**`**

**Team Affiliation**:       **Team #/Name:**

**Author/ Team Captain Name**:       **Team Captain Email:**

**Faculty Supervisor:**       **Supervisor Email:**

**Revision #**:       **Revision Date**:

**1.0 DAC operation, hazards, and safety:** Describe your ChemE Cube’s design, intended mode of operation (DAC), Regeneration Technology, major hazards and their control.

|  |
| --- |
| **Describe your Cube’s design and DAC mechanism:** |
| **Regeneration Category (for questionnaire) and short justification based on DAC mechanism**. |
| **If team competed in 2023 or 2024, please list any major design changes for your cube, and how the DAC and regeneration processes have been changed from the previous Cubes** |
| **For cube & also for auxiliary processes as applicable**  **Expected Operating Conditions:**  **Temperature**:  **Pressure**:  Inlet CO2 range: \_\_\_\_\_\_\_\_\_\_\_\_ to \_\_\_\_\_\_\_\_\_ ppm  Outlet CO2 range: \_\_\_\_\_\_\_\_\_\_\_\_ to \_\_\_\_\_\_\_\_\_ppm |

|  |  |
| --- | --- |
| **Hazards inherent in design (for Cube & auxiliary processes, if applicable):** Please number in order of decreasing hazard  **Add rows as needed for each hazard** | **Safety measures to prevent and mitigate hazards. Every hazard identified above must be addressed here**: |
|  |  |
|  |  |

**2.0 Operating Instructions**

Explain how the cube operates, and if maintenance is required (meter calibration, etc.). Be brief, this is for a potential future user, not for your use on competition day. How will the user introduce ambient air into the cube and what if any operations and maintenance is required for continuous operation (i.e. adsorbent replenishment, waste disposal etc.)?

**3.0 Technical Specifications data sheet**

**Isometric drawing of Cube and the DAC System** (enlarge space as needed)

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**PFD and P&ID of your process:**

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**Cube Details:**

|  |  |  |
| --- | --- | --- |
|  | **Yes** | **No** |
| **Cube Volume is 1 ft3 or smaller and dimensions are 1 ft or less:** |  |  |
| **Cube Operates at or below 120W** |  |  |
| **Operating Flow Rate is between 2 and 20 SCFM** |  |  |
| **Operating Temperatures do not exceed 130 °F** |  |  |
| **Operating Pressure does not exceed 5 psig** |  |  |

|  |  |
| --- | --- |
| **Adsorbent Capacity (fl oz)** |  |

**Bill of materials-expand as necessary (label on isometric drawing).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item # (isometric)** | **Description** | **Material** | **McMaster-Carr (or similar site) Equivalent Part Link** | **Cost ($)** |
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**Capital Cost of Cube (will most likely be the sum of the bill of materials. If it is different, provide an explanation):**

**4.0 Control Software Program (if you have a control system). Provide a copy of your code. Explain the purpose of your code and how it affects your cube.**

**5.0 If pressurization system can exceed 5 psig, describe how the cube’s pressure is maintained and less than 5 psig and how exhaust pressure is lowered to below 1 psig.**

**6.0 Photos of Completed Cube**

Please add photos of your complete, constructed cube after construction has been completed. These pictures must be current. The entire cube must be visible in at least one picture. Also, remove the top/or a side to expose cube interior and electrical controls if necessary. You must include multiple (at least 6) views of the cube **(top, bottom, left, right, front and back**). Please adjust the following cells to fit. *A drawing or AutoCAD document will NOT be accepted*

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**7.0 Hazards Analysis**

This page applies to your home institution – not the competition site. Please attach a floor diagram of the laboratory where you will be building and testing your cube. List the location of available safety equipment and spill response supplies on this diagram.

**Available Safety Equipment** – Provide the location of each item shown below at the institution where the cube will be manufactured and tested. Show the location of this equipment on the floor plan above. If not available, type “NA” in the field. Please pay attention to Safety requirements listed in chemical SDS’s

|  |  |
| --- | --- |
| **Item** | **Location** |
| Fire Extinguisher: |  |
| Eyewash: |  |
| Safety Shower: |  |
| Telephone: |  |
| First Aid Kit: |  |
| Spill Containment |  |
| Respirator: |  |
| Other: |  |
|  |  |

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

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

**Personal Protective Equipment (PPE)**

Check all PPE that will be worn during the development/operation of this ChemE Cube in the lab. Include type of gloves used and confirm they meet SDS requirements.

|  |  |  |  |
| --- | --- | --- | --- |
| Long Pants | Safety Glasses | Hard Hat | Apron |
| Long Sleeves | Splash Goggles | Insulated Gloves | Ear Protection |
| Non-porous Shoes | Face Shield | Chemical Gloves | Respirator |
| Other |  |  |  |

**8.0 Cube Hazard Analysis**

**Primary Hazards Checklist:** Consider each treatment process within the cube and indicate whether a hazard is present.

|  |  |
| --- | --- |
| **Hazard**  **(check if present)** | **Control mechanism** |
| **Pressure:** Do any processes generate pressure above 1 psig? If so, check this box. | Any equipment within the cube (tubing, etc.) operating above 1 psig should include a certification from the manufacturer that it can safely operate at that pressure. If gas is generated within the cube, indicate how it will be vented safely.  All components exposed to pressure are certified to operate at this pressure. Provide a copy of the manufacturer’s pressure specifications in the appendix.  There is a vent present to relieve gases. No gas under pressure above 1 psig will be vented. |
| **Toxicity:** Check this box if any chemicals with a GHS acute toxicity of 1 | Doubly contained and handled properly. Appropriate PPE will be worn at all times.  No chemicals with GHS hazard rating of 1 are allowed |
| **Temperature:** If the exterior surface of the cube is below 32°F or above 90°F, check this box. If interior components operate above a temperature of 90°F, check this box. | Cube may not operate with an exterior surface temperature above 120°F. Burns are unlikely below this temperature.  Insulation or barriers on internal components are present to prevent accidental contact with hot or cold surfaces/components outside the range 32°F–90°F. |
| **Electrical:** If electricity is used within your cube, check this box above. | Exposed wiring and electrically energized components are ignition, electrocution, and a shorting / fire hazard. Alligator clips and twisted wire connections are not allowed – use terminal connections, binding posts or banana plugs for a more secure connection. Design includes methodology used for wire sizing  Proper electrical insulation and connections provided. |
| **Mechanical:** Check this box if there are any fast moving parts (meshing gears, belts or chains) that are pinch hazards. | Guards present and adequate. |
| **Biohazards:** Check this box if biohazards are listed on the SDS for any treatment or challenge water chemicals. | No biohazards greater than biosafety level (BSL) 1 either during the design, development, preparation or competition phase. Appropriate PPE will be worn at all times. |

**9.0 Fabrication Hazard Analysis**

Check all hazards that may be encountered during your ChemE Cube construction. List the major source(s) of the hazard and describe how the hazard(s) will be controlled. If both construction and operation columns are checked in an individual row, then the hazards should be identified separately. Consider 3D printing, and other construction methods that may be needed.

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| **Hazard** | **Present During** | | | **Control Method(s)1** | **PPE Required1** |
| **Construction** | **Operation** |  | |  |
| Pressure |  |  |  | |  |
| Toxicity |  |  |  | |  |
| Flammability |  |  |  | |  |
| Reactivity / Instability |  |  |  | |  |
| Hot Surfaces/ High Temp > 130°F |  |  |  | |  |
| Cold Surfaces/ Low Temp < 32°F |  |  |  | |  |
| Electrical |  |  |  | |  |
| Arc welding |  |  |  | |  |
| Gas welding |  |  |  | |  |
| Lathe |  |  |  | |  |
| Milling machine |  |  |  | |  |
| Handheld power tools |  |  |  | |  |
| Drill press |  |  |  | |  |
| Other mechanical  hazards |  |  |  | |  |
| Paint spraying |  |  |  | |  |
| Ionizing radiation |  |  |  | |  |
| Laser radiation |  |  |  | |  |
| Asphyxiates |  |  |  | |  |
| Open flames |  |  |  | |  |
| Potential Spills |  |  |  | |  |
| Biohazards: |  |  |  | |  |

**10.0 Chemical Information**

**Description of Chemistry/Chemical Reactions:** Provide details below on any chemical reaction(s) that occur in your process. Please show the species involved, the stoichiometry and the heat of reaction, if available. Also list side reactions and any other reactions that may impact safety.

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**Table 1:** Please list all Chemicals, concentrations and quantities that will be **shipped** to competition site. This is so the Host can prepare to receive, store and transport your chemicals.

|  |  |  |  |
| --- | --- | --- | --- |
| **Chemical Name** | **Chemical State**  **Solid, Liquid, Gas** | **Concentration**  **Be sure to list units!** | **Amount Sending To Competition Site** |
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**Notes:**  Please include any special storage requests that the Host should be aware of, and how many boxes you expect to ship.

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**Table 1a:** Please list all Chemicals, concentrations and quantities that will be **used** during **one** Competition Run.

|  |  |  |  |
| --- | --- | --- | --- |
| **Chemical Name** | **Chemical State**  **Solid, Liquid, Gas** | **Concentration**  **Be sure to list units!** | **Quantity needed per Run (Include Units)** |
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**Table 2:** Please list all Chemicals that you expect to **generate** and **dispose** of during the overall competition (up to 3 runs including prep/testing as applicable). This should be WASTE/ USED chemicals only.

|  |  |  |  |
| --- | --- | --- | --- |
| **Chemical Name** | **Concentration**  **Be sure to list units!** | **Amount** | **Waste Classification (Acid, Base, Organic, Metal, Oxidizer, Other)** |
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**Table 3:** Please list any unused chemicals that you expect to have **leftover** after the competition is done.

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| --- | --- | --- | --- |
| **Chemical Name** | **Chemical State**  **Solid, Liquid, Gas** | **Concentration**  **Be sure to list units!** | **Amount Expected to be Leftover** |
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**11.0 Treatment Chemical Hazard Documentation (attach SDS to this EDP)**

**Chemical Properties and Hazards for ALL CHEMICALS,** including reactants, intermediates and products.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemical Name** | **Physical State**  **(S, L, G)** | **GHS Ratings\*** | | | **Incompatible Chemicals**  List chemicals present within the laboratory | **Flash Point**  **Temp.** | **Flammability Limits** | |
| **P** | **H** | **E** | **LFL** | **UFL** |
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**\*GHS Ratings: P** – Physical, **H** – Health, **E** – Environmental

**Chemical Toxicology, Regulation and Disposal:** List the same chemicals that appear above, in the same order.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Chemical Name** | **Toxicology** | | | **Hazardous**  **Waste Number** | **OSHA**  **Regulated?** | **Personal Protective Equipment**  **Specific to this Chemical** |
| **TWA** | **PEL** | **Other** |
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**12.0 Standard / Safe Operating Procedures Page**

Provide step-by-step details for each of the sections shown below. Identify the hazards, the control methods and the personal protective equipment (PPE) required. Provide adequate detail so that the reviewers of this document will have adequate understanding of your procedure to pass judgment on the safety of the cube.

The **Start-Up Procedure** section should list all the steps required to prepare your cube for DAC of CO2. Example: prepare absorbent/adsorbent check electrical connections, etc.

The **Operating Procedure** should describe all steps to operate your cube for the DAC of CO2. Example: Flip exterior switch to ‘ON.’

The **Shutdown Procedure** should describe the steps normally taken to shut down your cube at the end of CO2 capture. Example: Flip exterior switch to ‘OFF.’

The **Cleanup / Waste Disposal** section should list all the steps required to clean the cube of all chemicals and proper chemical disposal, if necessary. Example: Remove filter and rinse under clean water for 30 seconds. Empty trap.

The **Emergency Shutdown** section should have only one or two steps required to stop your cube and bring it to a safe state. Example: In the event of overheating, unplug power from wall receptacle.

|  |  |  |  |
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| **Sequence of Steps** | **Potential Hazards** | **Procedure to Control Hazard** | **PPE or Equipment Required** |
| **Start-up Procedure** |  |  |  |
|  |  |  |  |
| **Run Time Procedure** |  |  |  |
|  |  |  |  |
| **Shutdown Procedure** |  |  |  |
|  |  |  |  |
| **Cleanup / Waste Disposal** |  |  |  |
|  |  |  |  |
| **Emergency Shutdown** |  |  |  |
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**13.0 Safety Rules**

Safety rules for the competition are listed below. Failure to follow these ruleswill result in a multi-year disqualification of your university from competition and possible fines.

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| --- |
| **Item** |
| (a) No transport of **any chemicals** in private, university or rental vehicles either to or from the competition. |
| (b) Chemicals must not be stored in hotel rooms or other facilities not rated for chemical storage. Approved chemical storage will be provided at the host site. |
| (c) No testing in hotel or dorm hallways, warehouses, or other facilities that are not designed for chemical handling. This includes at your university and the competition site. |
| (d) No improper disposal of chemicals at the conclusion of the competition. All chemicals shipped to the competition site must be disposed of in a safe and environmental fashion following all local, state and national regulatory measures. Chemical disposal will be provided by the host site. |
| (e) No chemicals with any of these GHS hazards may be used: explosives, flammable gases, flammable aerosols, oxidizing gases/liquids, flammable solids, flammable liquids, self-reactive substances, pyrophoric solids or liquids, self-heating substances, substances which on contact with water emit flammable substances, organic peroxides, or radioactive substances. |
| (f) Only air may exit the cube during the competition. No other liquid, or gas under pressure may be released. |
| (g) The exterior temperature of the cube must remain below 120°F. |
| (h) Cube must work autonomously. Cube may not be opened during the DAC challenge. When the competition begins, students will only be permitted to establish air flow with the starting of a fan and monitor instrumentation. |
| (i) All interior components must be sealed such that challenge water does not build up inside the cube. Cube interior should be dry at the start of the competition, so that leaks can be observed. |
| (j) All wiring and electrical components must be covered to prevent the possibility of electrical shock or ignition of any component. No alligator clips may be used, banana plugs and binding posts are acceptable. |
| (k) Guards must be present to protect operators from mechanical hazards (if any). |
| (l) No biological organisms with a biohazard greater than level 1 may be used. |

**14.0 Safety Certifications**

**Team Affiliation**:       **Team #/Name:**

**Primary Student Contact Name**:       **Email:**

**Faculty Supervisor:**       **Email:**

**Required 3D printer/fabrication/laboratory safety training:**

Each student team is expected to have completed a safety training at their university regarding the use of the 3D printing equipment, other fabrication methods, and use of the laboratory. Below, please record the date and location of required safety training for each team member.

List below each student team member and the date and location of safety training:

**Team Member Name Training type (3DP/fab/lab) Date**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_

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**Faculty Certification:**

I certify I have reviewed the safety rules, that this student team has completed the above safety training, has completed an engineering documentation package detailing their design, and has completed an internal product safety review under my supervision or with an outside expert.

Faculty Advisor Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Faculty Advisor Signature \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_

Outside Expert Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Outside Expert Signature \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_

**Student rules Certification**

We certify that we have followed all of the safety, competition rules, have completed an engineering documentation package, and have completed a safety review with our faculty supervisor or with an outside expert. We agree to abide by the AIChE Code of Conduct and Ethics. We understand and agree that we will not be allowed to compete in the Chem-E-Cube Competition if our completed EDP package is not resubmitted by the posted deadline.

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| --- | --- | --- | --- |
| Team Member Signatures |  | Date |  |

**15.0 Management of Change Form**

**Person requesting change: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date: \_\_\_\_\_\_\_\_\_**

**Summary /Description of Change:**

**Reason for Change:**

**Signature of Requestor: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date:\_\_\_\_\_\_\_\_\_\_**

**APPROVAL**

**Ensure that the EDP documentation has been revised and the implication of the change to safety has been reviewed and approved by the supervising faculty.**

**Signature of Advisor: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_**

**Signature of Team Member: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_**

**Signature of Team Member: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_**

**Signature of Team Member: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_**

**Signature of Team Member: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_**

**Signature of Team Member: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_**

**Team Waste Tags**

Please fill out a waste tag fully describing each of your competition day waste streams, using the form below. This 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.

**ALL SOLID WASTE MUST BE DISASSEMBLED, MADE SAFE AND BE LIQUID FREE**

**Bring Tags Cut Out to Competition**

**Team Name:**  **No.:**

**Waste Description:**

**Composition:**

**Disposal Waste Stream (select only 1):**

☐ Flammable ☐ Organic

☐ Acid ☐ Base

☐ Aqueous (pH 6-9) ☐ Solids (pH 6-9)

**Notes:**

**Team Name:**  **No.:**

**Waste Description:**

**Composition:**

**Disposal Waste Stream (select only 1):**

☐ Flammable ☐ Organic

☐ Acid ☐ Base

☐ Aqueous (pH 6-9) ☐ Solids (pH 6-9)

**Notes:**

**Team Name:**  **No.:**

**Waste Description:**

**Composition:**

**Disposal Waste Stream (select only 1):**

☐ Flammable ☐ Organic

☐ Acid ☐ Base

☐ Aqueous (pH 6-9) ☐ Solids (pH 6-9)

**Notes:**

**Team Name:**  **No.:**

**Waste Description:**

**Composition:**

**Disposal Waste Stream (select only 1):**

☐ Flammable ☐ Organic

☐ Acid ☐ Base

☐ Aqueous (pH 6-9) ☐ Solids (pH 6-9)

**Notes:**