hood available.
- Entrants must arrange for safe disposal of waste chemicals, although we did provide for collection and disposal of waste acids.
- The entry must leave no residue on the table or surrounding area.

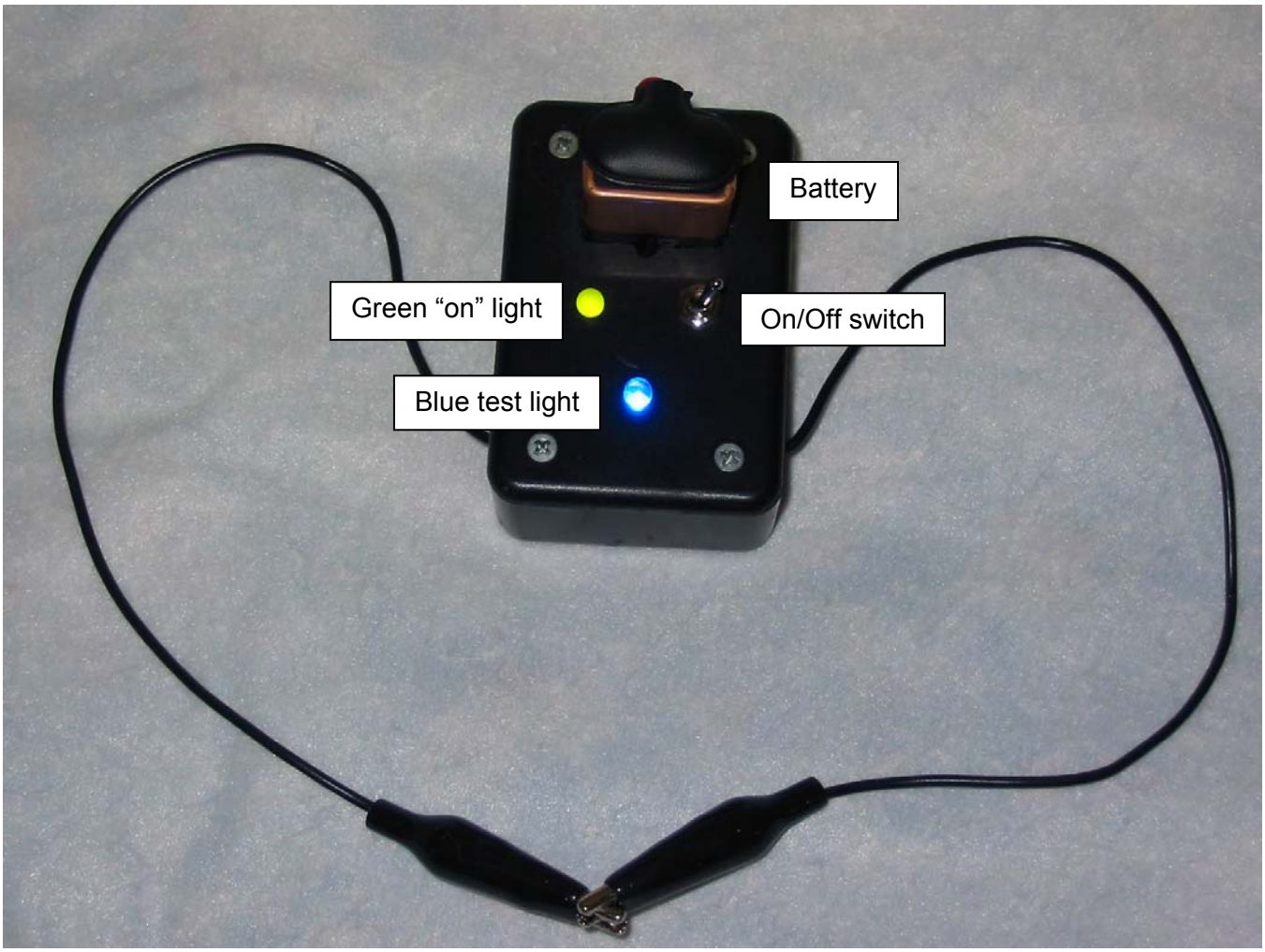

Figure 2. Picture of the light that the students must turn off and its electrical connections

- The light bulb may not be turned off by destroying it.
- The entry must fit on a table 2’ by 6’.
- Students may bring no more than 250 mL of each chemical, which must be transported safely to the competition site.
- Chemical containers must be properly labeled with the name of the chemical, the concentration, the student’s name, the school name, the teacher’s name, and a phone number.
- Chemicals must be brought to the competition table immediately upon arrival and stored there until the team leaves.
- Appropriate gloves and safety goggles must be worn during the setup, operation, and takedown of the entry.

The judges have the final decision on whether the safety precautions have been followed. Designs that are deemed unsafe are disqualified from the competition.

The students are required to submit Design Documentation, as shown in Figure 3, with their entry. The design documentation is partly for the judges to assess the safety of the design but also for the team to let the judges know when to start timing.

2005 TULSA ENGINEERING CHALLENGE
DESIGN DOCUMENTATION

CHEMICAL SWITCH COMPETITION

PLEASE TYPE OR PRINT CLEARLY AND LEGIBLY

Name of school: _____

School address, city, zip: _____
_____

Sponsoring teacher: _____

Phone number: _____

Name(s) of entrant(s):(1) _____

(2) _____

Chemicals used (name, concentration, and amounts)

_____
_____

Chemical switch mechanism: describe how the chemicals above are used to turn off the light bulb:

_____
_____

Timing start point: The competition officials will start timing your entry at this designated point. This should be something like when you have shaken up your chemicals and set the entry down to react, or when you drop a wire into an acid bath, or start dripping a second reactant into the first.

_____
_____

Figure 3. Design Documentation to be submitted with each entry.

Because rules for the entire Engineering Challenge were late this year, and the Chemical Switch Competition rules were later than the rest, only one team competed [2]. To generate interest for future competitions, we brought chemicals for students to try on-site. The students had two choices of mechanisms. The first was to dip a wire completing the circuit into an acid, which will eat through the wire to break the circuit. The second was to use a gas-generating reaction to inflate a balloon, which will move a wire to break the circuit. After the students chose a mechanism, they chose their chemicals. We brought sulfuric, hydrochloric, and acetic acids in concentrations of 1 – 6 M. Copper, zinc, magnesium, and aluminum strips or wires were available, as well as magnesium and zinc turnings and baking soda. We provided gloves and safety glasses for the students, and they were allowed to do at least some

of the pouring and assembly. Many students tried the reactions throughout the day, but not very many turned the circuit off after about 20 seconds. We intentionally supplied reaction combinations that would not work and let the students try them. Then we could talk with them about reaction kinetics and how they would go about choosing a better reaction.

This competition is a simple way for students who are being introduced to chemistry to extend those lessons to engineering. It requires the students to develop a way of using a chemical reaction to break a circuit, to choose an appropriate chemical reaction, and time the reaction's functioning. Very few engineering fairs include these chemical aspects in their competitions, and it is hoped that other locales will introduce this or a similar competition to their engineering fairs. Visit www.tulsaengineer.org for information on the Tulsa Engineering Challenge and the 2005 rules for the Chemical Switch Competition.

Acknowledgements: Chris Carpenter and Justin Smalling are the University of Tulsa electrical engineering majors who designed and built the test circuit.

Web References:

[1] Tulsa Engineering Challenge: www.tulsaengineer.org
[2] University of Tulsa Department of Chemical Engineering news article: www.ce.utulsa.edu/PhotoAlbum/TulsaEngineeringChallenge/TulsaEngineeringChallenge.htm