**Project Safety Plan**



# UC Irvine Rocket Project

**November 8, 2018**

**Advisors**

Professor Mark Walter & Professor Ken Mease

**Leads**

Rasheed Aziz, Mitchell Martinez, Michael Decker, Matthew Johnson, Jacob Shoham, Tan Nguyen, Griffith Wagner

**Members**

Aleeza Roque, James Jamgotchian, Seungmin Lee, Zihan Chen, Amy Yee, Caitlyn Copeland, Derek Nguyen, Sergio Sandoval, Paul Badalian, Mithil Hari, Kevin Chen, Steven Campos, Tim Iwamoto, Cameron Goedinghaus, Cesar Ramirez, Adam Park, Wes Hellwig, Srinath Gopalakrishnan, Michel Soliman, Brian Fox, Xavier Orellana, Richard Umboh, Sebastian Rosiak, George Ahl, Owen Browne

|  |  |  |  |
| --- | --- | --- | --- |
| Release and Revision | | | |
| Rev | Description | Date | Approved By |
| [-] | Creation of documentation guidelines for the UC Irvine Rocket Project | 10/28/18 | Rasheed Aziz |
| 1 | Completed cover page |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

# Project Safety Plan

As mentioned in Section 5.1 of Doc5, Safety is paramount for all in-house manufacturing, assembly, and then testing activities. Furthermore, you must also ensure the safety of all persons who may come in contact with any phase of your project. This contact could occur during manufacturing, during a tour, during accidental or intentional visiting of your work space, or during project display. While each team does have a safety manager, safety is the responsibility of all team members. Each team should post and review the following guidelines:

1. General
   1. Always ask a knowledgeable member of the team if unsure about equipment, tools, procedures, materials handling, any other concerns. If there is no one on the team with the necessary expertise, find and expert to understand the risks and to train you.
   2. Safety managers should ensure that team members have proper training for the equipment to be used in student-fabrication.
   3. Be cognizant of your own actions and those of others
      1. Point out risks and mitigate them
      2. Review procedures and relevant Material Safety Data Sheet (MSDS) before commencing potentially hazardous actions
   4. Safety Equipment
      1. Only close-toed shoes may be worn in lab
      2. Always wear goggles where applicable
      3. Always use breathing equipment, i.e., face masks, respirators, etc, where applicable
      4. Always wear gloves where applicable, e.g., when handling epoxy and other chemicals
2. Equipment and Tools:
   1. The following are risks of equipment and tool handling:
      1. Cuts
      2. Burning
      3. General injury
   2. Ways to mitigate these risks:
      1. Always wear appropriate clothing, e.g. closed-toed shoes.
      2. Always wear appropriate safety equipment
      3. Always ask if unsure
      4. Err on the side of caution – this means that if you’re uncomfortable proceeding with tool or equipment, STOP what you’re doing and ask for assistance.
3. Chemicals
   1. The following are risks of chemical handling:
      1. Irritation of skin, eyes, and respiratory system from contact and/or inhalation of hazardous fumes.
      2. Secondary exposure from chemical spills
      3. Destruction of lab space
   2. Ways to mitigate these risks:
      1. Whenever using chemicals, refer to MSDS sheets for proper handling
      2. Always wear appropriate safety gear
      3. Keep workstations clean
      4. Keep ventilation pathways clear
      5. Always wear appropriate clothing

The safety plan in Sec. 6.1 will help reinforce these guidelines.

**UC Irvine Rocket Project**

|  |  |
| --- | --- |
| **Department:** | **Mechanical and Aerospace Engineering** |
| **Date Plan was written:** | **11/8/18** |
| **Date Plan approved by Faculty Advisor:** | **Insert** |
| **Faculty Advisor Name(s)/Phone(s)/Email(s):** | **Professor Mark Walter/ (949)824-3245/** [**m.walter@uci.edu**](mailto:m.walter@uci.edu)  **Professor Ken Mease/ (949)824-8585/ kmease@uci.edu** |
| **Lab Phone (if applicable):** | **N/A** |
| **Project Team Leader Name(s)/Phone(s)/Email** | **Rasheed Aziz (Project Manager)/**  **(510)676-9774/** [**raaziz@uci.edu**](mailto:raaziz@uci.edu)  **Mitchell Martinez (Chief Engineer)/**  **(310)662-3392/** [**mitchezm@uci.edu**](mailto:mitchezm@uci.edu) |
|  |  |
| **Location(s) used by this project:** | **UC Irvine Rocketry Lab** |
| ***Project Start Date:*** | **February 23, 2018** |
| ***Project Duration:*** | **Insert** |

***This proposal is not meant to serve as a procedural guide to tasks but as tool to help students, principal investigators, staff and EH&S identify training needs, hazard controls, personal protective equipment and other issues that students need to be alerted prior to conducting work.***

**Section I.**

**List of Hazardous Materials Involved**

List all types of hazardous materials and the approximate quantities they will be used in.

|  |  |  |
| --- | --- | --- |
| Name/ Hazard Class  (Ex. *Oxidizer, Flammable, Corrosive etc.)* | Required PPE | Reviewed the following: |
| 1. LOX/Oxidizer, Cryogen, Flammable, Gases Under Pressure | * **Blue cryogenic gloves** * **Safety glasses with side-shields** * **Face shields** * **Close-toed shoes** * **Long sleeves** * **Long pants** * **Non-flammable clothes** | * Safety Data Sheet (SDS/MSDS) * Spill/Accidental Release Measures |
| 1. LNG/Cryogen, Flammable, Gases Under Pressure | * **Blue cryogenic gloves** * **Safety glasses with side-shields** * **Face shields** * **Close-toed shoes** * **Long sleeves** * **Long pants** * **Non-flammable clothes** | * Safety Data Sheet (SDS/MSDS) * Spill/Accidental Release Measures |
| 1. LIN/Cryogen, Gas Under Pressure | * **Blue cryogenic gloves** * **Safety glasses with side-shields** * **Face shields** * **Close-toed shoes** * **Long sleeves** * **Long pants** * **Cryogenic apron** | * Safety Data Sheet (SDS/MSDS) * Hazardous Waste Disposal Procedures * Spill/Accidental Release Measures |

**Section II.**

**Equipment and Experimental Apparatus**

* List all equipment used and Personal Protective Equipment (PPE) that presents any hazards.
* This should include any shop equipment, equipment that utilizes high/low temperatures, pressures or any other parameters that could possibly result in injury to personnel.
* Engineering controls are safety controls either part of the equipment or externally installed that guard against safety accidents such as equipment guards, safety alarms, detector etc.



|  |  |  |  |
| --- | --- | --- | --- |
| **Equipment** | ***Major Hazard*** | **Required PPE** | **Engineering Controls** |
| **Injector Valves** | * Oil/Grease Cause Combustion | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Pressurant Tank** | * Combustion * Structural Failure | Gloves, Safety Glass/Goggles, Face Mask, Lab Coat, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Pressurant Tank Relief Valve** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Lab Coat, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Pressurant Remote Vent Valve** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Lab Coat, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Fuel Tank** | * Combustion * Structural Failure | Gloves, Safety Glass/Goggles, Face Mask, Lab Coat, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Fuel Tank Relief Valve** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Lab Coat, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Fuel Remote Vent Valve** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Fuel Fill Port** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Oxidizer Tank** | * Combustion * Structural Failure | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Oxidizer Tank Relief Valve** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Oxidizer Remote Vent Valve** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Oxidizer Fill Port** | * Fire * Leaks * Personnel Exposure | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |
| **Igniter** | Explosion, Sparks | Gloves, Safety Glass/Goggles, Face Mask, Non-Flammable Clothing, Long Pants, Close-Toed Shoes, Long Sleeves | Blockhouse, Fire Fighting, Viewing Bunker, First Aid, Webinars, Explosive Magazines, Pyrotechnic Operators. |

**Section III.**

**Personal Protective Equipment (PPE)**

This section indicates all PPE as required by both *Section I*-*Hazardous Materials* and *Section II*- Equipment.

1. **Hand Protection**

* Blue cryogenic gloves

1. **Eye Protection**

* Safety glasses/goggles
* face shields

1. **Skin and Body Protection**

* Long sleeves
* Long Pants
* Close-toed shoes
* Cryogenic apron

**Section IV.**

**Training Requirements**

Using the information in Sections I, II and III-Identify any training that would need before starting your project.

|  |  |
| --- | --- |
| **Equipment Training** | **Operations Training** |
| **Compressed Gas Cylinders (LOX, LNG, LIN)** | **Pyrotechnic Devices** |
| ***Insert*** | ***Insert*** |
|  |  |
|  |  |

**Section V.**

**Member Training**

***Provide the complete team roster. Next to each name, include all of that member’s training certifications and any special expertise. Be specific and refer also to Sec. IV. Do not feel like each row in the table must be one line. This table will allow you to determine if any members do not have the required training and who has expertise that can be leveraged.***

|  |  |  |
| --- | --- | --- |
| Member Name | *Training/Expertise* | Notes |
| *Insert* | ***Insert*** | ***Insert*** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

**Section VI.**

**Operational Procedures**

**i. Combustion Chamber Standoff Grease Flame Test**

Nominal Procedures

1. Fit all three copper tubes with the stainless tube fittings and use a syringe to fill with high temp grease flush to both ends.
2. Beginning with the first tube, perform the following for all tubes:
3. Insert a thermocouple lead into one end of the tube (hereafter referred to as the PT end), embedded within the grease.
4. Using kapton tape, affix thermocouple leads at 1”, and 3” on the tube starting at the PT end. Wrap the 3” thermocouple with extra tape to shield against errant flame exposure.
5. Record temp at thermocouples through labview.
6. **Person B:** Record temp at thermocouples with the infrared probe (should be identical to above).
7. While holding the tubewith the long pliers/pincers, hold the fitting end (hereafter referred to as the F end) up and expose to a direct flame from the mapp torch. Ensure tube is pointed away from everyone during burn.
8. **Person C:** When the flame starts the DAQ should begin recording temperature from all thermocouples.
9. **Person B:** Record the temperature of the center of the F end using the infrared thermometer. This person will have to manually note/record the readings.
10. Sustain the flame aimed directly onto the F end for a total of **15** seconds.
11. Extinguish the torch. Allow sufficient time to cool before further handling.
12. Remove all thermocouples.
13. Visually inspect grease and note anything significant (loss of material, melting/running of grease, anything else)
14. Measure the depth of grease material lost from the F end. Record temp over time curves acquired by the DAQ.
15. Repeat steps 3-13 for every size copper tube. Then transfer the 1/8" AN fitting to the stainless section and repeat the test for the stainless tube.

Contingency Procedures

1. Upon splatter of high temperature grease onto test personnel/equipment, or undesired ignition or combustion, the test will be aborted and the following steps will be adhered to:
2. Extinguish the torch
3. Put down the pipe and torch, remaining calm not to drop the pipe and cause high temperature grease to splatter in all directions
4. As soon as the hazardous situation is recognized, **Person C** will immediately pick up the fire extinguisher and move to put out the hazard
5. Upon containment of the hazard, Person A will be assessed to determine if further medical attention is needed
6. Call 911 if necessary
7. After allowing sufficient time to cool, Test equipment will be assessed for any damage
8. If situation has not resulted in any injuries or damage, test may be re-set up and re-done

**ii. Integrated Electric Regulator Test**

Nominal Procedures

100 psi test:

1. Turn on compressor until capacity, and set regulator to 0 psi output

1. Set E.REG to 0 psi output
2. Regulate up the compressor to 100 psi
3. Set E.REG to 25 psi output
4. Verify PTreg and PTdownstream read the same value for 2 minutes
5. Increment 25 psi and repeat step 5, until 100 psi limit is reached
6. Once at 100 psi, open ball valve half way to induce flow rate change which creates a pressure drop
7. Observe the downstream pressure transducer as the E.REG corrects pressure drop back to 100 psi

500 psi test:

1. Close **all** regulators, set them to 0 psi output
2. Open nitrogen cylinder **slowly** until fully open
3. Use manual regulator to output a 500 psi downstream pressure
4. Actuate solenoid valve, and set E.REG to 100 psi output
5. Verify PTreg and PTdownstream read the same value for 2 minutes
6. Increment 100 psi and repeat step 5, until 400 psi limit is reached
7. Once at 400 psi, open ball valve half way to induce flow rate change which creates a pressure drop
8. Observe the downstream pressure transducer as the E.REG corrects pressure drop back to 400 psi

Contingency Procedures

1. In the case of an excess of pressure loss, or bursting of a component, make sure source of pressure is completely closed and let system vent itself

2. In the case of injuries due to high pressure bursting of components, seek whatever help deemed necessary

**iii. LNG Filling**

Nominal Procedures

     Background: LNG is transferred into the CH4 propellant tank from the FAR site LNG dewar

1. Confirm with FAE that we are permitted to begin LNG fill operations
2. Ensure Helium flow valves are closed to prevent tank pressurization
3. Ensure LNG fill valve is closed
4. Ensure LNG injector valve is closed
5. Ensure fill line Tee relief valve is closed
6. Vent LNG dewar to 30 psi
7. Ensure data acquisition systems are active
8. Open test stand LNG remote vent valve
9. Remove dewar cap and connect transfer hose to test stand and dewar
10. Open test stand LNG fill valve
11. Open LNG dewar globe valve to begin fill process
12. Ensure no leaks are occurring in LNG plumbing system
13. Continue filing until LNG is discharged from LNG remote vent
14. Close LNG dewar globe valve
15. Allow for 60 second tank cold soak
16. Open LNG dewar globe valve for LNG Tank top-off
17. Continue filling until LNG liquid is discharged from LNG remote vent
18. Close LNG dewar glove valve
19. Close Test Stand LNG fill valve
20. Vent fill line/transfer hose using Tee relief valve on fill line
21. Disconnect transfer hose
22. Loosely cap LNG fill on dewar to prevent pressurization due to any boil-off occurring around the dewar globe valve
23. Send LNG dewar away from test area

Contingency Procedures

1. Upon small or large spill, undesired ignition or combustion, the test will be aborted and the following steps will be adhered to:
2. Close the liquid valve.
3. As soon as the hazardous situation is recognized, immediately pick up the fire extinguisher and move to put out the hazard.
4. If the fire extinguisher fails to put out the fire, evacuate the area and call 911.

**iv. LOX Filling/Transfer**

Nominal Procedures

      Pre-Fill Checks and Transfer Line Installation

1. Before use, always confirm that the CGA fittings are appropriate for the product identified on the cylinder label.
2. Make sure that all connections and fittings have undergone a cleaning and storage per UCIRP Liquid Oxygen-Methane Plumbing Preparation Requirements LOX cleaning procedure.
3. Install male-male adapter CGA 440 to 1/2" NPT to LOX cylinder. The CGA 440 side should be connected to the LOX cylinder liquid withdrawal valve.
4. Install Tee remote relief valve assembly 1/2" NPT to male side of adapter
5. Install 1/2" NPT cryogenic transfer hose to Tee remote relief valve assembly and use appropriate male nipple fitting to connect.
6. Install other end of 1/2” NPT cryogenic hose to the male 1/2" NPT inlet of the test stand plumbing system.
7. Ensure all connections are fastened properly. Avoid cross-threading.

      LOX Fill Procedure

1. Slowly open the liquid valve to obtain the desired rate of flow. This valve can be adjusted to obtain the proper liquid flow rate.
2. Filling should continue until LOX begins to flow out of rocket LOX tank relief valve. Close the receiving equipment’s valve.
3. Close the liquid valve of the cylinder and relieve pressure from the hose.
4. To prevent back-contamination in the container, all valves should be closed when operation has been completed.
5. Disconnect or remove the hose from the receiving equipment.

Contingency Procedures

1. Upon small or large spill, undesired ignition or combustion, the test will be aborted and the following steps will be adhered to:
2. Close the liquid valve.
3. As soon as the hazardous situation is recognized, immediately pick up the fire extinguisher and move to put out the hazard.
4. If the fire extinguisher fails to put out the oxidizer-fed fire, evacuate the area and call 911.

**v. Water Flow Test**

Nominal Procedures

1. Fill Tanks with water or have them filled before the test
2. Open all valves to prepare for flushing.
3. Flushing process using water at a relatively low velocity(~1-2 ft/s). This will allow the water to clear out any air bubbles or other contaminants that may affect pressure losses during the actual test.
4. Close all valves with water still in system to ensure no air bubbles.
5. Pressurize system to the testing pressure of 400 psi.
6. Open all valves and set the flow rate to desired value.
7. Allow flow rate and velocity to stabilize.
8. Measure water pressure at input and output using the pressure transducers.
9. Turn off water flow input and close all valves.
10. Repeat for higher flow rate.

Contingency Procedures

1. Contingency procedures detail steps to be followed to bring a hazardous situation back to a peaceful state
2. Again, it is better to be overly precise than having sparse information
3. Included in these steps will be calling 911 if necessary and contacting authorities if necessary

**Section VII.**

**Public Safety**

Provide a detailed description of how the public will be kept safe during incidental and/or intentional contact with your project.