Calendar Year 2026 Competition Official Rules (inclusive of Student Regional Conference and Annual Conference)

<table>
<tr><th></th><th>Date</th><th>Checklist of Important Deadlines</th></tr>
<tr><td>□</td><td>August 1st – October 31st, 2025</td><td>Learn about the Annual Student Conference at www.aiche.org/asc

Review Chem-E-Car Competition Rules, EDP Document & Safety Training information at https://www.aiche.org/students/chem-e-car-competition/chem-e-car-competition-rules

Submit questions at www.aiche.org/chemecarquestions. For questions about rules, be sure to select that your question is about either the Competition Rules or Safety Rules on the form.</td></tr>
<tr><td>□</td><td>February 21th – August 1st</td><td>All teams are required to complete and submit an Engineering Documentation Package (EDP) 5 weeks before competition date.

Teams will receive EDP Review Feedback on the safety aspects of their design so they can prepare for the On-Site Safety Inspection.

Submission links and deadlines can be found in the table below.
<table>
<tr><th>Region</th><th>EDP Submission Link & Deadline</th><th>Conference Dates</th></tr>
<tr><td>North Central</td><td>February 21st</td><td>March 27-28, 2026</td></tr>
<tr><td>Southwest</td><td>February 21st</td><td>March 27-28, 2026</td></tr>
<tr><td>Mid-Atlantic</td><td>February 21st</td><td>March 28-29, 2026</td></tr>
<tr><td>Southern</td><td>February 28th</td><td>April 3-4, 2026</td></tr>
<tr><td>Mid-America</td><td>March 6th</td><td>April 10-11, 2026</td></tr>
<tr><td>Rocky Mountain</td><td>March 6th</td><td>April 10-11, 2026</td></tr>
<tr><td>Pacific Northwest</td><td>March 6th</td><td>April 10-12, 2026</td></tr>
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		Eckhardt Northeast	March 13th	April 17-April 18, 2026
		Western	March 20th	April 25-26, 2026
		Latin America - Procesa	April 8th	May 13-16, 2026 *(tentative)*
		India	TBD	TBD
		Brazil	TBD	TBD
		Indonesia	TBD	TBD
		Saudi Arabia	TBD	TBD
☐	**Competition Weekend**	Bring all items to On Site Safety Inspection & Competition • Poster • Printed EDP, EDP Supplement and MOC Form in binder/folder • Printed EDP Review Feedback • Printed Waste Tags to use at competition • Chem-E-Car • PPE for all team members • Portable personal electronic device covers		

Summary of Changes

January Changes to Competition Rules

a. New award added for Annual Student Conference competition

January Changes to Safety Rules

a. Maximum allowable concentration of acetic acid reduced from 60% to 50% (19.)
b. Pressure definitions and limits clarified by tying MAWP to the weakest system component at a specified temperature (21.1.1) and capping MOP at 200 psig at any temperature (21.1.2)
c. Restrictions clarified for 26. No Plastic in Pressure Service
d. The use of PVC rigid pipe under pressure is explicitly banned (26.1)
e. **The Chem-E-Car Committee would like to provide advance notice that in the January 2027 rule set, lead-based batteries will no longer be permitted (17. Disallowed Chemicals)**

January Changes to Appendices

a. Appendix A (3) – requires vessels with unknown MAWP to have their MAWP certified by a commercial firm, eliminating option for teams to self-certify

January Changes to EDP Template

a. (a) Pressure section of Hazard checklist updated to align with changes to rules regarding pressure, including requirement of all car components to operate at a MAWP greater than the MOP and requirement that Plastic tubing in pressure service have manufacture documentation for actual pressure service

Chem-E-Car Competition Overview

The objectives of the AIChE Chem-E-Car Competition:

- 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 demonstrate the ability to safely control a chemical reaction by changing the amount or concentration of a chemical species (reactant, catalyst, or other species that has a direct relation to the control of a chemical reaction);
- To design and construct a car that is powered with a chemical energy source that will travel 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 regional conferences and the second is held at the Annual Student Conference at the site of the AIChE Annual Student Conference.

No chemical or mechanical work should be completed on your car until an initial safety review has been conducted by your Chem-E-Car Advisor or outside expert. The Safety Training Course & Quiz training should also be completed before you begin work.

Please note that the Regional Competitions and Annual Competitions are separate competitions. Passing the safety inspection at the Regional Chem-E-Car Competition does not guarantee that your team will pass the safety inspection at the Annual Student Conference Chem-E-Car Competition. Additionally, you will not have access to the same resources at the Annual Competition that you might have at the Regional competitions and vice versa. Fume hoods and air compressors will not be available at the Annual Competition. If you have any questions about what will be available to you at Annual, please reach out to the Chem-E-Car Committee via the Questions Form.

All Chem-E-Car Teams must be from active Student Chapters that submitted a Student Chapter Annual Report online to AIChE. Visit www.aiche.org/studentchapterannualreport to submit a report.

There is a poster session, safety inspection and a performance session at each competition, as detailed below.

During the competition, each team will be asked to introduce its entry to the audience, giving the school name and briefly discussing the propulsion and stopping mechanisms. Teams will also have the opportunity to submit a video showcasing their team at the Annual Student Conference competition.

Regional Conference Competition

- Schools may be limited to one entry per University, at the discretion of the Regional Conference Host Chapter and Regional Safety Coordinator

- The official rules listed apply for the regional conference competition and the Annual Student Conference Competition.
- An AIChE-appointed safety and rules coordinator will attend each regional competition. This coordinator is the final authority regarding Chem-E-Car Competition® rules, safety concerns, violations, disqualifications, and the like, for that Regional Competition only.
- The coordinator's judgment applies only to the regional competition and is not binding on judgments at the competition at the Annual Student Conference.

Regional Conference Awards

Sponsored by 

- **Performance Competition:** 1st place: $200 & 2nd place: $100
- **Poster Competition:** 1st – 3rd Place: Certificates

Annual Student Conference Competition

The top teams from Regional Chem-E-Car Competitions will be awarded the opportunity to compete at the global competition taking place at a future AIChE Annual Student Conference in the United States. This is the only way to earn an invitation to this global event.

North America Regionals

- Mid-America: Top 3
- Mid-Atlantic: Top 5
- North Central: Top 5
- Northeast: Top 3
- Pacific Northwest: Top 2
- Rocky Mountain: Top 3
- Southern: Top 5
- Southwest: Top 2
- Western: Top 3

International Regionals

- Brazil Top 1
- China Top 3
- Latin America Top 1
- India Top 2
- Indonesia Top 1
- Middle East Regional Top 3

Only one entry per school, via this qualifying procedure, will be allowed at the Annual Student Conference competition no matter how many compete at regional competitions

NOTES:

- If your team participated in a regional conference but did not qualify for Annual, or if your team is located in a region that does not offer a regional conference, you may fill out the Chem-E-Car waitlist form, released annually and linked here, to be added to the waitlist sometime in July or August of each calendar year.

Annual Student Conference Competition Awards

Sponsored by  *and the* ***H. Scott Fogler Endowment Fund***

The **Annual Student Conference** Competition associated awards are:

- **The H. Scott Fogler 1st place award:** $2000 USD and a trophy
- **2nd place:** $1000 USD and a trophy
- **3rd place:** $500 USD and a trophy
- **4th & 5th place –** trophy
- **Best Use of a Biological Reaction to Power a Car** *sponsored by the Society for Biological Engineers*- $500 USD
- **SAChE Safety Award** *for the best application of the principles of chemical process safety* - trophy
- **Spirit of the Competition** *for the team displaying the most team spirit as decided by a panel of judges*- trophy
- **Most Innovative Car Design** *to be decided by judges* - trophy
- **Golden Tire Award** *for the most creative car as decided by the teams*- trophy
- **Best Video –** trophy
- **Chem-E-Car Poster Award** – 1st- 5th place- trophy
- **Outstanding Sportsmanship Award-** trophy
- **Best Team Name-** trophy
- **Chem-E-Car MathWorks Modeling and Simulation Award 2026** *for teams that excel in utilizing MathWorks tools for the design and simulation of their Chem-E-Car, sponsored by MathWorks* - trophy

Chem-E-Car Competition Poster Session & Safety Inspection Rules

1. **Poster overview:**
   - 1.1. A poster board must be displayed with the autonomous vehicle on the day of the competition. This poster should clearly describe:
     - How the car is powered by a chemical reaction
     - How it stops on a chemical reaction
     - Unique features of the car
     - Environmental and safety features in the design
     - Vehicle design description, drawings and testing results

2. **Team Members:**

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

3. **Minimum Score:**
   3.1. A team must achieve a passing score 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:

- Quality of the poster and team member presentations (50%)
- Design creativity and unique features of the vehicle and safety considerations (35%)
- Demonstration of knowledge of reactions, calibration methods by all team members, and ability by team members to answer questions posed by the judges (15%)

4. **Winners:**
   4.1. Winners of the poster competition will be announced at the end of the performance competition.

5. **Safety inspection:**
   5.1. During the poster competition, an audit team will inspect each vehicle to ensure that all of the safety requirements have been met and that the vehicle will operate without risk to the operators, contest staff and spectators.
   5.2. If the audit team deems the vehicle safe to operate, then the vehicle will be given permission to compete.
   5.3. This permission is not automatic and must be earned by adhering to the guidelines/procedures outlined below. If a car is deemed unsafe, then it will not be given permission to compete.
   5.4. The Chem-E-Car Competition Safety Judges at the competition site have the final say in regard to permission to compete, regardless of whether a car was given permission to operate at a previous Regional competition.

Chem-E-Car Competition Performance Session Rules

6. **Distance**
   6.1. Each car will be given two opportunities to traverse a specified distance.
   6.2. The required 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 ± 0.005 m.
   6.3. Teams may not make significant changes to their vehicle once the poster session has concluded, unless they have prepared, and have an approved management of change (MOC). Teams are only allowed to change the amount or concentration of one or more chemical species used in the car's chemistry.
   6.4. The distance will not change for the final round.

7. **Course Layout and Distance Measurement**
   7.1. The course will be no more than 5 meters wide in a straight line. *For regional conferences the course may be less than 5 meters wide, depending on the university track location.*
   7.2. At the Regional Competitions only 1 track will be used. At the Annual Student Conference Competitions, 2 identical tracks will be set up and run in parallel.

7.3. The car will start with its front end just touching the designated starting line, with the goal of keeping the car in bounds to a designated finish line. The performance is determined by the distance from the front-most point of the car to the finish line, whether or not the car stops before or after the finish line.
7.4. A vehicle that goes out-of-bounds on the left or right side will be *given a penalty for that run of +3 meters.*
7.5. *"Out of bounds" is defined as when any part of the car touches or crosses the boundary. If tape is used to mark the side boundary or the out-of-bounds after the finish line, the inside edge of tape is considered the course boundary (If a wall is set as track boundary then contact with the wall is out of bounds).*
7.6. If the car starts going backwards at the starting line, the score will count as 0 m traveled.
7.7. The site location may also dictate an out-of-bounds region past the finish line. Vehicles traveling across the plane of the out-of-bounds region will be disqualified for that attempt.

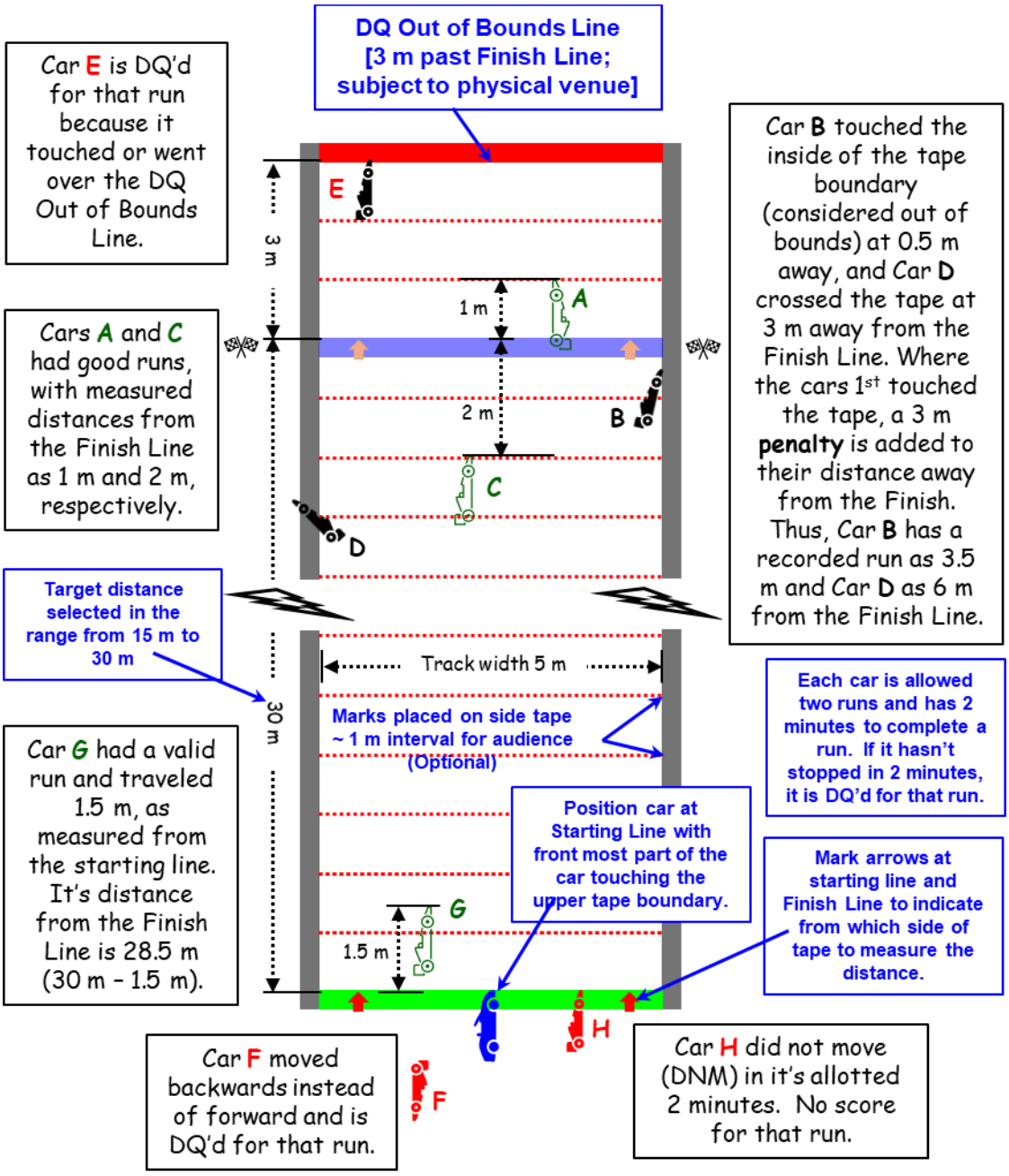

Figure 1: Performance course layout including sample scoring scenarios

8. **Race Logistics**
   - 8.1. A Chem-E-Car Competition® judge (or MC) will announce each team just prior to the start of their attempt.
   - 8.2. Each car will have two (2) attempts to complete the course. Each attempt is limited to a two (2) minute time limited for the car to start and completely stop. Any car that does not stop within the two minutes will be disqualified for that attempt.
   - 8.3. The best score of the two attempts will be used to determine the winner.

8.4. In the event that 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 immediately.
8.5. The competition order will not change between the first and second rounds. There will be a short 15 minute break between rounds of the competition.

9. **Starting Line Procedure**
   9.1. The car must start moving, traverse the distance, and come to a stop within a 2 minute time interval.
   9.2. At the starting line, 1 team member will be asked to head to the finish line. Team members are responsible for picking up their car after the distance is measured.
   9.3. Once the car is placed on the starting line and the 2 minute time interval begins, all wheels must remain on the ground. Pushing the car or picking up the car/part of the car will result in a disqualification for that attempt.

10. **Competition Order Logistics**
   10.1. The distance and run order is announced one hour before the competition starts.
   10.2. If a car is disqualified that was scheduled to start before your car, then you will move up one position in the starting order.
   10.3. Five (5) minutes before the start of the competition, the first three (3) teams for each track are called to the start. The first team for each track will be at the starting line, the second team at the ready table, and the third team prepared to move to the ready table.
   10.4. The first team is given a one-minute warning before the competition starts.
   10.5. Each team is given two (2) minutes for the car to start moving from the time they are called to the starting line.
   10.6. Cars are permitted two (2) minutes to traverse the distance and stop.
   10.7. The timing will also stop if the car travels out of bounds.
   10.8. If the car does not stop within the two-minute period, then it is disqualified from that round of the competition.
   10.9. After the car stops, its distance is measured. Once the distance measurement is completed, the next team moves from the ready table to the starting line.
   10.10. Repeat 10.5 – 10.9 for the remainder of the competition.

11. **Vehicle Drive System**
   11.1. An objective of this contest is for students to demonstrate the ability to control a chemical species (reactant, catalyst, or other species that has a direct relation to the control of a chemical reaction).
   11.2. The only energy source for the propulsion of the car is a chemical reaction.
   11.3. The distance a vehicle travels must also be controlled by a chemical reaction, based on a quantifiable change and direct control of the concentration of a chemical species.
   11.4. This chemical reactant species must be a solid, liquid, or vapor.

12. **Vehicle Design**
   12.1. 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.
   12.2. Both the chemical reaction propelling the vehicle and the start/stop reaction (if there is one) must be physically on the vehicle during the competition (i.e., pre-loading of a drive system such as a capacitor assembly is not allowed).

12.3. The vehicle must be powered by a chemical reaction and must be stopped by a quantifiable change, and direct control, of the concentration of a chemical species.

12.4. This chemical reactant species must be a solid, liquid, or vapor.

12.5. **Autonomous vehicle:** The car must be an autonomous vehicle and cannot be controlled remotely. Pushing to start the vehicle is not allowed. Any forward movement of the car at the start not related to the chemical reaction will lead to disqualification. "Bleeding" the time off at the starting line or prior to the starting line is prohibited. Raising the vehicle at the starting line to allow the wheels to begin turning is not allowed.

12.6. **On-board computer control system (ex Arduino or Raspberry Pi unit)** are allowed but must not in any way control/ measure the distance traveled. The program must be loaded onto the controller/computer/processor prior to the competition, and the settings may not be changed after the competition begins, **which is defined as the time when the distance is announced.**

12.7. Wired or wireless communication with the on-board computer/controller is not allowed once the competition begins and during the competition.

12.8. Teams may be asked to provide a copy of their complete programs to the rules committee on the competition day.

12.9. **Encoders:** Teams are also not allowed to use an encoder to regulate the velocity of the vehicle in order to control the distance.

12.10. **Voltage regulators:** Teams may not use a voltage regulator to modulate the voltage/amperage from their propulsion system reaction to their car's motor. MOSFETs, H-Bridge Motor Drivers, MOSFET triggers, transistors, Zener diodes, voltage or current limiters, rapidly changing relays (relays used as simple on-off switches with no toggling is OK), capacitors, and the like are not permitted. Any component used to step up, step down, or smooth out power (this includes voltage and/or current) from your battery to your motor is considered a "voltage regulator" under this rule.

12.10.1. This change was intentional. Not to remove batteries, but to stimulate creativity. The goal of the competition from when it was conceived by Dr. Fogler was for the chemistry to control the distance the car travels, not the electronics, Arduinos, or microprocessors.

12.10.2. You may measure voltage and/or current and fully cut power in order to protect equipment from over energization. The power may not be toggled back on after it has been cut.

12.11. **No Mechanical brakes:** No mechanical force can be applied to the wheel, gears, driveshaft, etc., or ground to slow or stop the car (e.g. no brakes).

12.12. **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 (such as 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. This would be considered a mechanical timing device and would not be allowed.*

12.13. **ICE:** Internal combustion engines using an alternative fuel (e.g., biodiesel, ethanol, etc.) are allowed. The fuel MUST be completely synthesized by the students (no additive blending is allowed). *Succinct safety procedures for the maintenance and operation of this engine must be demonstrated by the team, with considerations to indoor operation. Internal combustion engines are not allowed to emit visible combustion smoke to the competition space and are subject to sound restrictions. See the Safety Rules for a more complete discussion.*

12.14. **Thermo-Electric Device (Power system):** Thermo-electric thermopiles purchased from a manufacturer must be run with at least one side (hot or cold) controlled by a chemical

reaction. *NOTE: Phase changes (including melting and crystallization), mixing and dissolutions are not considered a chemical reaction.*

12.15. **Fuel Cells:** 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. Any team that purchases a commercial fuel cell or builds their own fuel cell must synthesize the fuel that is used; example, if the team purchases a commercial methanol fuel cell, they must synthesize the methanol and provide verification of their procedure. Hydrogen for fuel cells MUST be generated by a chemical reaction on site or on the vehicle and not from a commercial device or pre-loaded canister. Appropriate process safety must be followed during fuel synthesis. The synthesis procedure must be clearly defined in the EDP.

12.15.1. Fuel cells with an internal voltage regulator are not permitted (see rule 12.10)

12.16. **Commercial batteries:** No commercial batteries of any kind (for example, AA batteries) are allowed as the power source used to move the car. Commercial batteries are allowed for specialized instrumentation (e.g. detectors, sensors, valves, mixing, pumps).

13. **Size of Car**

13.1. All components of the car must fit into a box of dimensions no larger than 40 cm x 30 cm x 20 cm. The car may be disassembled to meet this requirement.

13.2. 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.

14. **Capital Cost of Vehicle:**

14.1. The cost of the all vehicle components and the chemicals must not exceed $3500 USD. *The vehicle cost includes the donated cost of any equipment.*

14.2. 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.

14.3. The cost of pressure testing is also not included in the capital cost of the car.

14.4. 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.

14.5. Teams are required to include their vehicle's capital cost in their EDP.

15. **Changes to Car Design from Previous Years**

15.1 If a team competes at the AIChE Annual Student Conference Chem-E-Car Competition (for example, in 2025), the team must make substantial changes to both the propulsion system and stopping mechanism the following calendar year (i.e., in 2026).

15.2 Whether a change is sufficiently "substantial" will be up to the discretion of the Chem-E-Car Committee. For example, changing the acid in a sodium-bicarb and acid reaction will not be considered a "substantial change".

15.3 Structural improvements to the car chassis or reaction chambers are encouraged whenever necessary but will not be considered a significant enough change without a change to the propulsion system and stopping mechanism chemistry

16. **Team Member Status and Conduct**

16.1. All team members present must be active AIChE members and must be registered for the Student Regional Conference or Annual Student Conference where the competition is

taking place.

16.2. Faculty and graduate students can only act as sounding boards to student queries. The faculty cannot be idea generators for the project.

16.3. 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.

16.4. All questions posed by rules and safety judges at the safety inspection and poster session must be answered by the undergraduate student team members. The ability to explain car design, operation, safety and/or rules compliance is the responsibility of the undergraduate students.

16.5. 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 in the EDP.

16.6. During the performance competition session, only five (5) team members are allowed in the pit area at once. Team members can be swapped out during the competition.

16.7. All team members and the faculty advisor MUST have completed the required safety training course, which is available at www.aiche.org/chemecar. All participating students must retake the course annually.

16.8. All student chapter teams that are competing in the Chem-E-Car Competition must have submitted a Student Chapter Annual Report online to AIChE. *Note: New AIChE Student Chapter established after January 1, are exempt from this requirement.*

17. **Winning Team and Awards**

17.1. The winning team is the car that stops closest to the competition distance. This is defined as the absolute value of the distance between the front-most part of the car and the finish line, whether or not the car stops before or after the finish line.

17.2. In case of ties, the team with the best average from the two attempts may be declared the winner.

17.3. Winners of the Chem-E-Car Performance Competition will be known immediately following the performance competition.

18. **Onsite Safety Judges and Rules Coordinators:** If there is any uncertainty on an issue of safety or other judging criteria, please contact the Chem-E-Car Committee. The decisions of the onsite rules and safety judges are final.

Calendar Year 2025 Competition Safety Rules

Chem-E-Car Safety Program Overview

The objectives of the AIChE Chem-E-Car Competition Safety Program are to ensure the safe preparation and operation of vehicles during all phases of the competition, including construction, testing and the competition. An audit of your system design and safety compliance will be conducted from the documentation your team provides.

The safety audit of your vehicle will occur in two stages:

- Online audit where teams will submit a fully completed Engineering Documentation Package (EDP) electronically and receive feedback. A member of AICHE staff will communicate EDP instructions to all teams. Failure to meet the posted deadline and by not submitting a **fully completed** EDP will result in exclusion from the competition. The EDP template is available for download on the Chem-E-Car Competition Rules Website at https://www.aiche.org/students/chem-e-car-competition/chem-e-car-competition-rules.
- Onsite Audit on competition day where teams must bring printed EDP, EDP Supplement, EDP feedback and MOC Form in a folder or binder and be ready to answer questions from safety reviewer Failure to pass this stage of the competition will result in receiving a disqualification from the competition.

Competition Safety Rules

1. **Safety Audit: Online**
   - **1.1. EDP.** An engineering documentation package (EDP) for your Chem-E-Car must be **fully** completed and submitted by the posted deadline. Use the EDP Template found on the AIChE website (EDP Template Link). Please rename the title of the EDP Template using the format UniversityName-EDP.pdf. Example: ***OregonStateUniversity-EDP.pdf*** A complete EDP will include the following in the following order:
   - **1.1.1. Job Safety Analysis:** Includes a description of your car and how it works.
   - **1.1.2. Photos:** Pictures of your vehicle after construction has been completed. These pictures must be current. The entire car must be visible in the picture. Remove the top to expose electrical controls if necessary. Multiple detailed views of the car are required. *A drawing or AutoCAD document is NOT acceptable.*
   - **1.1.3. Safety Training and Rules Certifications Page:** This page must be signed by all team members and your faculty advisor. Judges will use this page to determine: (1) If the starting and stopping mechanisms are compliant with the rules, (2) If everyone

has completed the required safety training and (3) that you have identified the major hazards and have controlled them properly. The certification page must be signed by the date of the competition. *Note that your group must have a minimum of 10 hrs. of operating time on the car prior to the faculty member signing. Note: The time you spend building the car cannot be counted as operating time.*

1.1.4. Hazards Analysis: Complete all pages, including attaching the floor plan/diagram of the laboratory where you are building your car.

1.1.5. Chemical Information: Includes a description of the chemistry involved, and a list of chemicals to be sent to the competition if in person, or to be used at the competition, if virtual

1.1.6. Chemical Hazards and Disposal: This section requires your team to conduct chemical research related to the chemicals you handle. List the properties for every chemical. Refer directly to the SDS for this information Resources like the NIOSH pocket guidebook, CAMEO, and New Jersey Hazardous Substance Fact Sheets can be used for supplemental information as needed.

1.1.7. Standard/Safe operating procedures page: Provide step-by-step details for the safe run prep, starting line procedure, shut-down, and clean-up of your vehicle. This page should be detailed enough so that someone unfamiliar with your vehicle should be able to safely prepare solutions for and operate it.

1.1.8. Equipment Table: A complete list of every piece of equipment on the car <u>in table format</u>, including the manufacturer of each piece of equipment. *Include operating limits (max temperature and pressure) for each piece of equipment, and ensure material compatibility where pertinent. When manufacturing spec sheets are absent, students should rely on the material properties for these limits.* Include a CAD or other diagram indicating where each piece of equipment is located within the design of your car. Use the same naming scheme in the diagram as in the equipment list. If your car has electronic circuitry, include a circuit diagram indicating components according to the equipment list.

1.1.9. Pressure: For Cars with Pressure Greater than 5 psig (0.345 barg): *Please complete and add the following to your EDP document*: A quantitative design basis for pressure relieving load; Sizing calculations for a pressure relief device; and Test procedure and results for a pressure relief. *Please see Appendix A of the Safety Rules for full instructions on what is required for Pressure Testing.*

1.1.10. Hydrogen gas discharge calculations (include for any flammable component). If you are using hydrogen gas, and plan to discharge a small amount, you must provide calculations demonstrating that the discharge stream is below 1/4 the LFL when mixed with ambient air. State any assumptions you make regarding the ambient air flow rate. As an example, if the LFL is 10%, the safe discharge would be under 2.5%.

1.1.11. Management of Changes to the car: After the online EDP review, you must complete any changes suggested by the EDP Reviewer and document these changes according to the process you outline. At a minimum, this should include a Management of Change (MOC) form available through AIChE. **This MOC must be presented during the onsite safety inspection.**

1.1.12. Capital Cost of Vehicle Calculations: Referencing the competition rule surrounding Capital Cost of Vehicle, use the space to show the capital cost of your vehicle and all related calculations.

1.1.13. Team Waste Tags: Please fill out a waste tag fully describing each of your competition day waste streams, using the forms in the EDP Template. These must be completed and included with your EDP. You must print and bring enough copies to accommodate all the waste you might generate. A completely filled out waste tag will be required before any team is allowed to dispose of waste into an AIChE waste collection system. NOTE: ALL SOLID WASTE MUST BE DISASSEMBLED, MADE SAFE AND BE LIQUID FREE

1.2. EDP Supplement. Please combine the following information in another single, separate PDF and should be titled "UniversityName-EDP-Supplement.pdf". Example ***OregonStateUniversity-EDP-Supplement.pdf*** . This helps the EDP reviewers to locate both files on the AIChE website easily. If for some reason you must submit a revision please follow this example naming: ***OregonStateUniversity-EDP-Supplement-V2.pdf*****.** NOTE: the first page of your EDP Supplement should be a Table of Contents, with the headings listed below. Please create sub numbers for each SDS and Manufacturer's equipment, so that it is easy for you and reviewers to find each item.

- **1.2.1. Safety Data Sheets** (SDS) made or revised after 2012 for all chemicals used or generated by reaction.
- **1.2.2. Manufacturer's specification documents** or specifications for custom-built components. For any commercial or custom built components, students must list material and compatibility.
- **1.2.3. Safety Training Course Certificates** for each team member + advisor
- **1.2.4. Any additional information** you need to save regarding your EDP that is not contained within the original EDP document.

2. Safety Audit:

2.1. Onsite (In-person). On the day of the competition, an audit team will inspect each vehicle to ensure that all of the safety requirements have been met and that the vehicle will operate without risk to the operators, contest staff and spectators. The Safety Judges at the competition site have the final say in regard to permission to compete, regardless of whether a car was given permission to operate at a previous regional competition.

2.2. Permission to compete. If the audit team deems the vehicle safe to operate, then the vehicle will be given permission to compete. If a car is deemed unsafe, then it will not be given permission to compete therefore rendering it unfit to run during the performance competition.

3. Disallowed Chemical Handling/ Illegal Chemical Transport & Storage

3.1.1. Transport Chemicals. Teams are not allowed to transport hazardous chemicals by car to the competition site. No chemicals shall be transported in private, university or rental vehicles to or from the competition site, even over short distances.

3.1.1.1. **Household Chemicals.** Common household chemicals, in the concentration in which they are sold, such as baking soda, vinegar, etc., are exempt from this rule. To qualify as a common household chemical, the chemical must be available for purchase and pickup from a retail location such as a grocery or

hobby store. Your team assumes all liability for safely and legally transporting these household chemicals.

3.1.2. Shipping Chemicals. Chem-E-Car teams should work with their University EHS (Environmental Health and Safety – or similarly named) department to make sure everything is shipped according to all DOT Hazardous Material Shipping laws. Make sure everything is properly labeled.

3.1.2.1. All hazardous and/or regulated chemicals that are shipped to a competition site must be shipped in their original packaging with all labeling from the supplier intact and legible.

3.1.2.2. No chemicals will be shipped back to a team or their university after the competition.

3.1.3. Illegal Chemical Storage. Chemicals must not be stored in hotel rooms or other facilities not rated for chemical storage. The exception to this rule is common household items such as baking soda and salt.

3.1.4. Student Made Batteries: *No student or team may transport or ship a student made battery that contains hazardous materials within the battery casing (i.e. a premanufactured lead acid battery containing acid). Doing so is in direct violation of Rule 3.1.1 Transport of Chemicals.*

3.1.4.1. Students may transport battery components provided they are non-hazardous and have been cleaned, neutralized, and made safe from any previous use.

4. No Compressed Hydrogen Gas Cylinder Usage

4.1. Hydrogen Generation. All hydrogen used on the vehicles (for instance with fuel cells) must be generated on-site or on the vehicle keeping the pressure below 5 psig (0.345 barg). Appropriate safety precautions and safe operation must be demonstrated. (See safety rule 10 regarding the need to purge air/oxygen from systems containing hydrogen. Hydrogen generation cannot begin until chemicals are given out on competition day.

4.2. Commercial Hydrogen Storage Canisters. Filling of vessels from a compressed hydrogen gas cylinder or commercial hydrogen storage canisters (such as hydrostiks or solid–core hydrogen cartridges) will not be allowed.

5. Illegal Testing of Vehicles

5.1. Testing Location. 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. No mixing of chemicals, including common household chemicals is allowed in the hotel or in dorm hallways.

6. Disposal of Chemicals. Disposal of waste represents both significant risk and cost to the competition. Teams are expected to be knowledgeable in all of their generated waste streams. All chemicals shipped to and waste generated from the competition site must be disposed of in a safe and environmentally friendly fashion in compliance with all local, state and national regulatory measures. Please minimize chemicals shipped to the competition site in order to reduce disposal costs.

6.1. On-Site Disposal. Teams are responsible to make each of their waste streams safe for disposal in one of the following available waste streams: Acid, Base, Organic, Aqueous,

Solid Waste. All team assembled items disposed in solid waste must be separated into their individual components with a neutral pH (pH 6-8) and contained in their own water tight container with a copy of their Team Waste Tag securely attached to the container.

6.2. Team Waste Tags. Team Waste Tags must be completed ahead of the competition based on anticipated waste streams and included at the end of the teams Engineering Design Package. Team Waste Tags must accompany all discharges of waste into AIChE waste containers and include at a minimum: Description of waste, Concentration, Volume, Team name, Table number.

6.3. Illegal Disposal. Failure to follow these rules on chemical handling may result in a safety incident being attributed to your team and possible suspension from future competitions. *See 28, Accidents/Incidents*.

7. Flames/smoke/noise. All cars are restricted from having any open flames or emitting any smoke. Cars shall not have internal flames. Any team that generates any open flame or smoke in the prep area or on the track will be disqualified.

7.1.1. Internal combustion engines (ICE). The only exception to this rule is that an internal flame is allowed in a commercial internal combustion engine (ICE) that uses an alternative fuel that is synthesized by students. Cars with ICEs are not allowed to produce smoke during the attempt. Succinct safety procedures for the maintenance and operation of this engine must be demonstrated by the team. In addition, cars with an ICE must show a demonstrable and significant student design component.

7.1.2. Noise. Noise from internal combustion engines must not exceed 90 db (as measured from a distance of 1 meter).

7.1.3. Gas Discharge. Gas discharge from an ICE shall be permitted when the exhaust has been properly filtered by a catalytic converter or other filter media to remove hazardous exhaust materials with including soot, obnoxious odor, and smoke.

7.1.4. Gas Discharge from a reaction: Any byproducts with an NFPA health rating of 3 or 4 must be scrubbed or removed prior to discharge.

8. ***Lasers****: Lasers direct a focused beam of energy on a target area and depending on the type and power may cause serious bodily harm and/or fire potential. Any lasers used in the design of a car require careful design and consideration in the design's hazard analysis.*

8.1. The use of IEC Type 3B and Type 4 lasers are not permitted to be used.

8.2. The maximum power output for any lasers used, regardless of color, shall be limited to 5 milliwatts maximum.

9. Solder: You cannot use solder containing lead in the manufacture or assembly of your car. There is to be no *planned* soldering at the competition. Soldering should be reserved for repair purposes only and minimized. All planned soldering should be done with adequate ventilation (ideally in a hood) at your home institution prior to the competition.

10. Liquid/Vapor/Odor Discharge. No liquid discharge, including water, is allowed. No obnoxious odor is allowed either through discharge or during use. All liquid products of reaction should be properly collected and contained within the vehicle, and properly disposed of (example, use of a scrubber/ holding tank). Discharge should only occur during emergency relief situations to protect the equipment from rupture and/or explosion.

10.1.1. Hydrogen Discharge. An exception to the 'no gas discharge' rule is that a small amount of hydrogen discharge is allowed. Students should provide calculations in the EDP to prove to the reviewer that any discharged hydrogen stream is diluted to below 1/4 of the LFL, as discussed in Section 1.1.10 of the Safety Rules.

10.1.2. Release of Pressurized Gas. Although pressure relief devices are required as a means of protection, the release of pressurized gas during the competition (greater than 5 psig [0.345 barg]) is not allowed. If a PRV functions during the attempt for any reason that attempt will be disqualified.

10.1.3. Gas Discharge Unpressurized, untreated gas discharge as a reaction byproduct is allowed without filtration for gases containing an NFPA health rating of 0, 1, or 2. (Example - water vapor, or CO_2 are OK, H_2S and SO_2 are NOT OK). The onsite safety personnel may disqualify any entry where the gas discharged by a vehicle is deemed improper. Disqualification due to excessive gas production is at the discretion of the observing safety committee, and the ruling is final and cannot be challenged

11. Reactive Materials. Teams using any chemicals with potential air/oxygen reactivity (e.g., flammable gases) **MUST** purge the system with an appropriate inert gas before the reactive gas is introduced into the system. The volume of inert gas used to purge the system must be at least three (3) times the volume of the system. Purging may be accomplished through the use of a small inert gas canister.

12. Open and/or Improperly Secured Containers. All containers on the vehicle containing chemicals (including water) 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 of preventing escape of the chemical during any phase of the competition, including an accident involving tipping over of the vehicle.

13. No Open containers, pipetting, or chemical pouring at the Starting Line or at the ready table. No open containers or manual pouring/pipetting of chemicals is permitted at the starting line or ready table. Built-in chemical reservoirs must be filled at the team's preparation table and securely attached to the car prior to moving to the ready table and starting line. Manual or automatic valves or switches can be used at the starting line. Violations will result in that run being disqualified. the built-in chemical reservoir is still subject to containment requirements, MOC compatibility, double containment, lid, etc., if necessitated based on the chemical(s) contained. All containers on the vehicle must have a secure lid and must be properly managed to prevent spillage.

13.1. Starting Line Procedure. All chemicals must be on the car and secured in fixed containment on the vehicle **before** walking to the starting line**.** Nothing may be carried away from the start line or left at the ready table**.** If any parts fall off the car either at the starting line or in competition will result in disqualification of that attempt. All containers, packets, etc. must be properly labeled and contained.

13.2. No Manually Plunged Syringes at the Starting Line or at the ready table. Teams cannot manually plunge a syringe at the starting line or the ready table. Manually plunged syringes cannot be included in the car design. This rule change is also to

promote better and safer design. Labeled syringes or pipettes can be used at the team's preparation table, but sharp needles are not permitted.

14. **No Sharp Needles.** Sharp needles cannot be used in any capacity (including, but not limited to in the operation and preparation of the vehicle) in Regional or Annual competitions.
15. **No Tied Balloons.** No pre-tied balloons are permitted in the competition space. This is primarily related to bringing balloons into the competition space containing lighter-than-air gases for reactions or purging. Mylar balloons floating to the ceiling are banned by most all ASC venues, as they have been known to trigger fire alarms in the past.
16. **No Specially Regulated Carcinogenic Chemicals.** A number of carcinogenic chemicals are listed by OSHA as a special carcinogenic hazard. The handling of these chemicals is outside the scope of the management systems available during the competition. Such chemicals are therefore not permitted. See www.osha.gov for details. These regulated chemicals include:

1,2-Dibromo-3-chloropropane	Beta-propiolactone
1,3-Butadiene	Bis-chloromethyl ether
2-Acetylaminofluorene	Chromium (VI)
3,3'-Dichlorobenzidine	Cadmium
4,4'-Methylenedianiline	Coal tar pitch volatiles
4-Aminodiphenyl	Ethylene oxide
4-Dimethylaminoazo-benezene	Ethyleneimine
4-Nitrobiphenyl	Formaldehyde
Acrylonitrile	Inorganic arsenic
Alpha-napthylamine	Methyl chloromethyl ether
Asbestos	Methylene chloride
Benzene	Methylenedianiline
Benzidine	N-nitrosodimethylamine
Beryllium	Respirable Crystalline Silica
Beta-naphthylamine	Vinyl chloride

17. **Disallowed Chemicals.** No chemical, raw material, intermediate or product that is highly reactive or unstable will be permitted. This includes chemicals with any of the following GHS hazard classifications: explosives, flammable liquids (Category 1), flammable solids (Category 1), self-reactive chemicals (Type A or B), pyrophoric solids, pyrophoric liquids, self-heating substances, substances which in contact with water emit flammable gases, oxidizing liquids (Category 1), oxidizing solids (Category 1), organic peroxides (Type A or B), acute toxicity (Category 1), and carcinogenicity (Category 1). This also includes any chemical on the extremely hazardous substances list published by EPA.

18. **No Liquid Hydrogen Peroxide Concentrations Greater than 30%.** Liquid hydrogen peroxide is very unstable and difficult to handle at concentrations greater than 30%.
19. **Acid Concentration Limits.** The risks associated with acids increase with higher concentrations. The maximum concentration allowed of commonly used acids are listed below. For acids not listed, please use the Chem-E-Car Questions form to check if your acid in your proposed concentration(s) is allowed. In general, if a fume hood is needed to dispense your acid, it is not permitted.

Acid	Maximum Concentration
Acetic Acid	10 M (50% vol)
Hydrochloric Acid	3M (10% vol)
Sulfuric Acid	5 M (30% vol)
Nitric Acid	Not permitted

20. Carbon Compound Restrictions. Dry primarily carbon containing compounds, such as carbon black, graphite, or activated carbon, in powder form are not allowed. You may ship wetted carbon compounds to the competition site following all DOT regulations and in conjunction with your university.

21. Pressure Restrictions. Pressurized vessels and vehicle components represent a significant explosion hazard due to the substantial energy contained in the pressure. The student team must also demonstrate that the proper safety systems have been installed to prevent an explosion.

21.1.1. The maximum allowable working pressure (MAWP) is the highest pressure the weakest component of your pressurized system can handle at a specified temperature. *Note that the MAWP for the 'car system' may be less than the MAWP the manufacturer listed for the pressure vessel. For example, the manufacturer of a pressure vessel may list the MAWP as 100 psig at 25°C, but if the vessel is connected to a piping system in which the weakest component has an MAWP of 50 psig at 25°C, then the MAWP of the overall system is 50 psig at 25°C (i.e., limited by the weakest component).*

21.1.2. The maximum operating pressure (MOP) may not exceed 90% of the MAWP of the overall pressurized system. No vehicle is permitted to have an MOP greater than 200 psig (13.8 barg) at any temperature (i.e., pressure systems on cars are not permitted to operate above 200 psig under any conditions). For initial design purposes, the MOP can be estimated from stoichiometry; however, the actual pressure must be measured once the car is operational. Student teams must demonstrate through appropriate pressure measurements that the pressures during normal operations do not exceed equipment specifications.

22. Pressure Gauge. All vessels and equipment with pressures greater than 5 psig (0.345 barg) must have a pressure gauge that reads from 0 gauge pressure to 2 times the MOP.

23. Emergency Relief Devices. All vehicles with pressures greater than 5 psig (0.345 barg) must have an industry-standard relief valve set at no more than 1.1 times the MOP of the vehicle.

23.1. Relief Device Testing. This valve must be tested and evidence must be provided in the safety documentation. If using a fixed set point PRV, the manufacturer specifications must be included in the EDP document. If using adjustable set point

PRV, proof that the PRV has been tested to that set point with a faculty member signature must be included in the EDP.

23.2. Sizing Calculations. All Emergency Relief Devices must be properly sized. Emergency relief system calculations must be included in the EDP documentation and they must be reviewed and approved by your faculty advisor. In addition, the following design specifications for the emergency relief device must be clearly stated in the EDP:

- Total quantity of reacting material assumed
- Concentration of the reactant(s) and
- Initial temperature

An example of pressure relief device sizing is included in the Chem-E-Car Safety Training Course. Additionally, an online copy of Crowl and Tipler's "Sizing Pressure-Relief Devices" is available in the Resources section below and may be used as a reference for sizing pressure relief devices. ***Note the important clarification below the resource hyperlink regarding a typo in the online copy.***

23.3. 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. Consideration must also be given for any entrained liquid or solids that might carry over from the vessel and prevent proper relief function. If a pressure reduction valve (pressure regulator) reduces pressure downstream to a value **above** atmospheric pressure, ALL piping and equipment downstream of the pressure reduction valve/regulator **must** be rated for that pressure or protected by an appropriate relief valve/frangible/rupture disk.

23.4. Piping. 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.

Pressure Restrictions Example

A vehicle system has the following components.

- Reactor with MAWP = 1800 psi at 25°C
- Steel tubing with MAWP = 150 psig at 25°C

The MAWP of the Vehicle system = 150 psig at 25°C (weakest component in system)

MOP = 135 psig (90% of 150psig)

PRV maximum set point = 149 psig (1.1 x 135psig)

Appropriate pressure gauge range= 0 to 270 psig.(2 x MOP)

24. Pressure Testing. All components, including vessels, piping and fittings, valves, gauges, filters, must be certified to operate at a MAWP greater than your vehicle's MOP (and the MOP may not exceed 90% of the vehicle's MAWP). *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*

under the supervision of a faculty member. See Appendix A on Pressure Vessel Test Protocol and Procedure.

25. **Proper Management System to Prevent Over or Mis-Charging Pressure System.** Student teams must also be aware that the internal pressure in the vessel is dependent on the amount of reactant(s) charged. Students must demonstrate that proper management systems and controls are in place to ensure that the proper quantity of reactant is charged to the vehicle.

    25.1. Standard Operating Procedures. The following steps must be included in the Standard Operating Procedures of your vehicle to ensure proper charging:
    - **25.1.1.** The quantity to be charged should be agreed upon by all team members and must be supported by data obtained from operating the vehicle.
    - **25.1.2.** At least one team member should observe both the measuring and charging operation to ensure that it is done properly.
    - **25.1.3.** The car should be tagged once the charging is completed. This tag should remain until the attempt is finished.

26. **No Plastic in pressure service.** If plastics under pressure are used on the vehicle, the plastic must be certified by the manufacturer's data for the particular temperature, pressure, pressure at the operational temperature, and gas, or liquid being used in the plastic by the team. The manufacturer's data/datasheets must be available at all safety inspections to show to the inspector/EDP reviewer for verification.

    26.1. PVC rigid pipe. PVC plastic pipes, especially with glued or threaded fittings, are not allowed to be used under pressure. There are previous incidents that have occurred with this piping under pressure and thus, it is not allowed.

    26.2. Plastic tubing examples
    - **26.2.1.** A particular manufacturer-certified plastic tubing is rated to 200 psig (13.8 barg) at room temperature (25 ^{o}C) using compressed air. This tubing may not be used at a higher temperature (i.e.100 ^{o}C) unless the manufacturer has indicated that the tubing is certified to be used at 200 psig and 100^{o}C with compressed air.
    - **26.2.2.** If a plastic tubing is certified to be used for compressed air service at 100 psig and 25 ^{o}C, it may not be used with other gases; for instance CO_2, O_2, or other gases, unless the manufacturer certifies that the tubing is rated for these specific gases at these conditions.

27. **Chemical Containment**

    27.1. Primary Containment. 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.
    - **27.1.1. Lids**. All lids on containers containing chemicals must be securely attached to the container and should cover the entire container opening. Please ensure 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 for use as container covers. However, caution must be exercised to ensure no pressure build up occurs in a vessel not rated for pressure.

    27.2. Secondary Containment. Secondary Containment is required for all liquids on the car. The secondary containment on the vehicle must be of suitable durability and size to hold the contents of any spilled chemicals on the vehicle. It is not required to have a lid for the second containment however it is good practice. *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.

28. Temperature Hazards. All exposed surfaces on your vehicle with temperatures greater than 150ºF (65.5ºC) or under 32ºF (0ºC) must either be insulated or covered to prevent contact with human skin.

29. Electrical Hazards

29.1. Preventing Electrical Shock or Ignition. All wiring and exposed electrical components must be insulated or covered to prevent the possibility of electrical shock or ignition of any component of a vehicle.

29.2. No Alligator Clips. Alligator clips and twisted wires represent both an electrical shock hazard and an ignition source for flammable vapors and/or liquids and are not allowed. Use more robust electrical connectors such as banana plugs or binding posts.

29.3. Charging Batteries. The charging of student-made batteries must be done in a safe way and documented within the EDP.

30. 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.

31. Oxygen Service All components in oxygen service must be compatible with oxygen at elevated concentrations, which is defined as any atmosphere with an oxygen concentration greater than 20.9 volume percent. Reactions that generate oxygen (e.g., decomposition of hydrogen peroxide) will result in oxygen-enriched atmospheres. Components that must be compatible in oxygen service include vessels, piping, filters, regulators, valves, and electronic components. Metallic components are preferred because nonmetals are more susceptible to oxygen ignition. Electronic components, regulators, and/or lubricants for moving parts in oxygen service must be rated by the manufacturer for oxygen service and the rating/certification must be included in the EDP Supplemental. The equipment must not have been used previously for another chemical service that could leave residual ignitable material. In particular, gas regulators used for hydrocarbon gas service can ignite and potentially explode when placed into oxygen service.

31.1. Cleaning. All equipment in oxygen service must be thoroughly cleaned before being placed into 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. Cleaning of the oxygen system must be done by disassembling all components to their individual parts. The cleaning procedure must be documented as part of the EDP Supplemental.

32. Biohazards If any biological organisms are used during any phase of the design, development, operation, competition and preparation of your Chem-E-Car, they must be no more than Level 1 biological hazards (also called biosafety level 1). This would include any bacterial, fungal, viral, or yeast organisms. *Proper handling procedures must be followed to minimize human exposure. All leftover cultures, stocks, and other regulated wastes must be collected, packaged and decontaminated according to local, state and federal regulations.*

33. **Accidents/Incidents.** If a safety incident occurs during the competition, the AICHE student chapter advisor of that team will be informed that an incident analysis report must be submitted to studentchapters@aiche.org. This safety incident report must be approved by the Chem-E-Car Competition® Student Chapters Subcommittee before any team from that university is allowed to compete in Regional or Annual Student Conference Chem-E-Car competitions.

34. **Competition Day Rules**
    - **34.1.** **PPE**: Each team must provide the appropriate personal protective equipment (PPE) for use in the chemical prep area, as identified in their JSA, and must use them properly. This includes lab coats, safety glasses, gloves, masks, face shields, and hearing protection. The personal protective equipment must be used appropriately by all team members depending on the hazards encountered during the chemical preparation.
    - **34.2.** **Electronics in prep area:** All portable personal electronic devices must be covered while in the prep area. Smaller portable personal electronic devices such as calculators and especially cell phones must be kept in clear plastic bags (e.g. Ziploc bags) throughout the competition. Teams will also be required to place screen covers and disposable keyboard covers over laptop and tablet touch screens and keyboards. The purpose of this rule is to prevent contamination of portable personal electronic devices. Teams are responsible for providing clear plastic bags, screen covers, and keyboard covers for their portable personal electronic devices. Failure to follow this rule will result in all team electronic devices being removed for the remainder of the competition from the prep area.
    - **34.3.** **Labeling Containers.** All containers with chemicals, including bottles, beakers, and plastic bags must be properly labeled. The label must minimally include the name of the chemical(s), and the name of the Chem-E Car team.
    - **34.4.** **Spill Containment at Table.** All chemical pouring or mixing in the preparation area must be done with spill containment. Your team must use a large tray compatible with your chemicals, with a volume large enough to hold your chemical quantities.
    - **34.5.** **Chemical Distribution.** All chemicals will be made available to the teams in the chemical preparation area at least two (2) hours prior to the performance competition. Absolutely no chemicals will be available for any team prior to three (3) hours before start of the competition. This includes battery-operated cars. Any requests to charge batteries overnight or longer than three (3) hours before the competition starts will not be granted.
    - **34.6.** **One Car in chemical prep area.** Each team is only permitted to have the car that passed the onsite safety inspection in the chemical prep area during the competition.
    - **34.7.** **Testing of vehicles in chemical prep area.** Teams can only test their reactions if the cars are held or supported on a stationary stand. The car wheels are not allowed to touch a solid surface (table or floor) under power.

35. **Requesting Assistance.** There is no restriction on requesting assistance for vehicle safety. Teams are encouraged to request additional safety assistance from their faculty advisor, other faculty members, other universities, other teams, and professional practitioners in industry and elsewhere.

Resources

National Fire Protection Association (NFPA). 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.

National Institute for Occupational Safety and Health (NIOSH). An excellent source of information on the hazardous properties of chemicals. www.cdc.gov/niosh. In particular, they support a free, on-line guide to chemical hazards called the *NIOSH Pocket Guide to Chemical Hazards*. This is available at http://www.cdc.gov/niosh/npg/default.html.

Occupational Safety and Health Administration (OSHA) Information about Hazard Communication Standard (HDS), which is now aligned with the Globally Harmonized System of Classification and labeling of Chemical (GHS). Information on Safety Dara Sheets, & labeling can be found at https://www.osha.gov/dsg/hazcom/.

Information on GHS can be found at https://www.osha.gov/dsg/hazcom/ghsguideoct05.pdf

Crowl and Tipler, "Sizing Pressure-Relief Devices": https://www.aiche.org/sites/default/files/cep/20131068_r.pdf

NOTE: Equations (5) and (6) in Crowl and Tipler's "Sizing Pressure-Relief Devices" have a typo. The exponent (y+1)*(y-1) is incorrect, and instead should read (y+1)/(y-1)

SACHE module: *Emergency Relief system Design for Single and Two-Phase Flow*

AIChE Chem-E-Car Competition Safety Training Course: www.aiche.org/chemecar

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.

No plastics such as: PVC, Tygon Tubing, cPVC, polyethylene terephthalate (PETE), ABS, PC, etc. are permitted for pressurized vessels or piping systems or for gases or liquids above manufacturer's temperature recommendations. All plastics have microscopic defects called crazes that grow into cracks as a result of hoop stresses, which can over time cause failure and therefore represent a hazard. NO exceptions to this rule will be allowed.

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 is only one option 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. Any vessel with an unknown MAWP (whether custom-built or not) must have its MAWP certified by a commercial firm or qualified university hydrotesting facility. Students are not permitted to self-certify the MAWP of such a vessel. There are no exceptions to this rule.

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 Annual Student Conference 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. Safety Data Sheets (SDS) 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 all 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. SDS's must be available for all chemicals stored.

B. ALL chemicals stored must be properly labelled.

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/bases and flammables.

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. Leftover 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:

- Name, address and telephone number
- Product Identifier
- Signal word
- Hazard statement(s)
- Precautionary statements
- Pictograms

Pictograms are required on labels to alert users of the chemical hazards to which they may be exposed. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard. Here are examples of pictograms you may encounter.

Health Hazard

- Carcinogen
- Mutagenicity
- Reproductive Toxicity
- Respiratory Sensitizer
- Target Organ Toxicity
- Aspiration Toxicity

Flame

- Flammables
- Pyrophorics
- Self-Heating
- Emits Flammable Gas
- Self-Reactives
- Organic Peroxides

Exclamation Mark

- Irritant (skin and eye)
- Skin Sensitizer
- Acute Toxicity (harmful)
- Narcotic Effects
- Respiratory Tract Irritant
- Hazardous to Ozone Layer (Non-Mandatory

Gas Cylinder

- Gases Under Pressure

Corrosion

- Skin Corrosion/Burns
- Eye Damage
- Corrosive to Metals

Exploding Bomb

- Explosives
- Self-Reactives
- Organic Peroxides

Flame Over Circle

- Oxidizers

Environment (Non-Mandatory)

- Aquatic Toxicity

Skull and Crossbones

- Acute Toxicity (fatal or toxic)

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, compatible, and 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.