Safety Rules

Chem-E-Car

*some parts of this document are adapted from https://www.aiche.org/chem-e-car-competitionr-rules

1. DISALLOWED VEHICLES

Vehicles exhibiting any of the characteristics/observances described herein will result in its disqualification from the competition.

1.1 Flame/Smoke/Noise

1.1.1 **Any form of open flame and smoke emission are not allowed** in all of the cars' design and operation. Internal flames are also not allowed except in a commercial internal combustion engine, which uses an alternative fuel synthesized by the students.

1.1.2 **Visible smoke production is not allowed during the run**. Refer to the gas containment rules.

1.1.3 **Noise levels coming from the internal combustion engines must be kept below 90db** (as measured from a distance of 1meter).

1.1.4 The use of an internal combustion engine must show a significant student design component that can be demonstrated.

1.1.5 The team must be able to demonstrate and practice safety practice for the maintenance and operation of their engines.

1.2 Liquid/Vapor/Odor Discharge

1.2.1 **Any form of liquid discharge is not allowed.**

Liquid byproducts from reactions must be properly collected and contained within the vehicle, and then disposed properly (e.g. using of scrubber/holding tank).

1.2.2 **Any form of obnoxious odor and gas discharge are not allowed.**

A small amount of hydrogen discharge may be permitted as long as it is below the LFL/LEL of hydrogen for the given volume of the reactor, chamber or fuel cell in which the hydrogen is stored. The students should be able to perform calculations as part of the Engineering Documentation Package (EDP) to prove to the reviewers than any discharged hydrogen is below the LFL/LEL.

1.2.3 **Release of pressurized gas greater than 1 psig is not allowed.**

Pressure relief devices are required for protection purposes. However, functioning of a PRV during a run for any reason (accidental, incorrect setting, or as intended to protect the build-up of pressure) will result in disqualification.

1.2.4 **Unpressurized and untreated gas as a reaction byproduct are allowed to be discharged without filtration for gases containing an NFPA rating of 3 or less.**

For example, water vapor and CO_2 can be discharged whereas H_2S cannot.

Gas discharges from an ICE can be permitted only if the exhaust has been filtered properly using a catalytic converter or other filter media to remove hazardous material with an NFPA rating above 3 including soot, obnoxious odor and smoke.

1.2.5 **Onsite safety personnel will evaluate any gas discharged by a vehicle and will call for disqualification should the discharge be deemed improper.**

Disqualification due to excessive gas production will also be at the discretion of the observing safety committee. The ruling cannot be challenged.

1.3 Open and/or Improperly Secured Containers

1.3.1 **Chemicals with and NFPA rating of 2 or higher must be carried inside a container with a lid securely attached to the vehicle.**

Both the container and lid must be securely attached to the vehicle and must be capable of preventing any spillage during any phase of the competition. The team should take into consideration any form of accidents such as tipping over of the vehicle.

1.3.2 Open containers and pouring of chemicals with NFPA rating of 2 or more are not allowed at the starting line.

Mixing of chemicals may be done by using a small holding tank with a valve or a syringe provided on the vehicle. The chemical is added by either pushing on the syringe or by gravity flow through the valve.

1.3.3 Syringes are not allowed to be detached at the starting line.

If syringes are used to start the reaction, it must be securely fixed on to the vehicle and properly covered when carried to the starting line. Carrying of a detached syringe containing chemicals will be prohibited.

1.3.4 Labels must be properly written on all containers including syringes, packets, etc. that are brought to the starting line.

1.4 No Highly Reactive/Unstable Chemicals

1.4.1 Chemicals with an NFPA reactivity/instability rating of 4 are not allowed.

This applies to any chemical involved whether it is raw material, intermediate or product. 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" which 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.

1.4.2 Liquid Hydrogen peroxide with concentrations greater than 30% are not allowed.

Liquid hydrogen peroxide is very unstable and difficult to handle at concentrations greater than 30%.

2. PRESSURE RELATED RESTRICTIONS

Pressurized vessels and vehicle components are a significant explosion hazard because of the substantial energy contained in the pressure. For this reason, student teams must be able to demonstrate using appropriate pressure measurements that their normal operating pressures do not exceed equipment specifications. Teams cannot operate under the presumptions that their pressures are low. Appropriate documentation must be presented during the poster presentation for the safety auditors to examine. The student team must also demonstrate that the proper safety systems have been installed to prevent explosion.

The restrictions herein will apply to vehicles operating under pressure.

2.1 Maximum Operating Pressure

Maximum operating pressure is the highest allowable pressure within the vessel during normal operation. This can be estimated from the stoichiometry for initial design purposes; however, actual pressure measurements must still be carried out when the car is operated.

For example, a car operating with its heaviest load (500g water) and longest distance (50meters) can develop more than 200 psig (13.8barg) for a proposed reaction assuming the reaction is complete.

The maximum operating pressures must always be below the MAWP if the MAWP is known for the vessel. As a general principle, the maximum operating pressure should not exceed 90% of the MAWP. **Vehicles are not allowed to have a pressure greater than 500psig (34.5barg).**

2.2 Pressure Requirements

The following are requirements for vehicles that have pressures greater than 1psig (0.068barg).

2.2.1 All vessels and equipment must have pressure gauges

The pressure gauge must read from 0psig to 2 times the maximum operating pressure.

2.2.2 All vehicles must have an industry standard relief valve (Emergency Relief Device)

The relief valve must be appropriately sized and should be set at no more than 1.1 times the maximum operating pressure (not the MAWP).

Using the car from **2.1** as an example, the set pressure of the relief valve (the point when the relied valve begins to open) is a maximum of 220 psig (15.2barg).

The valve must be tested and evidence must be presented 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 The emergency relief device must be placed in a proper location.

For vessels, the relief valve must be at the top without any valves in 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.

Teams must take careful consideration of any entrained liquids or solids that might carry over from the vessel, which can prevent proper relief function.

2.2.4 PVC, cPVC and polyethylene terephthalate (PETE or PET) vessels are not allowed to be used for pressurized gases.

Microscopic defects from these type of plastics can result in hoop stress failure.

3. CHEMICAL CONTAINMENT HAZARDS

Proper measures and protocols must be practiced when handling of chemicals while preparing the vehicles to avoid human exposure. This applies to all chemicals including solvents, diluents, reactants, intermediate reaction species or products during operation with an NFPA toxic hazard rating of 2 or more. If these chemicals are present on the vehicle, then it must be under double containment to prevent spillage and human exposure. See Appendix B on Chemical Handling and Disposal.

3.1 Chemical Containment on Vehicle

3.1.1 The primary containment must be adequate to prevent any spillage of chemicals.

The containment must be able to prevent any leakage during normal transport and operation with considerations for accidents such as tip overs and collisions. The lid must be stout enough to provide only minimal release should the emergency conditions occur.

All lids must be securely attached to its corresponding containers and must cover the entire opening of the container.

Insure that any holes in the lid or container are just big enough to accommodate the "through hole item" — seal if possible.

3.1.2 Saran™ wrap, Parafilm™, aluminum foil and other similar materials are not considered adequate container covers.

3.1.3 The secondary containment must have a suitable size and durability to catch and hold any spilled chemicals on the vehicle.

3.1.4 Flammable and reactive chemicals must be contained.

3.2 Temperature Hazards

3.2.1 Insulation must be placed on exposed surfaces that can be hot or cold.

All exposed surfaces on the vehicle that is above 150°F (65.5°C) or below 32°F (0°C) must be insulated to avoid human skin contact.

3.3 Electrical Hazards

3.3.1 All wiring and exposed electrical components must be electrically insulated.

Any possibility of electrical shock or ignition of any component of the vehicle must be mitigated by proper insulation.

3.3.2 Alligator clips and twisted wires are not allowed.

Alligator clips and twisted wires can be an ignition source for flammable vapors and liquids. Safer and more robust electrical connectors such as banana plugs or binding posts must be used.

3.4 Mechanical Hazards

3.4.1 Any moving parts and pinch points must have guards.

Guards must be placed on parts that may present a pinch point which include gears, belts, linkages, actuator arms, etc.

3.5 Oxygen Hazards

Gases that are rich in oxygen are potential explosion hazard. The oxygen present in these gases may violently react with any combustible material such as hydrocarbon gas or liquid residue, paper, filters, valve packing or seat, regulator components and O-rings. In addition, small metals particles, which are always, present in metal components, can be accelerated during gas flow that can collide with a surface and provide 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 are requirements for oxygen service.

3.5.1 All components in oxygen service must have a rating for oxygen service from the manufacturer.

These components include vessels, piping, filters, regulators and valves. Metallic components are preferred over nonmetallic components to mitigate susceptibility to oxygen ignition.

3.5.2 All equipment must be cleaned thoroughly before being placed in oxygen service.

Effective cleaning will ensure the removal of particles, films, greases, oils and other unwanted matter. In addition, cleaning will prevent loose scale, rust, dirt, mill scale, weld splatter and weld flux deposited on moving and stationary parts from interfering with the component function and clogging flow passages. Cleaning will also reduce the concentration of finely divided contaminants that are easier to ignite than its bulk material.

All individual components must be disassembled during oxygen system cleaning. Appropriate cleaning solutions must be used depending on what material is being 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.

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3.5.3 Equipment that have been previously used for another service are not allowed.

Hydrocarbon liquid or gas residue from the previous service may contaminate the components. Gas regulators used for hydrocarbon gas service are very likely to explode when placed into oxygen service.

3.6 Biohazards

3.6.1 The use of any biological organisms are limited to biological hazard level 1 (also called biosafety level 1).

Bacterial, fungal, viral or yeast organisms used in any phase of the design, development, operation, competition and preparation of the Chem-E-Car must not go beyond biological hazard level 1.