University of Hawai‘i
Community Colleges
UHCC Project Imua: Mission 6

University Student Launch Project
2018-2019

Proposal

imua.wcc.hawaii.edu
Table of Contents

1.0 School Information Summary
   1.1 Name of School/Organization/Project Title p. 4
   1.2 Name of Administrative Staff Members p. 5
   1.3 Student Leads p. 6
   1.4 Safety Officer p. 6
   1.5 Team Overview p. 7
      1.5.1 Team Leads p. 8
      1.5.2 Safety Officer p. 8
      1.5.3 Social Media Officer p. 9
      1.5.4 Vehicle Engineers p. 9
      1.5.5 Payload Engineers p. 9
   1.6 NAR/TRA Section p. 9

2.0 Facility and Equipment
   2.1 Description of Facilities p. 10
      2.1.1 Main Facilities (WCC) p. 10
      2.1.2 Main Facility (HCC) p. 10
         2.1.2.1 HLE Facility p. 11
         2.1.2.2 Sheet Metals and Plastics Building p. 11
         2.1.2.3 Carpentry Building p. 12
         2.1.2.4 3D Printer p. 13
         2.1.2.5 HCC Student Parking Lot 1C p. 14
         2.1.2.6 Web Conferencing Capability p. 14
         2.1.2.7 Vendor Relationships p. 14
      2.1.3 Auxiliary Facilities/Events p. 14
   2.2 Necessary Personal, Facility, Equipment, Required p. 15
      2.2.1 Necessary Personal p. 15
      2.2.2 Necessary Facilities p. 16
      2.2.3 Necessary Equipment p. 16
      2.2.4 Components for the Rocket: p. 16
      2.2.5 Components for the Payload: p. 16
   2.3 Computer Equipment p. 17

3.0 Safety
   3.1 Safety Plan p. 19
      3.1.1 NAR/TRA Personnel Description p. 21
      3.1.2 NAR High Powered Safety Compliance p. 21
      3.1.3 Student Hazard Recognition and Avoidance Compliance p. 22
      3.1.5 Motor Procurement p. 23
      3.1.6 Acknowledgement of Safety Regulations p. 24
         3.1.6.1 Range Safety Inspection p. 24
         3.1.6.2 Range Safety Officer p. 24
         3.1.6.3 Range Safety Requirements p. 25
4.0 Technical Design

4.1 Proposed Approach to Rocket and Payload

4.1.1 General Vehicle Information/Dimensions

4.1.1.1 Fin and Fin Can Assembly

4.1.1.2 Variable Drag Assembly (VDA)

4.1.1.3 Avionics

4.1.1.4 Determination of the CG and the Thrust-to-Weight Ratio

4.1.1.5 Determination of the CP

4.1.1.6 Determining the Stability Margin

4.1.1.7 Determining of the Number of Shear Pins

4.1.1.8 Determination of the BP for Pyrotechnics

4.1.2 Projected Altitude

4.1.3 Determination of the Chute Sizes

4.1.4 Motor Designation and Selection

4.1.5 Primary Requirements for Rocket and Payload

4.1.6 Payload System Summary

4.1.6.1 Payload Housing

4.1.6.2 Payload Deployment System

4.1.6.3 Rover Body

4.1.6.4 Soil Recovery System

4.1.6.5 Payload Code

4.1.6.6 Rover - Electronics

4.1.6.7 Payload Test Plan

4.1.6.8 Payload Requirement Verification

4.1.7 Challenges and Solutions

5.0 STEM Engagement

5.1 Community Support

5.2 STEM Engagement Projects

6.0 Project Plan

6.1 Tentative Schedule

6.2 Preliminary Budget

6.3 Funding Source

6.4 Continuance

Appendix A: Center for Aerospace Education

Appendix B: NAR High Powered Rocket Safety Code

Appendix C: TRA Safety Code

Appendix D: Additional Safety Regulations

Appendix E: Rocket Risk Mitigation Tables

Appendix F: Pre-Launch Check List

Appendix G: Detailed Hazard Mitigation & MSDS
1.0 School Information Summary

1.1 Name of school/organization/Project Title

School: The University of Hawai‘i (UH) consists of ten campuses across the State of Hawai‘i. Three of those campuses offer baccalaureate and graduate degrees, while the remaining seven campuses are administered by the University of Hawai‘i Community Colleges (UHCC) System. This SLP 2019 proposal involves the joint participation of three UH campuses: Windward Community College, Honolulu Community College and the University of Hawai‘i at Manoa (UHM). This joint endeavor stems from the seamless articulation that has developed over recent years among these ten UH campuses, which allows and encourages students to enroll and participate in programs at multiple campuses across the system.

With its high percentage of Native Hawaiian students, the UHCC System is designated a Minority Serving Institution. Established by State law in 1964 as an integral part of the University of Hawai‘i, the UHCC’s primary missions are to broaden access to postsecondary education in Hawai‘i by providing open-door opportunities for students to enter quality educational programs (including baccalaureate transfer and remedial/developmental programs) within their own communities and to provide the trained workforce needed in the State and elsewhere.

All three campuses involved in our proposed SLP 2019 project are located on the island of O‘ahu:

University of Hawai‘i – Windward Community College (WCC)
45-720 Kea‘ahala Rd.
Kane‘ohe HI, 96744

University of Hawai‘i – Honolulu Community College (HCC)
874 Dillingham Blvd.
Honolulu HI, 96917

University of Hawai‘i— Manoa (UHM)
2500 Campus Road
Honolulu, HI 96822

For this project, the UHM students will team up with the WCC students under the supervisor of the WCC mentor. For editorial purposes in this proposal, the UHM team is included in all references to the WCC team and the joint WCC-HCC SLP 2019 team is referred to as the UHCC team.

Organization: Project Imua (Hawaiian: to move forward) is a joint faculty-student enterprise consisting of multiple community college campuses within the University of Hawai‘i Community College system and supported by the Hawai‘i Space Grant
Consortium. Project Imua’s primary goal is to encourage UHCC students to explore and enter STEM-based careers by engaging in team-oriented, problem-solving activities that emphasize the integration process involved in the design, fabrication, testing and documentation of launch-ready, small space-bound payloads supporting scientific and/or engineering experiments. Project Imua also seeks to establish and assess the feasibility of a permanent coalition of UHCC campuses for the collaborative development of payloads to be launched by the Hawai’i Space Flight Lab and other launch facilities.

Project Title: Imua ‘eono (Imua 6; Project Imua Mission 6: SLP 2019)

This project is to instill interest and possible pursuits in Science, Technology, Engineering and Mathematics for underrepresented students, as well as to foster collaboration between the satellite campuses.

1.2 Name of Administrative Staff Members

**Principle Investigator**
Dr. Joseph Ciotti
Phone Number: (808)-236-9111
E-mail: ciotti@hawaii.edu

Dr. Joseph Ciotti is a Professor of Physics, Astronomy and Mathematics at Windward Community College. He is the founder and director of WCC’s Center for Aerospace Education (CAE) [Appendix A] and acts as the college’s Associate Director for the Hawai’i Space Grant Consortium. He designed WCC’s Lanihuli Observatory as well as the planetariums at both WCC (Hōkūlani Imaginarium) and UH-Hilo (‘Imiloa Astronomy Center). He also established the college’s NASA Flight Training AEL. He serves as an Associate Director for Hawai’i Space Grant Consortium, the Project Manager for Project Imua, and the Coordinator for WCC’s Polynesian Voyaging and Navigation program. He has produced numerous planetarium shows and is a member of the International Planetarium Society. He is WCC’s Principle Investigator of a continuing NSF Grant — Pre-Engineering Education Collaborative I &II (PEEC I & II). He was selected as one of Hawai’i’s Teacher-in-Space finalists and continues to serve as a NASA Space Ambassador. Among his other recognitions are the Robert H. Goddard Memorial scholarship, the Carnegie Foundation’s Hawai’i Professor of the year and the Christa McAuliffe National Aerospace Educator of the Year.

**WCC (CoPI) Faculty Mentor**
Dr. Jacob Hudson
Phone Number: (808)347-8246
E-mail: jacobh@hawaii.edu

Dr. Hudson is a High Energy Particle Astrophysicist, is the Coordinator for the CAE’s NASA Flight Training facility, and a lecturer of Physics and Astronomy at the Windward campus of the University of Hawaii. Dr. Hudson has developed
curriculum for an introduction to Rocket Sciences, which is to be integrated into the recently developed Space Flight College within the College of Engineering. He mentored WCC students engaged in the Colorado Space Grant Consortium's RockSat-X programs for four years between Fall 2014 through Summer 2017. He is also an avid rocket enthusiast being L3 certified. He is a member of the National Association of Rocketry (NAR #82342 SR and an L3CC member), and the Tripoli High Powered Rocketry Association (TRA #05343 and is a TAP member). Dr. Hudson is a member of the Reaction Research Collaboration, and has been an active member with the Aerospace Rocketry Association of the Pacific (AeroPac), where he has made many flights of his Ho’ola rocket (using an M1419 motor) as part of the ARLISS (A Rocket Launch for International Student Satellites) program.

**HCC (CoPI) Faculty Mentor**
Dr. Shidong Kan  
Phone Number: (808)-845-9499  
E-mail: shidong@hawaii.edu

Dr. Shidong Kan is an Assistant Professor of Physics at Honolulu Community College. He is the college's Associate Director of Hawaii Space Grant Consortium (HSGC). Dr. Kan has taught various Physics courses at University of Hawaii at Manoa and Honolulu Community College including introductory physics, algebra based and calculus based physics. He is also the Principle Investigator of a Federal Grant - Pre-Engineering Education Collaborative II (PEEC II).

**HCC Faculty Co-Mentor**
Mevan Ranasinghe  
Mr. Ranasinghe lectures freshman and Sophomore Engineering classes at the Honolulu Community College pre-engineering program. He will assist Dr. Kan by serving as a co-mentor for the HCC team.

**HCC IT and Payload Specialist Staff**
Ms. Helen Rapozo is an IT specialist at HCC and will serve as a mentor for IT and payload development.
1.3 Student Team Leads
Because of the collaborative nature of our team, occupying several campuses, we two team leads. The WCC team will lead the design, and construction of the rocket vehicle while the HCC team will develop the deployed payload.

**Rocket Team Lead** - Damien Apilando ([damienap@hawaii.edu](mailto:damienap@hawaii.edu)) is a level 3 certified member of the Tripoli High powered Rocketry Association, an experienced programmer, and game designer. Damien played an instrumental role in Project Imua's RockSat-X project for the last year, has lead this year’s ARLISS project, and has shown himself to be a good organizer.

**Payload Team Lead** – Ryan Young ([ryancy@hawaii.edu](mailto:ryancy@hawaii.edu)) is in the HCC pre-Engineering program, with experience in designing circuitry, and is new to rocketry.

1.4 Safety Officer
Aolani Zidek ([azidek@hawaii.edu](mailto:azidek@hawaii.edu)) has been assigned as the safety officer of the team. She has been briefed about standard safety procedures by both Jacob Hudson, who has years of experience with preparations and flights with regards to high power rocketry, and also holds a level 3 certification from both NAR and TRA, and by Lisa Hayashi, the Laboratory Director on the Windward Community College campus. Because of this, we believed her to be the most ideal choice to overlook and implement the safety plans of the team.

Assisting Aolani, who is located primarily at WCC, will be Adriana Saymo ([afsaymo@gmail.com](mailto:afsaymo@gmail.com)) associated at HCC.

1.5 Team Overview
The project team faculty will consist of Principal Investigator Dr. Joseph Ciotti, Rocket Team Leader Dr. Jake Hudson, Payload Experiment Team Leader Dr. Shidong Kan, and HCC mentor Mr. Mevan Ranasinghe. The HCC staff IT and payload design specialist is Helen Rapozo.

There are currently twelve student team members. The Rocketry Team consists of three Windward Community College and three UH Manoa students with one of these students designated as the Rocketry Team Leader. The Payload Team consists of six Honolulu Community College with one of these students designated as the Payload Team Leader. In addition, several students have dual roles by also serving on our Safety and Website teams. While student roles are tentatively assigned by task in the Team Organizational Chart (figure 1.5), the student roles may change leading up to the Critical Design Review.
1.5.1 Team Leads
The Team Leads, Damien and Ryan, will be responsible for leading the team, managing risks and issues, and ensuring the team is successful during the competition. The Team leads will also perform the duties of Engineering team members as needed.

1.5.2 Safety Officers
There will be one Safety Officer for each of the Engineering teams; Aolani is for the Rocket Team and overall, with Adriana for Payload team. Safety Officers will be responsible for creation and implementation of the safety plan. The Safety Officers will also perform the duties of their respective Engineering teams.

Figure 1.1: SLP Team Organizational Chart showing Rocket Development by WCC on left, and Payload (Experiment) development by HCC on right.
1.5.2 Social Media Officer
The Social Media Officer for the team is Kathy Bronston (Katbronston@hawaii.edu). The Social Media Officer will be responsible for the STEM Engagement Plan, websites, and social media components for the competition. The Safety Officers will also perform the duties of their respective Engineering teams.

1.5.4 Vehicle Engineers
The vehicle engineers are responsible for the development, construction, and testing of the Rocket, and to make sure that the vehicle fulfills the desired mission criteria:
(a) The rocket will reach an altitude between 4000’ to 5500’ AGL.
(b) The rocket will be single stage using a dual deploy recovery system.
(c) The rocket will have a pad stay time in excess of 2 hours.
(d) The rocket will have separate and redundant avionic units.
(e) The rocket will use a standard 12 V direct current firing system.
These are designated as Energetics, Avionics, Recovery and Construction on our Organization Table.

1.5.5 Payload Engineers
Payload Engineers responsible for the development, analysis and testing of the Deployable Rover/Soil Sample Recovery system. The payload team is responsible for:
(a) Completion of the payload experiment requirements.
(b) Integration of the payload and electronics into the launch vehicle
(c) Testing of wireless communication from the payload to the remote deployment station.
These are designated as Electronics, (Payload) Recovery and Construction on our Organization Table.

1.6 NAR/TRA Section
The University of Hawaii Community College team will be associated with the NAR section Center for Aerospace Education Launch for University Students (CAELUS) NAR# 800. The goals of CAELUS are to support NAR activities on O‘ahu, operate and maintain a rocket range on the WCC campus in accordance with the NAR standards and Safety Code, and promote rocketry throughout Hawai‘i.

The team’s principle investigator, both UHCC mentors, as well as information technology (IT) resource, Helen Rapozo, are members of CAELUS. Therefore CAELUS will be active in mentoring the team, reviewing the team’s design, and assisting at launches. Additionally, several members of the UHCC SLP team belong to Tripoli Hawaii (TRA Prefect #105).
2.0 Facility and Equipment

2.1 Description of Facilities

2.1.1 Main Facilities (WCC)

The location of our main workroom is at Windward Community College (WCC), Hale ‘Imiloa Room 112. This room, part of the Center for Aerospace Education (CAE), is the Hawai‘i Space Grant Trainee workroom, and the Payload Environmental Test Facility (PET) at WCC. The HSGC/PET is a high-tech computer classroom originally designed to give students in grades 7-12 a project-based learning environment for applying skills in math and science, and was part of NASA’s Mobile Aerospace Education Laboratory program (MAEL). It has since been converted to a diagnostic testing room for payload construction and testing. This room is accessible to all SLP students and mentors during normal school hours, 7:00 a.m. through 9:00 p.m. It is also accessible on Saturdays from 8:00 a.m. to 4:00 p.m., and any other hours as needed. This is a semi-secure room, as it is normally closed and electronically locked. The room is considered semi-secure because students participating in other projects or study groups may be granted suitable access keys. Two small-scale, subsonic, wind tunnels, a zero-g drop tower, a shake-and-spin table, several solder stations, a 3D printer, and a miniature, programmable milling machine are available to the team members at this location.

The SLP team members may use the HSGC/PET room for assembly of rocket and payload parts. However, since construction, fabrication, and/or alteration of said parts may not be appropriate in that area during lecture hours, all such activities are constrained as appropriate. Since WCC has no machine shop facilities, construction may be completed elsewhere.

![Figure 2.1: Students working in Trainee Room.](image)

For more involved construction, the team also uses the Project Fabrication Workshop (PFW), which is our new room to construct and store our various rockets, payloads, equipment, and parts. The PFW is located in Lanihuli Iki, a building nearby Imiloa, and is a necessary addition to help facilitate with the construction of our larger rockets and various parts of our projects. We have
virtually unlimited access to this secured facility, which is under campus security patrol 24-7.

2.1.2 Main Facilities (HCC)

2.1.2.1 HLE Facility
The Honolulu Community College’s (HonCC) main workspace is the Robert Allen Memorial Lab, more commonly called the HLE (Hobbiest Level Electronics). The HEL lab is located at Building 72A on the HonCC campus. At this location we can:

1. Prototype electronic circuits using breadboards and 'through the hole' devices. These circuits typically use Arduino-based controllers as the main processor.
2. Test equipment using multimeters.
3. Build model rockets utilizing 18mm and 24mm motors.
4. Prepare electronic payloads, either commercially available or custom built.

Lab hours are Monday through Friday from 8:00am to 5:00pm but can be opened at other times with advance notice to campus facilities. Facility equipment includes tools and materials to prototype electronic circuits, construct model rockets, and test Arduino controllers. The lab provides the team with: internet access, email, telephone conferencing, CAD, Google Core Apps, and Office software packages.

![Figure 2.2: Robert Allen Memorial Lab or HLE](image)

2.1.2.2 Sheet Metals and Plastics Building
The Sheet Metals and Plastics Technology program is located in Building 17 on the Honolulu Community College (HonCC) campus. Facility equipment includes a
CNC plasma cutter, CNC router, main shear for up to ⅛ inch plate, turret punch, horizontal and vertical band saws, various bending, turning, and edging machines. By partnering with the Sheet Metals and Plastics program, the SLP team has access to metal and plastic based manufacturing. Components will be constructed by students training to enter the trade of sheet metal as apprentices under the safe supervision of instructors.

Figure 2.3: Sheet Metals and Plastics Workshop  Figure 2.4: Example of the level of detail

2.1.2.3 Carpentry Building
The Carpentry Technology program is located in Building 14 on the Honolulu Community College (HonCC) campus. Facility equipment includes table saws, surfaces, joiners, routers, jigsaws, various hand tools, lathes, a sanding machine, panel saw, vacuum pump, metal drill press, belt sander, and a CNC machine. By partnering with the Carpentry program, the SLP team has access to wood and fiberglass manufacturing. Components will be constructed by HonCC students training to enter the trade of carpentry as apprentices, under the safe supervision of instructors.
2.1.2.4 3D Printer
The Architectural Drafting Lab is located in Building 2 on the Honolulu Community College (HonCC) campus. The lab has a Dimension 1200es 3D printer which can turn CAD files into models using a production grade thermoplastic. The printer has a build volume of 10 x 10 x 12 inches and a layer thickness of .010 or .013 inches of model material. By partnering with the Tech II program administration, the SLP team has access to 3D printing. Components will be constructed under the safe supervision of instructors.
2.1.2.5 HCC Student Parking Lot 1C

The Student Parking Lot 1C is located nearby the Robert Allen Memorial Lab. The SLP team can use this space to launch model rockets up to and altitude of 150 feet. Launches higher than 150 feet are regulated by the FAA due to the proximity to the Daniel K. Inoue International Airport.

![Student Parking Lot 1C](image)

Figure 2.7 : Student Parking Lot 1C

2.1.2.6 Web Conferencing Capabilities

The SLP Payload team uses Building 5, room 130 for its conference calls and presentations. The room is equipped with desktop computers, a projector, and speakers. The team has access to a Logitech C920 HD Pro webcam during conference days.

2.1.2.7 Vendor Relationships

The SLP Payload team regularly works with the commercial vendors ExpressPCB and Advanced Circuits to manufacture various hardware it uses in its competitions. Most recently the team used a circuit board for a UAV project in its 2018 ARLISS competition.

2.1.3 Auxiliary Facilities / Events

WCC hosts the CAELUS (Center for Aerospace Education Launch for University Students) Rocketry Club of Hawaii launches on the third Saturday of each month from 2:00 p.m. to 5:00 p.m., during which the SLP team can conduct low powered launches for testing.

The CAE at WCC, with permission, has launched from the Kaneohe Marine Corps Air Station (KMCAS) in the past, and will likely be able to do so in the future.
The KMCAS has considerably more space available for larger, higher powered launch opportunities, which would not be capable at WCC. At those launches, KMCAS halts its flight operations and cedes its airspace control over to Federal Aviation Administration, allowing us to fly up to but not exceeding 2500 feet.

WCC is a liberal arts community college known for its Hawaiian language and science programs, and does not yet have an industrial program or machine shop. However, WCC has subcontracted several nearby industrial scale manufacturers for specific jobs when needed. Chief among these are:

Universal Manufacturers
1711 Kalani Street
Honolulu HI 96819
Ph: 808-845-5971
info@umhawaii.com

Oahu Makerspace
2004 Kahai Street
Honolulu HI 96819
Ph: 808-845-MAKE
ross@oahumakerspace.com

HCC also hosts the CAELUS (Center for Aerospace Education Launch for University Students) Rocketry Club of Hawaii launches on the first Saturday of each month between 11:30 a.m. and 2:30 p.m. The SLP students can launch small model rockets to loft individual payload components intended to be combined into the final SLP payload experiment. These facilities and launches will also be part of our educational outreach requirement. All students attending HCC and members of the overall community will be invited to subsets of these Saturday launches.

2.2 Necessary Personnel, Facilities, Equipment, Required

2.2.1 Necessary Personnel
Dr. Joseph Ciotti, acting as the principal investigator and project Imua Manager, is essential for management, coordination between campuses, and the funding of our SLP project. This includes travel and shipping costs associated with the project.

Dr. Jacob Hudson is the legal entity and mentor of the WCC team, leading the construction of the rocket. As such, he will be present at most of the team’s events. These events include the various types of launches that will be conducted. He will also be present at the SLP competition launch, since he is the designated Rocket Mentor and NAR point of contact.

Shidong Khan is the primary faculty mentor for HCC team of students, leading the construction of the payload.
Additionally, HCC has a resource consultant: Helen Rapozo. Helen is the point of contact with NAR and HCC CAELUS campus chapters. Her affiliation with NAR, and experience with student model rocket launches (CAELUS) at HCC, is necessary to insure safety protocol for launches at HCC.

For our team to be successful it is necessary that all team members complete their assigned duties. It is planned that all team members, except for Dr. Ciotti, will travel to Huntsville. However, it is only essential that Dr. Hudson and three team members travel to Huntsville to ensure proper safety and operations of the project.

2.2.2 Necessary Facilities

The facilities available to the SLP team have been mentioned in a previous section. However, the facilities that are essential for success are the Hale 'Imiloa Trainee workroom and usage of the KMCAS west field. The workroom acts as the headquarters for the team, as well as houses most of the fabrication equipment. Usage of the KMCAS west field is needed to conduct a powered test-flight of the completed rocket to demonstrate safe dual deployment, a requirement for the competition. There is no other location where we can launch a rocket and accompanying motor of that size and be able to retrieve it safely.

Should availability of KMCAS be curtailed, then a contingency would be to launch our project at an AeroPac sanctioned launch in the continental U.S. Since WCC has taken part in ARLISS (A Rocket Launch for International Student Satellites) and XPRs (Experimental Projects in Rocketry) for the past eleven years, there is existing infrastructure in place with the AeroPac group, and a test launch could easily be carried out.

2.2.3 Necessary Equipment

The equipment needed shall include but is not limited to:

1. Basic hand and power tools required for wood, fiberglass, composite and metal work, construction and fabrication.
2. Electronic/computer specific tools for electronic circuit fabrication, construction and testing.

Most necessary construction and fabrication tools are team member owned. Specialty tools not owned or available to team members may be purchased when the need arises, provided funding is available.

2.2.4 Components for the rocket:

Fiberglass tubing, G-10 fiberglass, birch plywood, plastics epoxy, aluminum tubing, aluminum sheet, paint, cyanoacrylate, resin.

2.2.5 Components for the payload:

Payload components for the primary Rover Deployment experiment include
fiberglass tubing, the nose cone and birch plywood bulkheads to house the Rover, its Deploying mechanism, the optional secondary experiment and additional avionics for the rocket that will be housed in the payload section, as well as the parachute for this section.

The electronics will include batteries, Arduino-based microcontrollers, radio receiver and electric motors that will help with the release of Rover and deployment of solar panels. The Rover itself would be constructed using aluminum or 3-D printed plastic and will have additional sensors to help track its movement. Plastic would be used for the wheels, gears and the possibility of using a track treads for the Rover.

Components for the secondary optional experiment, which will be a measure and store mission that will record the motion of the rocket in flight will include an Arduino-based microcontroller, one or two accelerometers, a MicroSD data storage system and a battery power source to power this experiment.

The electronics for the Rover, the Deploying mechanism, and the secondary optional experiment will be soldered on custom designed printed circuit boards.

2.3 Computer Equipment

The computer equipment accessible to team members includes:

NASA AEL Computers (HSGC/PET Trainee room): 8 desktop computer stations designed for the NASA AEL running Windows 7 Enterprise.

In addition to the school computers mentioned, team members will use personal computers to communicate via e-mail, Skype, and Google Groups.

The team will be provided the NASA AEL computer laptop for webcasting or video teleconferencing, with the following specifications:

a. Broadband connection
b. Windows XP
c. Built in microphone and speakers
d. Firewall, USB, and built in video camera
e. Personnel for firewall issues will be handled through WCC’s

For computer related issues and logistics, the WCC Information Technology Specialist, Bryan Tokuda, is available. Phone number: (808) 235-7307. Email: btokuda@hawaii.edu

Should communication with MSFC via Skype not be possible, a Life Size unit (the next generation of Polycom) is available.

Computer equipment is available at Honolulu Community College Building 72A, HLE (Hobby Level Extension) area. All computers are connected to the campus Ethernet network. The computers available for team members are:
A. iMac desktop computer with MacOS X 10.10.5 - this computer can be used for video conferencing using Google Talk/Hangouts.

B. Dell GX-520 desktop computer with Windows 7.

C. HP Zero Client with Windows 10 Education.

D. Four - HP Zero Clients with Windows 7.

E. HP Color LaserJet.

F. Monitors, keyboards and mouse units that can be used to support Raspberry Pi 2 and Raspberry Pi 3 operations (these systems will not be connected to the campus Ethernet network).

We have desk space in the HLE area so that users can bring in their own laptop computer, should they choose to do so. They can also access AC power and the campus WiFi network.
3.0 Safety

3.1 Safety Plan

The team’s current mentor, Dr. Hudson, is a level 3 certified member for both National Association of Rocketry (NAR) and Tripoli Rocket Association (TRA). The Team Official, Dr. Hudson, has overseen all launch operations and motor handling. His contact information can be found in section 1.2. The team’s Student Safety Officer is Aolani Zidek (azidek@gmail.com). The Safety Officer will be familiar with the rules and regulations contained in 27 CFR Part 55- Commerce in Explosives. All team members will abide by the launch site rules and all rulings made by the Range Safety Officer. The Safety Officer will be familiar with and maintain copies of the most current Safety Data Sheets (SDS) for the chemicals/ materials utilized by the team.

Responsibilities:
The Safety Officer is responsible for the following, emphasizing safety:

- Ensuring all team members have PPE and appropriate clothing while constructing and assembling payload
- Ensuring payload design is safe
- Maintenance of Safety Data Sheets and procedures
- Attentive in identifying new hazards during design

Aolani and Dr. Hudson has, and will continue to insure that the team follows all the NAR/TRA safety protocols throughout construction. Dr. Hudson and Aolani has briefed students on hazard recognition, accident avoidance, and conducted pre-launch briefings. Aolani, overseen by Dr. Hudson, has been, and will continue to be present during all phases of construction to ensure that all proper safety measures are taken while using the tools and equipment needed to complete the project. This includes the use of Personal Protective Equipment necessary to operate tools and machinery. In addition, Aolani is CPR/AED/First-Aid certified through the American Red Cross.

It is understood by the UHCC team that being familiar with all aspects of rocketry, including construction, pre- and post-flight preparation are essential to maintaining safety. The team has 3 level 2 certified members of TRA and a mentor that is level 3 certified for both NAR and TRA. The team also has two other students that are level 1. These certifications ensure that the team is adequately acquainted with Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C, and also has sufficient knowledge on handling and using low-level explosives (Ammonium Perchlorate Rocket Motors, APCP), fire prevention, Code of Federal Regulation Part 55, and NFPA 1127. All noncertified team members have been briefed, are aware, and will abide by all of these laws and regulations.

In addition to these rules and regulations, the entire team is aware and will be compliant of all federal, state, and local laws concerning the use of unmanned rockets and their components. References to safety regulations can be found in Appendix B-D. To ensure that no safety precautions are overlooked a very detailed
preflight checklist has been made (ref. Pre-Flight Checklist). This will guarantee that all rules and regulations are followed concerning the preparation and launch of our rocket. For greater safety precaution and knowledge, a flight card will be used before each launch to keep track of flights and flight results. The Rocket Team Mentor, Dr. Hudson, is in charge of purchasing, storing, transporting, and using the rocket motors. All flammable materials are stored in a type 3/4 indoor magazine storage device. The only person with access to this storage device is Dr. Hudson.

The team is also aware of the Material Safety Data Sheets (MSDS) for the materials needed for the project, which can be accessed from our website [link]. Hazard mitigations regarding these materials are showed in the table in Appendix G. The MSDS sheets are also shown in Appendix G.

The Hawaii team has purchased their motor from a mainland vendor, and is stored by the vendor until the team arrives. From the time of procurement through the point of use, the motor will be handled properly and the team shall follow all proper guidelines defined in all applicable federal laws and NAR/TRA regulations.

All team members understand and will abide to the range safety inspection of our rocket before its flight, and will comply with the determination of this safety inspection. The team also understands that the Range Safety Officer has the final say on all rocket safety issues, and as such has the right to deny the launch of our rocket for safety reasons.

Our workspace is divided between three areas: the Trainee Room, the room adjacent to the Trainee Room, and PFW (Project Fabrication Workshop). Each room is equipped with the necessary safety materials. The Trainee Room has two first aid kits, one fixed and the other is portable, and two fixed fire extinguishers. The adjacent room has an emergency shower and eyewash station, three ventilated work stations, a fire blanket, and a set of MSDS files. The PFW has a first aid kit and portable fire extinguisher.

The following table outlines the safety requirements and recommendations we follow throughout construction:

<table>
<thead>
<tr>
<th></th>
<th>Eyewear</th>
<th>Mask</th>
<th>Closed-toe Shoes</th>
<th>Gloves</th>
<th>Apron</th>
<th>Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Tools</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>r</td>
<td>R</td>
</tr>
<tr>
<td>Gluing</td>
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<td>R</td>
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<td>r</td>
<td>R</td>
</tr>
<tr>
<td>Fiberglassing</td>
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<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Soldering</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>

R = required  
r = recommended
3.1.1 NAR/TRA Personnel Description

The team's current mentor, Dr. Hudson, is a level 3 certified member for both National Association of Rocketry (NAR) and Tripoli Rocket Association (TRA). Additionally, Dr. Hudson is a Tripoli Prefect and TAP (Technical Advisory Panel) member, as well as being a L3CC (Level 3 Certification Committee) member. As the Team Official Dr. Hudson will oversee all launch operations and motor handling. His contact information has already been mentioned previously.

The team will be following all the NAR/TRA safety protocols (Appendix B and C). Dr. Hudson has briefed students on hazard recognition, accident avoidance, and will be conducting pre-launch briefings at every launch that the team is involved with. Hazardous materials will be handled according to the Materials Safety and Data sheets (MSDS – Appendix G).

3.1.2 NAR High Powered Safety Compliance

The Rocketry Team’s mentor, Dr. Hudson, is a level 3 certified member for both National Association of Rocketry (NAR) and Tripoli Rocket Association (TRA). Additionally, Dr. Hudson is a Tripoli Prefect and TAP (Technical Advisory Panel) member, as well as being a L3CC (Level 3 Certification Committee) member. Additionally, the Rocket Team Student lead, Damien Apilando is level 2 certified with TRA, and is the process of certifying at level 3. As the Team Official, Dr. Hudson will oversee all launch operations and motor handling. His contact information has already been mentioned previously. The team will be following all the NAR/TRA safety protocols. The team safety officer, Aolani and Dr. Hudson have briefed students on hazard recognition, accident avoidance, and will oversee the conducting pre-launch briefings.

The team has a level 3 certified member of TRA and a mentor that is level 3 certified for both NAR and TRA. The team also has two other students that are level 2 certified, as well as two students that are level 1. These certifications ensure that the team is adequately acquainted with Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C, and also has sufficient knowledge on handling and using low-level explosives (Ammonium Perchlorate Rocket Motors, APCP), fire prevention, Code of Federal Regulation Part 55, and NFPA 1127. All noncertified team members have been briefed, are aware, and will abide by all of these laws and regulations. In addition to these rules and regulations, the entire team is aware and will to be compliant of all federal, state, and local laws concerning the use of unmanned rockets and their components. References to safety regulations can be found in Appendix B-D.

To ensure that no safety precautions are overlooked a very detailed preflight checklist has been made (ref. Pre-Flight Checklist), this will guarantee that all rules and regulations are followed concerning the preparation and launch of our rocket. A flight card will be used before each launch. The team's mentor, Dr. Hudson, is in charge of purchasing, storage, transport, and use of the rocket motors. Any
flammable material is stored in type 3/4 indoor magazine storage device. The only person with access to this storage device will be Dr. Hudson.

3.1.3 Student Hazard Recognition and Avoidance

The UHCC safety officer Aolani and Dr. Hudson will ensure that all proper safety measures are taken while using the tools and equipment that will be needed to complete the project. This includes the use of Personal Protective Equipment necessary to operate tools and equipment.

The team will also be aware of and post the Material Safety Data Sheets (MSDS) for the materials needed for the project. MSDS are posted on our website (imua.www.hawaii.edu). Hazard mitigations regarding these materials are shown in the table in Appendix G.

3.1.4 Compliance

The UHCC SLP team is adequately acquainted with Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C, and also have sufficient knowledge of handling and using low-explosives (Ammonium Perchlorate Rocket Motors, APCP), fire prevention, Code of Federal Regulation Part 55, and NFPA 1127. All noncertified team members have been briefed, and will abide by all of these laws and regulations. In addition to these rules and regulations, the entire team will be compliant to all federal, state, and local laws concerning the use of unmanned rockets and their components. References to safety regulations can be found in Appendix B-G. To ensure that no safety precautions are overlooked, a very detailed preflight checklist will be made. This will guarantee that all rules and regulations are followed concerning the preparation and launch of our rocket.

A flight card will be used before each launch. The Rocket Team’s mentor, Dr. Hudson, is in charge of purchasing, storage, transport, and use of the rocket motors. Any flammable material is stored in type 3/4 indoor magazine storage device. The only person with access to this storage device will be Dr. Hudson.
At all CAELUS pre-launch briefings, students are reminded of...

1. All NAR rules are to be strictly adhered to.
2. There is a Launch Control Officer (LCO) that is in charge of determining proper pad assignment, control of launch order, determining of final launch readiness, and allowance onto the pad area.
3. There is a Range Control Officer (RCO) that is in charge of determining that the motor is proper for the rocket, the rocket is safe, the motor is retained properly, recovery system is intact, and allowance for entry to the launch readiness area.
4. It is understood that when the rocket is on the pad, the launcher is very much aware that of all the forces and possibilities in the universe, the one thing that cannot be done is to “unpush” the launch button after it has been pushed.
5. It is understood that when the rocket is on the pad, the launcher is very much aware of the fact that once launched, a rocket will do what it is constrained to do – that may not have been what it was designed to do.

3.1.5 Motor Procurement

The Hawaii team will be purchasing our motor from Mike Gentile’s company, Bay Area Rocketry, and trucked cross-country to the hotel we will be booked at in Huntsville. From the time of purchase through the point of use, the motor will be handled properly and the team shall follow all proper guidelines defined in all applicable federal laws and NAR/TRA regulations.
All team members understand and will abide to the range safety inspection of our rocket before its flight, and will comply with the determination of this safety inspection. The team also understands that the Range Safety Officer has the final say on all rocket safety issues, and as such has the right to deny the launch of our rocket for safety issues.

3.1.6 Acknowledgement of Safety Regulations

Safety is of paramount importance to the Hawaii team. It is understood by the UHCC Student Launch Project Team that the following three subsections will be strictly adhered to.

3.1.6.1 Range Safety Inspection

The UHCC team acknowledges that there will be a Range Safety Inspection of the rocket before it is flown. Determination that the recovery devices have been properly integrated into the rocket, that the Center of Pressure is a sufficient distance below the Center of Gravity for safe flight stability, that there is a proper thrust-to-weight ratio, and that there are no external obstructions that would inhibit the safe flight of the rocket. The inspecting official will issue a punch-list that must be completed before the rocket is allowed to the launch pad. Failure to complete the punch list means that no flight will occur. The UHCC team shall comply with the safety inspection or it will not be flown.

3.1.6.2 Range Safety Officer

The Range Safety Officer is required to have detailed knowledge of the National Association of Rocketry (NAR) High Power Rocket Safety Code. Additionally, the Safety Officer will be knowledgeable of the requirements set forth in the following: NFPA 1127, Code for High Power Rocketry, 14 CFR Subchapter F, Part 101, subpart C-Amateur Rockets, and all governing FAA regulations. The Range Safety Officer will be familiar with the rules and regulations contained in 27 CFR Part 55- Commerce in Explosives. All team members will abide by the launch site rules and all rulings made by the Range Safety Officer. Our range safety officer is Damien Apilando.

The UHCC team acknowledges that the Range Safety Officer (RSO) has the overall safety of the team, participating public attending the launch, as well as the surrounding grounds and overall air space that the launch will take place at, foremost. As such, the UHCC team acknowledges that the RSO has the final say on all rocket launches, including denial of launch for any safety issues they may find. The UHCC team shall comply with the RSO.
3.1.6.3 Range Safety Requirements

It is understood, and acknowledged by the UHCC team that failure to adhere to the safety requirements, either unaddressed items of the Rocket Safety Inspection punch-list or concerns raised by the Range Safety Officer, will result in not being allowed to launch.
4.0 Technical Design

4.1 Proposed Approach to Rocket and Payload Design

In order to reach the desired altitude, the overall strategy of the UHCC SLP team’s rocket design is to over power the rocket to guarantee that it reaches an unmodified height in excess of 5280 feet (but no higher then 6000 feet). Before lift-off, two drag shoes will be manually deployed at a specific angle so as to enhance the drag on the rocket, thus reducing the rocket’s in-flight altitude in an attempt to match our desired target altitude. Throughout the entire designing and building of the rocket, safety was and will continue to be the primary concern.

**Figure 4.1** A diagram showing the proposed flight profile of the rocket.

The launch vehicle’s primary payload will be Option 1 as defined in the 2019 NASA Student Launch Handbook and Request for Proposal: Deployable Rover/Soil Sample Recovery. A secondary experiment will also be included. It will measure and store the acceleration of the rocket’s flight. The secondary experiment will be completely independent of the primary experiment.
4.1.1 General Vehicle Information/Dimensions

In order to continue its efforts at promulgating interests in science, technology, engineering, and mathematics, the Center for Aerospace Education (CAE) would take the lead in construction of a re-usable rocket to perform diagnostic testing for several of our education outreach projects. The rocket would be designed to carry a non-specific payload, of limited weight and size, to a specific altitude of 1 mile (5280’), and then be recovered safely. To ensure re-usability, the rocket would deploy a drogue chute at apogee, and a larger main chute at a lower altitude – high enough for a safe landing, yet low enough to ensure retrieval in a limited area.

![Rocket Diagram]

Figure 4.2

The rocket is a little over 116 inches in length, with a 4-inch diameter. It has 4 trapezoidal fins, each having a span of 5 inches. The overall length of the rocket is determined by combining the payload needs with the logistics required by the dual deployment recovery system. The rocket design started with a choice of body diameter. This was determined by payload considerations to some extent, but mostly for chute packing considerations. A 4-inch diameter body tube was chosen because it gave the team a good flexibility in determining the payload volume, a reasonable chute packing volume, and a wide range of motors that could be used for various altitude flights. Once the diameter was set, the nosecone of standard ogive 1:5.16, yielded a nosecone length of (just a little under) 21 inches – which is
convenient because this shape is commercially available. The nosecone will contain most of the payload electronics, and directly aft of it, the payload package itself. Attached permanently to the shoulder of the nosecone is the payload carrier section of the rocket. The length of this section was determined by estimating the length of the payload, which is 10 inches. This nosecone/tube section, referred to as the payload carrier unit, will descend separately from the rest of the rocket when the main chute is deployed. The next section contains the rocket avionics, the stowed main chute, along with its deployment pyrotechnics, and the avionics container (6 inches in length). The length of this section is 42 inches, and is referred to as the Fore section. The avionics electronics will consist of an Altus Metrum TeleMega with GPS tracking and telemetry, and a PerfectFlight StratologgerCF as back-up. Both of these units have been flight tested at this last ARLISS launch.

The section below the Fore section is the Booster section, which houses the motor, the motor mount, the Aero Pack quick change 54 mm motor retainer, the fin can and 4 fins, the drogue chute, drogue deployment pyros, as well as the Variable Drag Assembly (VDA). The fin assembly is a 4-fin aluminum unit manufactured by Max Q Aerospace. The fins are machined from 0.125 inch 6006-T6 aluminum plate, and each fins is held to a can assembly using 11 hex bolts. Having fins that are removable has proven to be convenient for shipping purposes - previous SLP entries have shown that having the fins fixed made the cost of shipping exorbitant.

The rocket mass is estimated to have an unloaded weight of 26.4 lbs (12.0 kg) and a loaded, or pad weight of 32.2 lbs (14.5 kg).
The UHCC Team, while participating in previous SLP, ARLISS and RockSat-X attempts, has compiled a litany of ways that the postal delivery systems can damage a rocket before delivery to Huntsville. Additionally, fins that are permanently attached to the body tube cause an exponential cost in the shipping. As such, the UHCC team has purchase from Max-Q Aerospace a CNC machined aluminum fin can made for 4” diameter body tubes. The fins are machined from 0.125” 6061-T6 Aluminum plate, and then beveled. The four fins are held in place by four shaped plates that are bolted to the body tube. Each fin has the edge of two shaped plates, one on each side of the root chord, and bolted together with 12 bolts. The final assembly is one solid integrated structure that can be disassembled for transport.

Of interest, but not really a major concern, was of the fin flutter speed. The fin flutter speed, or the speed that yields an extraction of energy from the air stream flowing over the fins, could result in deformation of the fin while in flight. This deformation, usually a transient phenomenon, could in turn (if sustained) transform any rotational motion about a principle axis to rotation about a minor axis. In effect, fin flutter can transform rotation about the long axis into tumbling about the minor axis.

Determining the velocity of the onset of fin flutter is not hard, and was done as a NACA exercise back in 1958 [“Summery of Flutter Experiences as a Guide to the Preliminary Design of Lifting Surfaces on Missiles” NACA article TN4197, D. J. Martin 1958], and more recently a magazine article in Sport Rocketry [Sport Rocketry Magazine (March/April 2012 p. 18-22)];

\[
\frac{V_f}{a} = \frac{G_E}{39.9A^3 \left( \frac{t}{c} \right)^3 \left( \frac{A+2}{2} \right) \left( \frac{P_{atm}}{P_o} \right) + 2} = \frac{G_E}{1.337A^3 \left( \frac{t}{c} \right)^3 \left( \frac{A+2}{2} \right) + 2}
\]
Where $v_f$ is the flutter speed, and $a$ is the acoustical speed in air (speed of sound). $G_E$ is the effective shear modulus for 6061 T-6 Aluminum plate, and this can be found on-line and has a value of 28.0 GPa. The rest of the terms are based on the geometry of the fin shape. The ratio of the fin thickness to the root chord length is...

$$\frac{t}{C_R} = \frac{0.125'}{13.2'} = 0.010$$

The Aspect Ratio $A$, is the ratio of the span length and the median chord length.

$$A = \frac{s}{c} = \frac{2s}{(c_R + c_T)} = \frac{2(5.04')}{13.2' + 2.05'} = 0.6610$$

The tapper ratio $\lambda$, is the ratio of the tip chord length to the root chord length.

$$= \frac{2.05'}{13.2'} = 0.1553$$

Lastly, $P_{atm}$ is the atmospheric pressure 101.3 kPa at sea level, but 100 kPa is used to correspond to about 600 feet elevation, the average for Huntsville.

$$\frac{v_f}{a} = \left[\frac{20 \times 10^6 \text{Pa}}{1.337(0.6610)^3(100 \times 10^3 \text{Pa}) (0.010)^3 (2.661)} \sqrt{\frac{2.1553}{2}} \right] \sqrt{\frac{28.0 \times 10^4}{(1.45 \times 10^5 \text{Pa})(1.078)}} = 1.38$$

So, it looks like the rocket would have to reach Mach 1.4 before the onset of fin flutter. Since the rocket does not ever become sonic, this is not an issue.

### 4.1.1.2 Variable Drag Assembly (VDA)

As has been already mentioned, the overall strategy for obtaining a precise altitude is to slightly over power the rocket for an apogee above the desired target height. The Variable Drag Assembly consists of 2 hinged flaps (shoes) that will be deployed to preset angles prior to launch. Since the drag force acting on the rocket depends (to first order) directly on the cross-sectional area of the rocket, the VDA acts to vary the drag force to reduce the overall apogee to the desired height.

$$F_D = \frac{1}{2} C_D A_{CS} v^2$$
A simple calculation shows that the cross-sectional area varies as...

\[ A_{CS} = \frac{1}{4} D^2 + 2\left[\frac{1}{2}(bh) + bh\right] \sin \theta = \frac{1}{4} D^2 + 3bh \sin \theta \]

...where \( D \) is the main body tube diameter (4”), \( b \) is the tip chord width of the variable brake shoe (0.5”), \( h \) is the length of the brake shoe (4.25”), and \( \theta \) is the deployment angle. The percent change \( \Delta \% \) in the cross-section area due to the deployment of the drag shoes becomes...

\[ \% = \frac{A_{CS}}{\frac{1}{4} D^2} = 1 + \frac{12bh}{D^2} \sin \theta = 1 + \frac{12(0.5”)(4.25”)}{(4”)^2} \sin \theta = 1 + (0.50)\sin \theta \]

...which means that if the shoes are deployed to 90 degrees (full extension), the drag force could be increased as much as 50%. The team is aware that this is extremely simplistic in approach; the drag coefficient has been treated as a constant in this analysis – the drag coefficient is non-linearly related to the Reynold’s number, and the Reynold’s number is a function of the fluid flow. That being stated, the team does not expect to deploy the drag shoes at an angle greater than 30 degrees, which corresponds to an optimistic maximum altitude loss of 25%.

Whereas small wind-tunnel testing has shown this estimate to be over-optimistic by 16%, small scale testing using model rockets has shown that when the drag shoes are deployed to 45 degrees, the rocket lost ~12% of its un-deployed altitude with an uncertainty of +/- 8%. Small scale rocket testing will continue. It should also be mentioned that several rocket flights having one shoe fully deployed to 90 degrees,
with the other set at 0 degrees, have been made to show that the rocket is still stable should one of the shoe deployment retaining devices fail in flight.

4.1.1.3 Avionics

In high-powered rocketry it is a well-known maxim that “the up part is easy, the devil is in the recovery”. Arguably the most important section of the rocket is the avionics section. The AV section controls all aspects of the flight profile; monitoring the ascent rate, deploying the drogue at apogee, and the main chute at the desired distance.

The UHCC team has chosen the Altus Metrum TeleMega V3.0 as our primary unit, and the PerfectFlight Stratologger CF as a redundant unit. The Altus Metrum TeleMega unit is a high end recording dual deploy altimeter unit with integrated GPS and telemetry link and configurable pyro events. This unit uses a rechargeable 3.7V (850 mA) S1 JS-connected, battery for a power source.

The PerfectFlight Stratologger CF (Compact Footprint) is a high precision altimeter with full data logging and dual deployment capability. This unit uses a standard 9V dry cell for power. Because the flight events are so easily configured for this unit, it makes perfect sense to use this as a redundant avionics unit.

The schematic layout for these units are shown below:
Figure 4.11 Avionics Wiring Diagram

The power up switches are rotary contact switches, and are accessible from outside the rocket using a standard ¼" screwdriver.
4.1.1.4 Determination of the Center of Gravity (CG) & Thrust-to-Weight Ratio

One of the defining points for fixed-wing rocket flight stability is that of the Center of Mass, or for sufficiently small objects (where the acceleration due to gravity over its vertical length does not change appreciably), the Center of Gravity (CG). The CG is the point where the force due to gravity is said to act on our rocket and is the weighted average distribution of the mass elements that make up the rocket. In flight, the rocket will experience external torques, which will cause rotations about the CG.

<table>
<thead>
<tr>
<th>Component</th>
<th>Component</th>
<th>( y_i ) = Vertical Location (in)</th>
<th>Product ( m_i y_i ) (g-in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload Tube (10”)</td>
<td></td>
<td>26</td>
<td>7280</td>
</tr>
<tr>
<td>Nosecone</td>
<td></td>
<td>14</td>
<td>6538</td>
</tr>
<tr>
<td>Payload</td>
<td></td>
<td>22</td>
<td>66000</td>
</tr>
<tr>
<td>Bulkhead (fiberglass)</td>
<td></td>
<td>27</td>
<td>837</td>
</tr>
<tr>
<td>Eyebolt</td>
<td></td>
<td>27</td>
<td>864</td>
</tr>
<tr>
<td>Forward Body (42”)</td>
<td></td>
<td>53</td>
<td>50880</td>
</tr>
<tr>
<td>Coupler</td>
<td></td>
<td>32</td>
<td>8576</td>
</tr>
<tr>
<td>AV section</td>
<td></td>
<td>66.3</td>
<td>30697</td>
</tr>
<tr>
<td>Chutes (payload &amp; main)</td>
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</tr>
<tr>
<td>Coupler</td>
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<td>Booster Tube (42”)</td>
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<td>41173</td>
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<tr>
<td>Motor Retainer</td>
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<td>105.5</td>
<td>11605</td>
</tr>
<tr>
<td>Motor (loaded)</td>
<td></td>
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<td>297192</td>
</tr>
<tr>
<td>Centering ring (fore)</td>
<td></td>
<td>93</td>
<td>3255</td>
</tr>
<tr>
<td>Centering ring (mid)</td>
<td></td>
<td>105</td>
<td>3675</td>
</tr>
<tr>
<td>Centering ring (aft)</td>
<td></td>
<td>116</td>
<td>4060</td>
</tr>
<tr>
<td></td>
<td>( \Sigma m_i = 14,529 , g )</td>
<td>( \Sigma m_i y_i = 993,839.9 , g\cdot in )</td>
<td></td>
</tr>
</tbody>
</table>

So;

\[
y_{CG} = \frac{\sum_{i} m_i y_i}{m} = \frac{993839.9 \, g \cdot in}{14,529 \, g} = 68.4 \, in
\]

The Center of Gravity for our rocket will be 68.4” down from the tip of the Nosecone, or 47.6” up from the bottom. For comparison, RocSim has estimated the CG being located at 63.97” from the nose tip, about a 7% difference. Why the difference? RocSim
estimates the mass of the component parts via the use of installed data tables and estimated densities for given materials, whereas our data table was built up of actually measured values of the components. Anyway, of interest is the location of the CG should no payload be launched; the modified value of the CG location becomes 80.5” from the nose tip.

Whereas the above listing of the mass elements comprising our rocket is as complete as we can apriori make it, it is expected that the actual location will change due to other mass elements that we have not included (e.g. glue, bolts, etc). Because accurate location of this point is essential for our flight stability determination, and flight safety over-all, the actual location of the CG will be determined by a simple hang test just prior to the actual launches. Flight stability requires that the position of the CG be located at least two body diameters above the location of the Center of Pressure.

What directly comes out of this is that we estimate the lift-off mass of the rocket to be 14.529 kg, or a weight of 143 N ~ 32.2 lbs. We also estimate a burned-out mass of 13.264 kg, a weight of 130 N ~ 29.4 lbs. The burn-out mass consists of two units; the payload mass of 3.810 kg and the rest of the rocket, 9.454 kg.

4.1.1.5 Determination of Center of Pressure (CP)

The Center of Pressure (CP) is the point on a rocket where all the external aerodynamic forces are said to act. Unlike the center of mass, which depends on mass distribution, and can change with the flight of the rocket, the center of pressure depends only on the external shape of the rocket. There are several ways to calculate this point; one could estimate its location by determining the center of area of a two-dimensional representation of the final rocket. Another way is to follow the Barrowman method, which is very similar to calculating the center of mass only instead of mass elements one considers the drag coefficients \(C_N\) and their effective lever arm distances \(X\). Because it is standard practice among rocket enthusiasts to follow the Barrowman method, this is the method we shall follow...

For our ogive nosecone:

\[
(C_N)_N = 2 \\
X_N = 0.466L_N = 0.466(20") = 9.3" \ (9.32")
\]

where \(L_N = 20\)”, is the length of our nosecone.

For our four-fin rocket:
where the radius of the body \((R)\) is 2.0”, the fin semi-span \((S)\) is 4.75” (which we have taken to equal the length of the mid-chord of fin \(L_F\)), the body diameter \((d)\) is 4”, the fin root chord \((C_R)\) is 13”, the fin tip chord \((C_T)\) is 2”, the length of the rocket from nose tip to fin root chord leading edge \((X_B)\) is 103”, and the distance between the fin root leading edge and fin tip leading edge parallel to the body \((X_R)\) is 10.5”.

With these four results, the distance from the nose tip to the center of pressure can now be determined;

\[
X_F = X_B + \frac{X_R (C_R + 2C_T)}{3 (C_R + C_T)} + \frac{1}{6} \left( \frac{C_R + C_T}{C_R + C_T} + \frac{(C_R C_T)}{(C_R + C_T)} \right)
\]

\[
X_F = 103” + \frac{10.5” (17”)}{3 (15”)} + \frac{1}{6} \left[ 15” + \frac{(13”\cdot2”)}{(15”)} \right] = 109.2”
\]

This corresponds very closely to the CP value of 96.22” given us by RocSim, and corresponds to a distance of 19.7” from the base of the rocket.

4.1.1.6 Determining the Stability Margin

The Stability Margin is defined as the ratio of the difference between the locations of the Center of Gravity and the Center of Pressure to the rocket diameter,

\[
S = \frac{|X_{CG} - X_{CP}|}{d} = \frac{68.4” - 96.3”}{4”} = 6.98
\]

our rocket is over-stable. Whereas being over-stable is not really a stability problem, we must be aware of the surface cross-winds. An overstable rocket, due to a longer lever-arm, is prone to weather-cocking into the wind.

The question of whether our rocket is inherently stable without a payload mass being flown can also be determined, the value for the center of pressure does not change but the center of gravity has a new value of 80.5”. So,
\[ S = \frac{|X_{CG} - X_{CP}|}{d} = \frac{80.5" - 96.3"}{4"} = 3.95 \]

which is also over-stable.

**4.1.1.7 Determination of the Number of Shear pins**

In order for the rocket to maintain integrity until the desired moment of separation, two sets of shear pins will be used. A first set (of 2) will keep the booster section in contact with the fore section until the time of the drogue chute deployment, and the second set (of 6) will keep the payload section attached to the fore section until the main chute and payload are deployed. For our rocket, \( \frac{1}{2} \)"440 Teflon threaded screws will be used as shear pins for two major reasons: These have been flown numerous times for several past projects, are familiar to the team, and have worked well for us. Secondly, these are readily available to us.

In order to determine the proper number of pins, a simple stress test was performed. A bucket was attached to, and suspended below, a spare coupler unit that was held in place to a spare body tube by one of the Teflon screws acting as a shear pin. Mass was placed within the bucket until failure was reached. The total mass suspended was 20.6 kg, or 45.4 lbs. Combining this result with the cross-sectional area that the weight was distributed over the stem of the shear pin (3.2 mm X 2.4 mm), we get a stress limit of 3785 psi for a single shear pin. It should be mentioned that a literature search has listed Tensile Strength for Teflon as 3900 psi. For the rest of our calculations, we shall take a failure force 46 lbs/pin.

Once this maximum force value for a shear pin is determined, several items can then be determined. The force that the shear pins must overcome to keep the booster attached to the fore section is just the aerodynamic drag force that acts on the booster after burnout and continues till apogee. This drag force, to first order, is just the burned-out mass of the booster section, 4.4 kg or 9.7 lbs. This value is well within the failure limit of one stress pin, but two will give a redundancy that needs to be overcome by the Drogue deployment charge.

The harder value to calculate is the number of pins required to hold the payload section to the fore section while the Drogue chute is being deployed. To begin this, we need to assume a change in the speed of the forward section of the rocket as the deployment is occurring. Since the rocket (theoretically) will not be moving much at apogee, and the maximum drogue chute descent rate is fixed, we can take a change in speed of 25 m/s. This change in speed corresponds to an impulse of 95 Ns, acting on the payload section. As a conservative estimate, we assume a very short deployment time of 0.1 s (really equivalent to a sudden jerk), which yields an inertial force of 950 N. This corresponds to an inertial force of 215 lbs, which must be overcome by a number of shear pins. The number of shear pins needed to do this then works out to be 215 lbs/(46 lbs/pin) \( \sim 5 \). Again, we have added an extra pin for surety, and needs to be overcome by the main chute deployment charge.
4.1.1.8 Determination of the Black Powder for Pyrotechnic Charges

Determining the amount of Black Powder (BP) to deploy a chute, or separate a section of the rocket, is a delicate balancing of pushing hard enough to deploy the unit while not causing permanent damage to the rocket, or turning it into a pyrotechnic display more appropriate for the 4th of July. As it turns out, there is a semi-empirical, linear relationship between the amount of BP to be used and the product of the required ejection force ($E_{\text{eject}}$) and the length ($L$) of the section that the produced gas must expand into. The relationship is outlined by J.H. Wickman (“How to Make Amateur Rockets” 2nd Edition, section 18.5-6) and is based on several simple assumptions: the tube is instantly pressurized, no heat is lost to the rocket body tube, and the gas acts nearly ideally.

\[
P V = n R T_k = m \left(22.14 \frac{ft \cdot \text{lbf}}{R \cdot \text{lbm}} \right) T_R
\]

where $m$ is the mass of the gas produced (~the mass of the BP in lbs), $P$ is the gas pressure, $V$ is the volume the gas will occupy, and $T_R$ is the Rankine burning temperature of BP (which is 3307 R – the Rankine scale is the Fahrenheit scale that is calibrated to Absolute zero). The expansion volume is $A_{CS} L$, where $A_{CS}$ is the cross-sectional area of the gas volume, and the pressure is the ratio of the desired ejection force to the cross-sectional area ($F_{\text{eject}}/A_{CS}$). As such,

\[
PV = \left(\frac{F_{\text{eject}}}{A_{CS}}\right) (A_{CS} L) = F_{\text{eject}} L
\]

After rearranging,

\[
F_{\text{eject}} L = m \left(1934.7 \frac{\text{in} \cdot \text{lbf}}{\text{g}} \right)
\]

Solving for the mass, and after some experimentation, Wickman found that the addition of a 1.25 g offset was needed. The final semi-empirical relationship is…

\[
m(g) = \left(5.17 \times 10^{-3} \frac{g}{\text{in} \cdot \text{lbf}} \right) F_{\text{eject}} L + 1.25 \text{g}
\]

The determination of the ejection force is specific to the unit being deployed and is equal to the sum of the external aerodynamic forces acting on that section rocket (which really can be set to the weight of the part of the rocket) being deployed, the force of friction between the coupler and the booster (assumed to be ~2 lbs), and the force required to overcome the number of shear pins. So, for the drogue deployment this force works out to be 27.3 lbs + 2 lbs + (2 pins)(46 lbs/pin) = 121.3 lbs. Insertion of this, along with a gas expansion length of 19”, into the above expression yields a deployment charge of 2.44 g ~3g. Following the same procedure, the main chute deployment, and separation of the
payload section, requires an ejection force of 17.8 lbs + 2 lbs + (6 pins)(46 lbs/pin) = 295.8 lbs. This, and an expansion length of 21.5”, yields a deployment charge of 4.54 g ~ 5g.

Obviously, the inherent assumptions used to come up with these estimates can be questioned. Because deployment of the chutes is of utmost importance to the safety of the team, and anyone else in the vicinity, these values need to be tested. Ground testing of these charges has been performed to confirm that these values did indeed have enough force to separate the pinned units, and adequately deploy the chutes. Please consult our web site to see the videos of the deployment test for the drogue chute and the main chute.

4.1.2 Projected Altitude

As will be shown in section 4.1.4, many simulations were run using RocSim and OpenRocket, and an Aerotech K1050 motor will take the rocket to an altitude just over 5290’, which would require an energy lose of 0.1%. This would correspond to a drag shoe deployment angle that effectively is zero.

We have included a screen shot of a typical RocSim of our rocket using our desired rocket.

Figure 4.12
4.1.3 Determination of the Chute Sizes

The actual determination of the chutes sizes is a relatively easy process; the weight of the suspended descending unit is set equal to the drag force that the chute must supply at terminal velocity.

\[ W = mg = \frac{1}{2} C_D \rho A v_T^2 \]

where \( m \) is the mass of the descending unit, \( C_D \) is the drag coefficient (usually taken to be \( \approx 0.8 \)), \( \rho \) is the density of air (1.27 kg/m\(^3\)), \( A \) is the area of the chute, \( v_T \) is the terminal velocity of the descending unit. Assuming a circular shape for our chute, and solving for the diameter \( (D) \), yields…

\[ D = \sqrt{\frac{8g \sqrt{m}}{\pi C_D \rho v_T}} = \left( \frac{4.96}{s \cdot \text{kg}^{1/2}/v_T} \right) \sqrt{m/v_T} \]

For the drogue chute, \( m = 13.3 \text{ kg} \) and \( v_T = 25 \text{ m/s} \), which yields \( D = 0.72 \text{ m} \), \( \approx 2' 4" \).

Our project will have one phase where the entire rocket will be descending at 25 m/s (\( \approx 80 \text{ ft/s} \)), and the second phase will have two units descending at 7 m/s and 5 m/s. The former is assigned to the payload section, and the latter is for the rest of the rocket and will determine the main chute size. The descending speeds are determined by the fact that no descending unit should have a kinetic energy greater than 75 lb ft (\( \approx 102 \text{ J} \)).

\[ KE_{payload} = \frac{1}{2} mv_T^2 \Rightarrow v = \sqrt{\frac{2KE_{payload}}{m_{payload}}} = \sqrt{\frac{2(102\text{J})}{3.81\text{kg}}} = 7.31\frac{m}{s} \]

\[ KE_{main} = \frac{1}{2} mv_T^2 \Rightarrow v = \sqrt{\frac{2KE_{main}}{m_{main}}} = \sqrt{\frac{2(102\text{J})}{9.45\text{kg}}} = 4.64\frac{m}{s} \]

So, for the main chute, \( m = 9.45 \text{ kg} \) and \( v_T = 4.64 \text{ m/s} \), which yields \( D = 3.3 \text{ m} \sim 10’8" \).

For the payload section, \( m = 3.81 \text{ kg} \) and \( v_T = 7.31 \text{ m/s} \), yields \( D = 1.32 \text{ m} \sim 4"3" \).

4.1.4 Motor Designation and Selection

Proper motor selection requires several considerations, a suitable thrust to weight ratio, a predicted maximum altitude that is close to the desired altitude, and the physical constraints of the designed motor retention. As has been mentioned previously, it is hoped that with a proper choice in motor and bulk payload mass, the desired altitude of 5280 feet can be obtained. After reviewing the data of two full-scale flights at this last ARLISS launch, we came to the conclusion that the Aerotech K1050W fits our needs.
In the absence of air resistance, the maximum height a rocket will ascend to under a vertical launch situation is given by summing the height at motor burn-out and the height the rocket will coast to thereafter. As it turns out, a height determination can be found from knowing the mass of the rocket and the mass of the un-burned motor and then burned motor. If \( M_0 \) is the initial lift-off mass of rocket, \( M \) is the mass of the rocket at burn-out, and \( \dot{M} = (\dot{M}_0 - \dot{M})/t_{bo} \) is how quickly the motor is ejecting mass at an assumed constant speed of \( v_{ex} \).

\[
h = \left\{ v_{ex} \frac{M_o}{M} \left[ 1 - \frac{M}{M_o} \ln \left( \frac{M}{M_o} + 1 \right) \right] - \frac{g}{2} \left( \frac{M_o}{M} \right)^2 \left( 1 - \ln \frac{M}{M_o} \right) \right\} + \left\{ \frac{1}{2g} \left[ v_{ex} \ln \frac{M_o}{M} - g \frac{M_o}{M} \left( 1 - \frac{M}{M_o} \right)^2 \right] \right\}
\]

Whereas this method appears to give us all the information that we would require to make a proper motor selection, it does however neglect air friction, which we have found to be especially significant. To get a sense of how much air friction plays a part, using flight data from our last ARLISS flight of this rocket, a theoretical height determination using the above relation can be made. Our ARLISS rocket (using a K1050W) had a pad mass of 12.40 kg, a propellant mass of 1.261 kg, a motor burn time of just over 2 seconds, and a given impulse of 2451 Ns. These values combine to yield a mass-loss rate of 0.63 kg/s, and average thrust of \( \dot{F} = I / t \) 1225.5 N, and an exhaust velocity \( v_{ex} = \dot{F} / \dot{M} \) of 1945.2 m/s. Insertion of these values into the above yields an estimated altitude for the rocket of 2988 meters. The actual height was 1,770 m; roughly only 59% of the estimated height.

A much more realistic way to establish a height determination, one incorporating air resistance, would be to deal with discrete time elements, determining the motor mass loss, the average acceleration for that time interval, the instantaneous velocity at the end of that time interval, and the drag force at the end of the time interval. These values are then used to determine the next time intervals’ average acceleration, and the whole process is iterated until a maximum height (corresponding to a zero vertical velocity) is reached. This is what OpenRocket and RocSim does for us – in a very much quicker manner then done by hand, we might add!

Numerous simulations were run using both RocSim and OpenRocket on a list of certified Aerotech motors. All simulations had a maximum payload mass of 3 kg, yielding the following data table:

<table>
<thead>
<tr>
<th>Motor</th>
<th>Altitude</th>
<th>( v_{max} )</th>
<th>( a_{max} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1050W</td>
<td>1566 m</td>
<td>190 m/s</td>
<td>109 m/s/s</td>
</tr>
<tr>
<td>K700W</td>
<td>1359 m</td>
<td>162 m/s</td>
<td>78.9 m/s/s</td>
</tr>
<tr>
<td>K1275R</td>
<td>1258 m</td>
<td>168 m/s</td>
<td>123 m/s/s</td>
</tr>
<tr>
<td>K828FJ</td>
<td>1231 m</td>
<td>160 m/s</td>
<td>96.1 m/s/s</td>
</tr>
</tbody>
</table>
Due to previous experience, the team decided to limit the motor simulations to only Aerotech motors; it is the team’s opinion that Aerotech motors usually have a better performance while being very familiar. Combining the simulation results with the overall team strategy of overshooting the target altitude and then employing a hinge-brake assembly to adjust the drag on the ascending rocket to compensate for the over-shoot, determined the final decision making for a motor choice. Looking for motors that were within the 54 mm diameter motor mount (physical constraint), having a comfortable thrust-to-weight ratio (>5, Thrust constraint), attaining an altitude greater then 5280 feet (target), less then 6000 feet (altitude constraint), and not yielding too great of a maximum acceleration (stress constraint), gives us confidence that an Aerotech K1050W motor (using an RMS 54/2800 casing) fits our needs.

Motor Information (provided by Thrustcurve.org)
AeroTech K1050W-P

Manufacturer: AeroTech
Entered: Apr 2, 2009
Last Updated: Apr 2, 2009
Mfr. Designation: K1050W
Brand Name: K1050W
Common Name: K1050W
Motor Type: Reload
Diameter: 54.0mm
Length: 63.5cm
Total Weight: 2203g
Prop. Weight: 1265g
Cert. Org.: Tripoli Rocketry Association, Inc.
Cert. Date: 
Average Thrust: 1132.9N
Maximum Thrust: 2172.0N
Total impulse: 2426.4Ns
Burn Time: 2.1s
Case Info: RMS 54/2800
Propellant Info: White Lightning

4.1.5 Primary Requirements for Rocket and Payload

The primary design of the payload is to ensure it can reliably complete the tasks above despite various environmental conditions.

1. Teams will design a custom rover that will deploy from the internal structure of the launch vehicle.
2. The rover will be retained within the vehicle utilizing a fail-safe active retention system. The retention system will be robust enough to retain the
3. At landing, and under the supervision of the Remote Deployment Officer, the team will remotely activate a trigger to deploy the rover from the rocket.

4. After deployment, the rover will autonomously move at least 10 ft. (in any direction) from the launch vehicle. Once the rover has reached its final destination, it will recover a soil sample.

5. The soil sample will be a minimum of 10 milliliters (mL).

6. The soil sample will be contained in an onboard container or compartment. The container or compartment will be closed or sealed to protect the sample after collection.

7. Teams will ensure the rover’s batteries are sufficiently protected from impact with the ground.

8. The batteries powering the rover will be brightly colored, clearly marked as a fire hazard, and easily distinguishable from other rover parts.

Since it is the mission of UHCC’s rocket to promote interest in science, technology, engineering, and mathematics by providing a safe, reusable lifting body with safety being the primary concern. This means that the safety of our prelaunch, flight, and recovery are of the highest priority. As such, the primary requirement of our rocket and payload would be the ability for both to stay safe throughout their use. For this to happen the team must ensure that all safety requirements are maintained throughout the course of the project and mission. It is required that the payload functions as planned, safely deploying a rover, having it traverse a distance greater than 5 meters, and then obtaining a soil sample.

The rocket must have a safe and stable ascent to apogee (Our target height is planned to be 5280 feet). It must then deploy its recovery system properly. This includes the deployment of a drogue chute at apogee, and later a much larger main chute deployment at a lower altitude (tentatively set to 700 feet). It must also deploy the payload section at the desired altitude. Upon landing the launch vehicle should be completely intact and not be damaged. By intact we mean that the rocket should be flight ready if it were to undergo normal preflight preparations.

4.1.6 Payload System Summary

The payload section will be comprised of two sections: The first section is a cylinder, 9.5 cm in diameter and 21 cm in length, where the rover will be retained during flight. The second section is a nose cone, 10 cm in diameter and 50 cm in height which will contain the deployment system, various electronics to for telemetry, communication to the base station, and sending signals to the rover and deployment system.

The rover will be programmed to move at least 10 feet from the launch vehicle where it will then attempt to collect a soil sample of at least 10 mL. If the initial sampling is unsuccessful the rover will reattempt collection. If collection still fails the rover will move to a new location and try again. It will keep making two
attempts at new locations until it successfully collects 10 mL of soil sample.

### 4.1.6.1 Payload Housing

There are two sections of the payload. The first section is the cylinder section where the rover will be retained during flight. The second section a nose cone which will contain the deployment system, various electronics for telemetry, communication to the base station, and sending signals to the rover.

The SLP team determined in order to minimize drag for the rocket the maximum diameter the nose cone could be was 10 cm. The team kept the height at 50 cm in order to keep proportions for the rocket. The cylinder would be a height of 21 cm and a diameter of 9.5 cm in order to allow the cylinder to fit the dimensions of the nose cone.
The team is planning for the rover to be secured to a sled that will be placed inside the cylinder section of the rocket during flight. The sled will be created using ball
bearings in order to keep the rover in the correct orientation as the sled will head toward the the force of gravity. The sled will be secured using nuts and bolts to ensure that the sled does not slide inside of the nose cone.

Figure 4.15: Sled that will hold the rover in the cylinder

The telemetry device will be activated before launch and will constantly calculate the vehicles altitude and velocity to report back to the Base Station. The team is exploring the possibility of having an antenna deploy after landing in order to increase the range of the signal to the Base Station.

### 4.1.6.2 Payload Deployment System

Telemetry Device and the Deployment System will be housed in the nose cone. Once the cone and the cylinder have landed on the ground, the deployment system will activate and remove the cone from the cylinder. When the cone has successfully detached from the cylinder, the rover will be able to drive out from the sled and begin its mission upon activation from the team.
4.1.6.3 Rover Body
The rover body needs to be able to house all the rover’s components while still being compact enough to fit within the restraints of the cylinder mentioned above. The Anodized Aluminum Metal Chassis for a Mini Robot Rover was selected for initial tests. Aluminum provides stability for the rover while still being lightweight. Although this is a kit chassis, there is still freedom to modify for the rover’s specific needs because aluminum can be easily cut or drilled. Further testing will determine if the kit chassis will be used, or lead to the design of a custom chassis. The chassis is pictured below.

Figure 4.18: Anodized Aluminum Metal Chassis for a Mini Robot Rover electric

The motors the CAELUS team selected for initial testing on the rover are the
Continuous Micro Servo Rotation Servos (FS90R). These motors have enough torque (20.86 oz*in) to allow us to traverse the terrain while carrying the load of all of the chassis and all of our electrical components. Additionally, the motors are designed to fit on the proposed chassis thus simplifying the integration.

![Continuous Rotation Micro Servo](image)

**Figure 4.19: Continuous Rotation Micro Servo**

The motors will power the Wheels for Micro Continuous Rotation FS90R. The wheels have a slim profile but can still support the rover while it traverses the terrain. These wheels are also meant to fit with the proposed motors making integration easier.

![Wheel for Micro Continuous Rotation FS90R Servo](image)

**Figure 4.20: Wheel for Micro Continuous Rotation FS90R Servo**

### 4.1.6.4 Soil Recovery System

In order to achieve its mission requirements of collecting a minimum of 10 milliliters (mL) of soil sample and contain it in a sealed onboard container or compartment. The team is planning on creating a custom Soil Recovery System and include a photogate to detect successful soil collection.

A custom 3D printed casing of the tube will be created in order to minimize size and still making sure there is space for the motor, spring, linear actuator, and 10 mL of soil. For to maximize space efficiency soil recovery system will also double as the collection and storage of the sample.
The soil recovery system will be a spring loaded tube. As pressure is applied to the spring by a linear actuator, the spring will stretch and the tube will open. The faces of the two halves of the covering for the tube will have teeth to assist in the collection of soil.

When the motor stops moving the linear actuator, the spring will have less force applied to it and will contract, taking the actuator with it. This will cause the tube to close. As it closes, the two halves of the face of the tube will scrape the ground and push soil into the tube. Once all pressure is removed, the tube will return to its initial position, whilst containing the sample.

To determine if at least 10 mL of soil was collected after the Soil Recovery System
deploys the team will install a photogate on either side of the collection tube. If the photogate is obstructed then an appropriate amount of soil had been collected. If not then the Soil Recovery System will retry. If the retry fails then the Soil Recovery System will dump the sample, and inform the rover its needs to move to another location to re-attempt.

**4.1.6.5 Payload Code**

In order to meet the mission requirement of moving at least 10 ft. from the launch vehicle and then recovering a soil sample, the team will develop a custom algorithm in order to direct the rover. The code will use distance sensor feedback to detect obstacles during moment and wheel rotations to determine distance traveled.

Once at least 10 ft. away from the launch vehicle the Soil Recovery System will activate. The Soil Recovery System's photogate sensor will determine if at least 10 mL was collected. If the initial collection and retry was unsuccessful the code will loop back, moving the rover to a new location at least 10 ft. away from the launch vehicle and two feet away from the previously sampled location to make another attempt. Once an appropriate amount of soil is collected the mission is successful and the rover will deactivate.
Figure 4.23: Movement and Soil Collection Flowchart
4.1.6.6 Rover - Electronics
The on-board computer we intend to use is the Arduino Mega 2560. This was chosen for its ease of use, multiple I/O ports, and relevant libraries.

![Arduino Mega 2560](image)

Figure 4.24: Arduino Mega 2560

Since the rover is required to drive 10 feet, a distance sensor will be added to ensure it meets the required distance. The SparkFun Distance Sensor Breakout will be implemented for its 4m range and accuracy.

![SparkFun Distance Sensor Breakout](image)

Figure 4.25: SparkFun Distance Sensor Breakout
### 4.1.6.7 Payload Test Plan

<table>
<thead>
<tr>
<th>Item</th>
<th>Test</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>Payload Orientation</td>
<td>The payload section will be put into several different static and dynamic orientations to ensure the rover always lands in the proper position for deployment.</td>
</tr>
<tr>
<td>TP2</td>
<td>Landing Impact Protection</td>
<td>The payload will be exposed to a variety of tests to ensure the rover remains secure within the internal structure of the launch vehicle in the event the is subjected to high impact during landing or excessive roll during flight.</td>
</tr>
<tr>
<td>TP3</td>
<td>Object Avoidance</td>
<td>The rover will encounter various objects during our test runs so we can account for what types of obstacles that the rover cannot recognize.</td>
</tr>
<tr>
<td>TP4</td>
<td>Projection Release fail-safe</td>
<td>The projection system shall undergo several projection ideas to make sure that the payload is able to be released.</td>
</tr>
<tr>
<td>TP5</td>
<td>Coding functionality</td>
<td>The rover will undergo several test runs in different environments to ensure that the code fits for different terrains and overall successful function.</td>
</tr>
<tr>
<td>TP6</td>
<td>Motor calibration</td>
<td>Ensure each of the rover’s motors move with the same speed and torque.</td>
</tr>
<tr>
<td>TP7</td>
<td>Sensor calibration</td>
<td>Sensors used to determine the rover’s distance from the landing bay will undergo rigorous testing to ensure the robot moves the required distance.</td>
</tr>
<tr>
<td>TP8</td>
<td>Soil recovery system efficiency</td>
<td>The soil recovery system will undergo test runs to determine efficiency of the system and to determine the duration of drilling time.</td>
</tr>
<tr>
<td>TP9</td>
<td>Wireless communication stability</td>
<td>Wireless connection between rover, antennae, and controller will be stress tested to ensure that the connection is stable over long distances.</td>
</tr>
<tr>
<td>TP10</td>
<td>Rover mobility</td>
<td>Rover will undergo several test runs to ensure wheels easily maneuvers out of rover sled and around various obstacles.</td>
</tr>
<tr>
<td>TP11</td>
<td>Soil containment</td>
<td>Soil containment tube will undergo</td>
</tr>
</tbody>
</table>
securement test to make sure no soil is lost during transportation

| TP12  | Battery capacity | The Battery will be stress tested to ensure that there is enough keep constant power to the motors, antennae, sensors, etc until each requirements are fulfilled. |
| TP13  | Communication interference | Communication connections between the rover and antennae will undergo tests to determine if there are any other forms of communication that would interfere with deployment process. |

### 4.1.6.8 Payload Requirement Verification

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirement</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.1</td>
<td>Teams will design a custom rover that will deploy from the internal structure of the launch vehicle.</td>
<td>Team will come up with two designs that will allow the rover to maneuver out of the vehicle.</td>
</tr>
<tr>
<td>4.3.2</td>
<td>The rover will be retained within the vehicle utilizing a fail-safe active retention system. The retention system will be robust enough to retain the rover if atypical flight forces are experienced.</td>
<td>The team has suggested that the rover will sit inside of a ball bearing sled that will keep the orientation of the rover upright even during atypical flight forces.</td>
</tr>
<tr>
<td>4.3.3</td>
<td>At landing, and under the supervision of the Remote Deployment Officer, the team will remotely activate a trigger to deploy the rover from the rocket.</td>
<td>The nose cone will contain an antenna that will allow the Remote Deployment Officer to trigger the deployment process.</td>
</tr>
<tr>
<td>4.3.4</td>
<td>After deployment, the rover will autonomously move at least 10 ft. (in any direction) from the launch vehicle. Once the rover has reached its final destination, it will recover a soil sample.</td>
<td>The rover will use the dead reckoning program to ensure that the rover travels at least 10 ft. then initiate the soil recovering process.</td>
</tr>
<tr>
<td>4.3.5</td>
<td>The soil sample will be a minimum of 10 milliliters (mL).</td>
<td>The sensors within the attachment of the soil recovery system will determine if the minimum amount of soil has been reached.</td>
</tr>
<tr>
<td>4.3.6</td>
<td>The soil sample will be contained in an onboard container or compartment. The container or compartment will be closed or sealed to protect the sample after collection.</td>
<td>The soil recovery system will recover soil until the 10mL sample has been collected and will then stop the actuator from applying pressure to the spring, thus closing the tube containing the soil sample.</td>
</tr>
<tr>
<td>4.3.7</td>
<td>Teams will ensure the rover’s batteries are sufficiently protected from impact with the ground.</td>
<td>The rover’s battery will be secured using screws and bolts</td>
</tr>
<tr>
<td>4.3.8</td>
<td>The batteries powering the rover will be brightly colored, clearly marked as a fire hazard, and easily distinguishable from other rover parts</td>
<td>The HonCC Rocketry Team will use yellow, clearly marked labels that will allow anyone to distinguish the batteries from other rover parts</td>
</tr>
</tbody>
</table>

### 4.1.7 Challenges and Solutions

![Image](image_url)

Figure 4.26: The Project Imua Launch Team at XPRs (L to R; Dylan, Dr. Hudson, Matthew, Julien, Damien)

The rocket designed above was built and flown at this last XPRs (Experimental Rocket Projects) launch in Black Rock Nevada. The flight was very stable on the ascent, with a near perfect deployment of the drogue at an apogee of 5790 feet (with the VDA closed and NO payload mass). The rocket did have one flight glitch; at 700
feet the deployment charges went of but did not deploy the main. Later we
determined that one of the charges disconnected on ascent, and the redundant
charge lead to a ‘Blow-by’ (the ejection gases were able to deploy the nosecone but
did not eject the main). The rocket was in very good shape at recovery, but it was
clear that it did not fly as intended. Whereas it is hoped that the satisfactory launch
of our rocket at this last XPRs event, with the subsequent video link at our website,
would satisfy the requirements of the pre-flight, we understand that we will have to
make significant changes to the rocket design which would require us to re-fly the
rocket. The two biggest changes are:

1. To enhance the main chute deployment, a piston will be introduced between
the Main chute deployment pyro and the main chute.
2. The Payload team will need a specific orientation for them to be successful in
fulfilling their mission criteria; as such an Inverted Y-sling needs to be
designed and test for the payload section.

This brings us to our major challenge for the SLP team; the launching facility for
flight-testing of our rocket, and the subsequent recovery testing of this program.
Because of the size of our island, we are limited in land space and air space
clearance. It is difficult to launch and receive air space clearance for rockets of the
design that we our proposing. A solution we have conceived would be to launch at
the near-by U.S. Marine base (Kaneohe Marine Corps Air Base; KMCAS). Because of a
relatively large abandoned airfield the Marine base has, it would help in giving us
the area needed to do a test flight of our rocket. However, 3 sides of this area lead to
water. This has caused problems for us in the past. A possible solution to this would
be to make the rocket water recoverable, but that is still being discussed.

Should availability of the KMCAS be curtailed (a very distinct possibility), then an
alternative solution is to fly the rocket at a sanctioned AeroPac launch, or Rocketry
of California (ROC) event on the mainland. This has been done in the past (at cost),
but remains as a viable option for the team.

A secondary concern for the team is the procurement of the motor (Aerotech
K1050) to be used during the actual launch at Huntsville. What we have done in the
past, and is still our current plan, is to purchase the motor from a mainland vendor
(e.g. Bay Area Rocketry) and have the motor trucked to Huntsville. Should the
trucking of the motor prove to be too great a challenge, another vendor, closer to the
launch site may be utilized.

Payload Technical Challenges

<table>
<thead>
<tr>
<th>Test</th>
<th>Challenge</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTC 1</td>
<td>Verify the proper amount of soil is collected during Soil Sample Recovery.</td>
<td>Team will test different sensors to determine which is best at detecting the correct volume is collected</td>
</tr>
<tr>
<td>PTC 2</td>
<td>Ensure the Soil Collector works for multiple soil types</td>
<td>Rigorous testing of Soil Sample Recovery system on multiple soil types</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>PTC 3</td>
<td>Ensure the soil sample is closed after after collection</td>
<td>Team will develop a mechanism that will deploy to secure the soil sample after collection.</td>
</tr>
<tr>
<td>PTC 4</td>
<td>Cable and wire management</td>
<td>Team will ensure all electrical connections are secure. This includes verifying soldered connections and entanglement and disconnection avoidance.</td>
</tr>
<tr>
<td>PTC 5</td>
<td>Final dimensions for rover</td>
<td>Once designs have been chosen, the team will ensure that the final dimensions of the rover account for adequate spacing for components</td>
</tr>
<tr>
<td>PTC 6</td>
<td>Alignment of wheels</td>
<td>Ensure all wheels are in proper alignment to guarantee optimal driving.</td>
</tr>
<tr>
<td>PTC 7</td>
<td>Rover component management</td>
<td>Team will ensure that components are able to stay secure after encountering G forces from high altitudes and impact landings</td>
</tr>
<tr>
<td>PTC 8</td>
<td>Soil recovery system flow</td>
<td>The team will design a collecting method that will break soil into pieces that will allow easy and quick collection.</td>
</tr>
<tr>
<td>PTC 9</td>
<td>Programming fail safe</td>
<td>Coding will be written that if program malfunctions, the rover will restart its initial programing.</td>
</tr>
<tr>
<td>PTC 10</td>
<td>Wireless</td>
<td>Ensure controller can communicate with antennae on deployment system.</td>
</tr>
<tr>
<td>PTC 11</td>
<td>Rover deployment</td>
<td>Ensure rover can successfully exit the sled after deployment system is activated.</td>
</tr>
</tbody>
</table>
5.0 STEM Engagement

Educational outreach and the possibilities of students utilizing various aspects of rocketry, its dynamics, and motion to arrive at a broader interest in Science, Technology, Engineering, and Mathematics (STEM), is a very important goal to be met by our team.

5.1 Community Support

The Marine Corps Air Station (MCAS) at Kaneohe has offered the use of its airfields for aerodynamics and scale testing and community events. Since safety is our number one priority, there is always a fire truck on call for any incidentals. With their aid we were able to launch to an approximate 2,500-foot apogee (using a K1000 for the SLP 2012 project), which is the largest civilian rocket launched to date on the island of Oahu.

We are looking into several local sponsors, and some high-powered rocketry sponsors. Some sources approached are:

- Fiberglass Hawaii
- Parallax.com
- Oceanit
- Performance Kites
- Aerotech
- AeroPAC Model Rockets
- Rocketmotion

Sponsorship solicitation will begin with an explanation of our educational outreach goals to those targeted. Included with the solicitation for support will be offers for advertisement of said sponsor at outreach events, local launches, demonstration launches, and special events through various means, such as: “over the air thank you to said sponsor” at events where a public address system is available and in use, visual signage of banners and/or posters at launch tents, visual advertisement via clothing or patches of said sponsor on team clothing, visual advertisement on team public Web page, and arranged press coverage of events.

5.2 STEM Engagement Projects

It is our plan to encourage interest in STEM fields by using programs that would reach out to young students at the elementary and secondary levels and demonstrate the technology employed by NASA. Participating students would be educated about the varied career paths within STEM fields. Their potential roles within these applied fields would be encouraged through hands-on activities along with guided study devised for just that purpose.

In the state of Hawaii we are fortunate to have the Center for Aerospace Education (CAE) located at Windward Community College. Using this program, we hope to provide the tools, experience, and opportunities to enhance the learning
experience of high school and early college students. It is our goal to increase both
the general public awareness, along with the specific number of students involved
with the CAE. It should be mentioned that the CAE has an average of 20,000 visitors,
representing all facets of the education community, every year. It is thought that this
program will develop a diverse portfolio of educational initiatives that will target
students at all levels, and through different venues, be it school, the YMCA, the
YWCA, the Civil Air Patrol, the Boy Scouts, or Girls Scouts.

One of the major draws to the CAE is the Hokulani Imaginarium, which is a
high-tech planetarium and multi-media facility. The goal of the Imaginarium is to
instill an interest in astronomy and astrophysics in young learners. Many schools
will make field trip excursions to visit the Imaginarium. Since there is limited
seating in the Imaginarium, visiting schools will tour the Aerospace Exploration Lab
while awaiting their show. The Aerospace Exploration Lab is a 'hands-on' facility
where students can engage in activities that inspire students to pursue aerospace
sciences. While in the Exploration lab, SLP team members can engage students in
simple rocketry activities, and in general prosetillize about rocketry, upcoming
NASA endeavors, and progress of our SLP team.

We have a tentative schedule of schools visiting the CAE for the rest of this
year:

<table>
<thead>
<tr>
<th>Date</th>
<th>School</th>
<th>Est. Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/5</td>
<td>Kapunahala Elementary School</td>
<td>est. 90 students</td>
</tr>
<tr>
<td>10/16</td>
<td>Moanaloa Elementary School</td>
<td>est. 20 students</td>
</tr>
<tr>
<td>10/23</td>
<td>Kanoelani Elementary School</td>
<td>est. 125 students</td>
</tr>
<tr>
<td>10/24</td>
<td>Kailua Baptist Elementary School</td>
<td>est. 30 students</td>
</tr>
<tr>
<td>12/6</td>
<td>Wilson Elementary School</td>
<td>est. 100 students</td>
</tr>
<tr>
<td>12/7</td>
<td>Pohakea Elementary School</td>
<td>est. 30 students</td>
</tr>
</tbody>
</table>

No doubt, more schools will be added to this list.

Additionally, the SLP team through the CAE at Windward Community College
is already devoting many successful hours into building stronger community ties,
which has now enabled our outreach program to include outer-island advertising of
more school projects. For example, every Fall WCC hosts its annual outdoor festival
called Ho'olaulea. At Ho’olaulea CAE sponsors stomp rockets for children, while
informing the adults about aerospace projects taking place within their community.

The state of Hawaii is unique not only because it has 2400 miles of ocean
separating it from the Continental United States, but also the state itself is divided
into eight islands making events on one island difficult for the residents of another
island to attend. In past SLP endeavors, we have taken part in the “Bytemarks Café”
radio program. The Bytemarks Café is a one-hour radio magazine, hosted by the
local National Public Radio affiliate, that showcases the innovation and creativity in
the Hawaiian tech community. The program’s purpose is to raise awareness of the
local technological pursuits and engage the listener in the discussion through
audience call-ins, emails and blogs. We are confident that our participation has
brought a larger understanding of aerospace to the general public and has worked
to close the inter-island communication gap. Furthermore, press releases to all local
newspapers, and military periodicals, have been successful and will be instrumental
in the continuation of the development and growth of community involvement. We
will also incorporate social media into our educational effort – such as Instagram.
and FaceBook.

Detailed flyers and brochures to include what the WCC CAE SLP project has to offer students and how they can get involved in the numerous NASA opportunities encompassing science, technology, engineering and mathematics (STEM) will also be distributed to schools and organizations throughout the state in hopes that it will lead to better communication between the WCC CAE and the rest of Hawaii. We believe that the students of today will be the leaders, discoverers, and inventors of tomorrow and should be introduced to the opportunities that exist by being a part of this organization.

With this multifaceted approach, it is expected that all educational outreach goals will be fulfilled. The public is welcome to observe all our launch events at WCC, HCC and (with some restriction) MCAS. The Pacific Missile Range Facility on Kauai has also been a host to community events in the past, and has expressed a willingness to continue this collaborative effort. Support for our STEM engagement endeavors are being actively sought on the islands of Maui and Hawaii Island (The Big Island).
6.0 Project Plan

6.1 Tentative Schedule

Aug.  8/22 Request for Proposals released; begin initial concept design (brain-storm the payload)

Sept. Preliminary flight-testing using last year's rocket (ARLISS)
  9/1  CAELUS Launch at WCC
  9/10-16 ARLISS and Flight Testing
  9/19 Proposal due
  9/27 Ho‘olaula’a (Community Gathering) – General Educational Opportunity

Oct.  10/4 (?) Awarded
  10/5 STEM Engag. Oppor.: Moanaloa Elementary School (89 students)
  10/6  CAELUS Launch at HCC
  10/12 Preliminary Design Review (PDR) Q&A
  10/16 STEM Engag. Oppor.: Montessori Elementary School (11 students)
  10/20  CAELUS Launch at WCC
  10/23 STEM Engag. Oppor.: Kanoelani Elementary School (123 students)
  10/24 STEM Engag. Oppor.: Kailua Baptist Elementary School (30 students)
  10/26 Social Media Presence Deadline

Nov.  11/2 Preliminary Design Reports (PDR) due
      & CAELUS Launch at HCC
  11/11 CAELUS Launch at WCC
  11/15-19 Preliminary Design Review (PDR) teleconferences
  11/17 HSGC Presentation
  11/24 CAELUS Launch at WCC
  11/27 Critical Design Review (CDR) Q&A

Dec.  12/1 CAELUS Launch at HCC
  12/6 STEM Engag. Oppor.: Wilson Elementary School (100 students)
  12/7 STEM Engag. Oppor.: Pohakea Elementary School (30 students)
  12/15 CAELUS Launch at WCC

Jan.  1/4 Critical Design Reports (CDR) due
  1/5  CAELUS Launch at HCC
  1/7-22 Critical Design Review (CDR) teleconferences
  1/19 CAELUS Launch at WCC

Feb.  2/2 CAELUS Launch at HCC
  2/16 CAELUS Launch at WCC
  2/22 Planned Full Scale Low Power (FSLP) Test

Mar.  3/2 CAELUS Launch at HCC
  3/4 Flight Readiness Reports (FRR) due
  3/8-21 Flight Readiness Review (FRR) teleconferences
  3/16 CAELUS Launch at WCC

Apr.  4/3-7 Team Travel to Huntsville
  4/3 Launch Readiness Review (LRR)
  4/6-7 Launch day
4/26 Post Launch Assessment and Report (PLAR) due

6.2 Preliminary Budget

The preliminary project budget, which totals $61,261, is broken down into operational funds of $11,901 (which includes supplies and travel for two mentors to the SLP launch in 2019) and student fellowships of $49,360 (which includes 12 student fellowships over two semesters and 8 student travelers to the SLP launch). Table 2.1 itemizes the supplies, mentor travel expenses and student fellowships for the WCC and HCC campuses. Stipends for the UH Manoa students, who will be assigned to the WCC team, are itemized in a separate column.

As is often the case when asking for funds, the final awarded budget may be lower. The minimum budget that would be essential for the success of this project would total $49,843. This reflects a reduction in the number of travelers to Huntsville — with only one campus mentor and three students (one per campus). The travel expenses would in effect be reduced by $11,418. Note that although only three students would travel to Huntsville based on this minimum budget scenario, all 12 students would receive full semester stipends for Fall 2018 and Spring 2019.

#### Preliminary Budget for Both Campuses Combined (updated 9-9-18)

<table>
<thead>
<tr>
<th>A. Supplies</th>
<th>WinCC</th>
<th>HonCC</th>
<th>UH-Manoa Students Only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Structure</strong></td>
<td>Airframe</td>
<td>$350</td>
<td>$350</td>
</tr>
<tr>
<td>Sub-Total $600</td>
<td>Fiberglass/epoxy</td>
<td>$150</td>
<td>$150</td>
</tr>
<tr>
<td><strong>2. Propulsion</strong></td>
<td>Additional Materials</td>
<td>$300</td>
<td>$300</td>
</tr>
<tr>
<td>Sub-Total $500</td>
<td><strong>Structure Sub-Total</strong></td>
<td>$600</td>
<td>$600</td>
</tr>
<tr>
<td><strong>3 Electronics</strong></td>
<td><strong>2. Propulsion</strong></td>
<td>K550W Motor</td>
<td>$250</td>
</tr>
<tr>
<td>Sub-Total $1,285</td>
<td>54/1706 Casing</td>
<td>$250</td>
<td>$250</td>
</tr>
<tr>
<td><strong>4 Payload</strong></td>
<td>Propulsion Sub-Total</td>
<td>$500</td>
<td>$500</td>
</tr>
<tr>
<td><strong>5 Subsystem Testing</strong></td>
<td><strong>3 Electronics</strong></td>
<td>Allimeters (2)</td>
<td>$200</td>
</tr>
<tr>
<td>Sub-Total $1,100</td>
<td>Displays</td>
<td>$75</td>
<td>$75</td>
</tr>
<tr>
<td><strong>B. Mentor Travel</strong></td>
<td>OnlyLogic</td>
<td>$225</td>
<td>$225</td>
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<tr>
<td>No. of Mentors</td>
<td>Sparkfun</td>
<td>$175</td>
<td>$175</td>
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<tr>
<td>2</td>
<td><strong>Electronics Sub-Total</strong></td>
<td>$200</td>
<td>$200</td>
</tr>
<tr>
<td><strong>C. Travel Fellowships ($1,670 each)</strong></td>
<td>Electronics Sub-Total</td>
<td>$1,083</td>
<td>$1,083</td>
</tr>
<tr>
<td>No. of Students</td>
<td>3 ground test units</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td>8</td>
<td>2 low altitude flight units</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>2 final flight units</td>
<td>$1,000</td>
<td>$1,000</td>
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<tr>
<td>$13,360</td>
<td><strong>Payload Sub-Total</strong></td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td><strong>D. Semester Fellowships ($1,500 each)</strong></td>
<td><strong>5 Subsystem Testing</strong></td>
<td>Estes</td>
<td>$450</td>
</tr>
<tr>
<td>No. of Students</td>
<td>Aerotech</td>
<td>$400</td>
<td>$400</td>
</tr>
<tr>
<td>12</td>
<td>LOC/Precision</td>
<td>$250</td>
<td>$250</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>Subsystem Sub-Total</strong></td>
<td>$1,100</td>
<td>$1,100</td>
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<tr>
<td>$36,000</td>
<td><strong>Operation Funds (A &amp; B)</strong></td>
<td><strong>A. Supplies Sub-Total</strong></td>
<td>$1,300</td>
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<tr>
<td>Fellowships (C &amp; D)</td>
<td><strong>B. Mentor Travel</strong></td>
<td>Number of Mentors</td>
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</tr>
<tr>
<td>$49,360</td>
<td><strong>Number of Mentors</strong></td>
<td>Airframe (1)</td>
<td>$1,100</td>
</tr>
<tr>
<td></td>
<td><strong>2</strong></td>
<td>Airframe (1)</td>
<td>$1,100</td>
</tr>
<tr>
<td></td>
<td><strong>3</strong></td>
<td>Auto Rental (2)</td>
<td>$440</td>
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<td></td>
<td></td>
<td>Room (3)</td>
<td>$1,080</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Room (3)</strong></td>
<td>$1,080</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>per diem (6) / week</strong></td>
<td>$450</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>per diem (6) / week</strong></td>
<td>$630</td>
</tr>
<tr>
<td></td>
<td><strong>B. Sub-Total</strong></td>
<td><strong>C. Sub-Total</strong></td>
<td>$2,708</td>
</tr>
<tr>
<td><strong>C. Travel Fellowship ($1,670 each)</strong></td>
<td><strong>Number of Students</strong></td>
<td><strong>Number of Students</strong></td>
<td><strong>Number of Students</strong></td>
</tr>
<tr>
<td><strong>Fall 2018 (7)</strong></td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Spring 2019 (7)</strong></td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>D. Sub-Total</strong></td>
<td>9,000</td>
<td>9,000</td>
<td>9,000</td>
</tr>
<tr>
<td><strong>Total WinCC</strong></td>
<td><strong>Total HonCC</strong></td>
<td><strong>Total UH-Manoa</strong></td>
<td>$4,009</td>
</tr>
<tr>
<td><strong>WinCC Fellowships (C &amp; D)</strong></td>
<td><strong>WinCC Fellowships (C &amp; D)</strong></td>
<td><strong>HonCC Fellowships (C &amp; D)</strong></td>
<td>$14,010</td>
</tr>
<tr>
<td><strong>Total WinCC only</strong></td>
<td><strong>HonCC Fellowships (C &amp; D)</strong></td>
<td><strong>Total UH-Manoa</strong></td>
<td>$18,019</td>
</tr>
</tbody>
</table>

### GRAND TOTAL WinCC + UHM

- **WinCC Fellowships (C & D)**: $4,009
- **HonCC Fellowships (C & D)**: $7,893
- **Total WinCC + UHM Fellowships (C & D)**: $21,820
- **Total WinCC only**: $26,350

### GRAND TOTAL HonCC

- **WinCC Fellowships (C & D)**: $4,009
- **Total HonCC**: $30,823

### GRAND TOTAL Project Imua

**$61,263**

### Comments:

- **1 Airframe**: (KHL to Den to HSV; HSV to ORD to KHL) $1,100
- **2 Auto Rental**: est. $440 full size SLV (Avis) $440
- **3 Room**: $110/night x 6 nights $720
- **4 Mentor per diem $64/day x 7 days** $448
- **5 Student per diem $30/day x 6 nights** $210
- **6 Student stipends** $1,500

---

**64**
6.3 Funding Source

The fund sources for WCC's and HCC's SLP endeavors would be provided by a supplemental grant awarded to Project Imua by the Hawaii Space Grant Consortium (HSGC), and the Pre-Engineering Education Collaborative (PEEC) grant [locally referred to as the Indigenous Knowledge of Education (IKE) project] awarded by NSF to several UHCC campuses (including WCC and HCC).

Project Imua (to move forward in Hawaiian) is a multi-campus, joint faculty-student enterprise within the University of Hawai‘i Community College system dedicated to designing, fabricating and testing small payloads and high-power rockets. Undergraduate students involved in Project Imua are engaged in aerospace-related projects, such as, the development and launch of small sub-orbital payload at Wallops Flight Facility. Project Imua students also collaborate across UH campuses on high-power rocketry projects by participating in competitions such as A Rocket Launch for International Student Satellites (ARLISS) in Nevada, and CanSat and SLP launches.

With its designation as a Minority Institution, the UH system has been awarded two consecutive NSF PEEC (IKE) grants that are designed to encourage underrepresented groups of Native Hawaiians, Pacific Islanders, Asian, and female students to pursue studies in the engineering fields, with a strong hands-on project-based component.

It is our plan to work off the desirable budget of $61,261, however we can successfully complete the project if any unforeseen funding barriers reduce final budget to $49,833. Currently we do not foresee any future barriers to the desired budget amount.

6.4 Continuance

After a three-year hiatus, and after having successfully launched three payloads into sub-orbital flight through the Colorado Space Grants’ RockSat-X program, the UHCCs would like to continue their STEM education efforts at the Student Launch Project (SLP). This will be the fifth year that the WCC CAE team has entered SLP, the first year for HCC, and the first year of a collaborative effort for UHCC campuses. It should be noted that while some of the mentors have had experience with SLP, the students are new to this experience and are looking forward to the challenge. WCC and HCC have jointly written a submitted a supplemental HSGC grant to fund Project Imua’s sixth high-power rocketry mission.

We have already recruited students from three campuses (WCC, HCC and UH Manoa) to collaborate efforts between the University of Hawaii satellite campuses. Both Honolulu Community College and Windward Community College have also initiated low powered rocket launches on their respective campuses to test developing payloads, rocket designs, as well as to satisfy community outreach efforts. A high-power test launch is scheduled at Black Rock, Nevada during the
2018 ARLISS international rocketry competition that WCC and HCC are participating in.

Together HCC and WCC form the major part of the CAELUS NAR section#800 chapter as well as the TRA prefect #105 (Tripoli Hawaii). Additionally, education outreach programs, previously outlined, are to be pursued by these same students as well as maintaining relationships with the Kaneohe Marine Corp Air Station.

Finally, members of CAELUS and Project Imua Mission 6 students involved in SLP 2019 are acting as resources for high schools and other organizations taking part in the AIA sponsored Team America Rocket Challenge (TARC).
Appendix A: Center for Aerospace Education

The Center for Aerospace Education (CAE) supports the College’s credit curriculum in astronomy, students engaged in Hawai‘i Space Grant projects (including Project Imua) and community outreach efforts in science education—with emphasis on K-12 students. The CAE operates and manages the following facilities: Hōkūlani Imaginarium, Aerospace Exploration Laboratory, NASA Flight Training Aerospace Education Laboratory, Lanihuli Iki Rocketry Facility and Lanihuli Observatory.

The annual attendance at all CAE venues averages 21,000 visitors.

Description and history of the CAE

The CAE was established in October 1985 as a result of its founder/director’s role as the Hawai‘i Teacher-in-Space candidate for the NASA Space Shuttle Challenger. The CAE operates and manages the following facilities:

- **Hōkūlani Imaginarium** (opened summer 2000; dedicated Oct 2001) is a high-tech, multi-media facility, which functions both as a planetarium and as a specialized theater in scientific visualization. Its 40-foot dome theater seats 84 and utilizes a Sky-Skan DigitalSky 2 full-dome system.

- **Aerospace Exploration Laboratory (AEL)** is the flagship of the CAE. Founded in 1988, its doors officially opened to the public on Feb 27, 1989. This resource center acts as a “hands-on” science exploratorium assisting K-12 students and teachers in discovering scientific principles through low-tech experiential activities. The AEL is located at Hale ‘Imiloa (Room 135).

- **NASA Flight Training Aerospace Education Laboratory** was dedicated in Oct 2002 in partnership with NASA Glenn Research Center. This facility provides flight-simulators for training in aviation and space exploration and supports WCC’s HSGC (especially assisting student aerospace research projects), physics and astronomy labs, and grades 5-12 student and teacher outreach. This facility also serves as the Payload Environmental Test Facility (PET) for students engaged in Project Imua, which focuses on the development of high-power rockets and small payload satellites. The facility includes two small-scale, subsonic, wind tunnels, a zero-g drop tower, a
shake-and-spin table, several solder stations, a 3D printer, and a miniature, programmable milling-machine.

- **Lanihuli Iki** is self-contained facility that further supports our undergraduate space research projects. This facility includes our Project Fabrication Workshop (PFW), which is used to construct and store Project Imua’s various rockets, payloads, equipment and parts.

- **Lanuli Observatory**, which was officially dedicated in October 2007, supports astronomical and meteorological learning activities. The observatory houses an on-site weather station and operates a NOAA weather satellite tracking station. It also operates a radio astronomy telescope in partnership with NASA Goddard Space Flight Center’s Radio Jove Project. This facility includes a heliostat (solar telescope), a 16-inch optical telescope and a cosmic ray telescope, which is operated in association with QuarkNet (FermiLab). The Observatory includes a Visitor’s Gallery/Control Room includes astronomy/space science instructional kiosks along with a 2-foot diameter Magic Planet interactive video display. This facility supports the college’s astronomy labs, HSGC student projects, K-12 outreach and the general public.

### CAE Mission and goals

The mission of the CAE is to inspire the community and students to actively engage in science activities through informal experience and formal education, to explore career options in aerospace science and industry, and to become informed, contributing citizens by becoming science-literate.

The goals of the Center for Aerospace Education are:

- Help students develop high-tech skills to succeed in a knowledge-based global economy;

- Increase enrollment and success of K-12 students in science, mathematics and technology courses in high schools;

- Generate greater interest in careers in science and help facilitate the successful transition of students from high school to post-secondary institutions; and,

- Increase the number of underserved students entering college who choose to major in science, technology, engineering and mathematics (STEM) and have the skills necessary to successfully complete their higher education.

For more information, [http://aerospace.wcc.hawaii.edu](http://aerospace.wcc.hawaii.edu)
Appendix B: NAR High Power Rocket Safety Code

**Certification.** I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.

**Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.

**Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 25 feet of these motors.

**Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the "off" position when released. If my rocket has onboard ignition systems for motors or recovery devices, these will have safety interlocks that interrupt the current path until the rocket is at the launch pad.

**Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher’s safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

**Launch Safety.** I will use a 5-second countdown before launch. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table, and that a means is available to warn participants and spectators in the event of a problem. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable.

**Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor’s exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 if the rocket motor being launched uses titanium sponge in the propellant.
**Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power rocket motor(s) intended to be ignited at launch.

**Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.

**Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater.

**Launcher Location.** My launcher will be 1500 feet from any inhabited building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

**Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

**Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.
Appendix C: TRA Safety Code

The following is a condensed version of the TRIPOLI HIGH POWER SAFETY CODE. The complete code can be found in the TRIPOLI handbook. The Tripoli High Power Safety Code is based on NFPA 1127. You may view the current version of NFPA 1127 on the NFPA Website.

Only a person who is a certified flyer shall operate or fly a high power rocket.


A person shall fly a high power rocket only if it has been inspected and approved for flight by a Safety Monitor for compliance with the applicable provisions of this code.

Motors

Use only certified commercially made rocket motors.

Do not dismantle, reload, or alter a disposable or expendable high power rocket motor, will not alter the components of a reloadable high power rocket motor or use the contents of a reloadable rocket motor reloading kit for a purpose other than that specified by the manufacture in the rocket motor or reloading kit instructions.

A high power rocket shall be constructed to withstand the operating stresses and retain structural integrity under conditions expected or known to be encountered in flight.

A high power rocket vehicle intended to be propelled by one or more high power solid propellant rocket motor(s) shall be constructed using lightweight materials such as paper, wood, plastic, fiberglass, or, when necessary, ductile metal so that the rocket conforms to the other requirements of this code.

A person intending to operate a high power rocket shall determine its stability before flight, providing documentation of the location of the center of pressure and center of gravity of the high power rocket to the Safety Monitor, if requested.

Weight and Power Limits.

Ensure that the rocket weighs less than the rocket motor manufacturer’s recommended maximum liftoff weight for the rocket motor(s) used for the flight. During pre-flight inspection, The Safety Monitor may request documentary proof of compliance.
Do not install a rocket motor or combination of rocket motors that will produce more than 40,960 newton-seconds of total impulse (4.448 newtons equals 1.0 pound).

Recovery.

Fly a high power rocket only if it contains a recovery system that will return all parts of it safely to the ground so that it may be flown again.
Install only flame resistant recovery wadding if wadding is required by the design of the rocket.

Do not attempt to catch a high power rocket as it approaches the ground. Do not attempt to retrieve a high power rocket from a place that is hazardous to people.

Payloads

Do not install or incorporate in a high power rocket a payload that is intended to be flammable, explosive, or cause harm.

Do not fly a vertebrate animal in a high power rocker.

Launching Devices

Launch from a stable device that provides rigid guidance until the rocket has reached a speed adequate to ensure a safe flight path.

Incorporate a jet deflector device if necessary to prevent the rocket motor exhaust from impinging directly on flammable materials.

A launching device shall not be capable of launching a rocket at an angle more than 20 degrees from vertical.

Place the end of the launch rod or rail above eye level or cap it to prevent accidental eye injury. Store the launch rod or rail so it is capped, cased, or left in a condition where it cannot cause injury.

Ignition Systems

Use an ignition system that is remotely controlled, electrically operated, and contains a launching switch that will return to "off" when released.

The ignition system shall contain a removable safety interlock device in series with the launch switch.

The launch system and igniter combination shall be designed, installed, and operated so the liftoff of the rocket shall occur within three (3) seconds of actuation.
of the launch system. If the rocket is propelled by a cluster of rocket motors designed to be ignited simultaneously, install an ignition scheme that has either been previously tested or has a demonstrated capability of igniting all rocket motors intended for launch ignition within one second following ignition system activation. Install an ignition device in a high power rocket motor only at the launch site and at the last practical moment before the rocket is placed on the launcher.

**Launch Site.**

Launch a high power rocket only in an outdoor area where tall trees, power lines, and buildings will not present a hazard to the safe flight operation of a high power rocket in the opinion of the Safety Monitor. Do not locate a launcher closer to the edge of the flying field (launch site) than one-half the radius of the minimum launch site dimension.

The flying field (launch site) shall be at least as large as the stated in Table 1. or Not less than one-half the maximum altitude expected, calculated, or simulated, or as granted by an FAA waiver or the authority having jurisdiction.

**Launcher Location**

Locate the launcher more than 1,500 feet from any occupied building.

Ensure that the ground for a radius of 10 feet around the launcher is clear of brown grass, dry weeds, or other easy-to-burn materials that could be ignited during launch by the exhaust of the rocket motor.

**Safe Distances**

No person shall be closer to the launch of a high power rocket than the person actually launching the rocket and those authorized by the Safety Monitor.

All spectators shall remain within an area determined by the Safety Monitor and behind the Safety Monitor and the person launching the rocket.

A person shall not be closer to the launch of a high power rocket than the applicable minimum safe distance set forth in Table 2.

**Launch Operations.**

Do not ignite and launch a high power rocket horizontally, at a target, or so the rocket's flight path goes into clouds or beyond the boundaries of the flying field (launch site).

Do not launch a high power rocket if the surface wind at the launcher is more than twenty (20) miles per hour.
Do not operate a high power rocket in a manner that is hazardous to aircraft.

**Launch Control.**

Launch a high power rocket only with the immediate knowledge, permission, and attention of the Safety Monitor.

All persons in the launching, spectator, and parking areas during a countdown and launch shall be standing and facing the launcher if requested to do so by the Safety Monitor.

Precede the launch with a five (5) second countdown audible throughout the launching, spectator, and parking areas. This countdown shall be given by the person launching the rocket, the Safety Monitor, or other flying site operating personnel.

Do not approach a high power rocket that has misfired until the safety inter-lock has been removed or the battery has been disconnected from the ignition system, one minute has passed, and the Safety Monitor has given permission for only a single person to approach the misfired rocket to inspect it.

**TABLE 1: LAUNCH SITE DIMENSIONS**

<table>
<thead>
<tr>
<th>Installed Total Impulse (N-sec)</th>
<th>Equivalent Motor type</th>
<th>Minimum Site Distance (feet)</th>
<th>Equivalent Dist. (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160.01 - 320.00</td>
<td>H</td>
<td>1,500</td>
<td>0.28</td>
</tr>
<tr>
<td>320.01 - 640.00</td>
<td>I</td>
<td>2,500</td>
<td>0.50</td>
</tr>
<tr>
<td>640.01 - 1280.00</td>
<td>J</td>
<td>5,280</td>
<td>1.00</td>
</tr>
<tr>
<td>1280.01 - 2560.00</td>
<td>K</td>
<td>5,280</td>
<td>1.00</td>
</tr>
<tr>
<td>2560.01 - 5120.00</td>
<td>L</td>
<td>10,560</td>
<td>2.00</td>
</tr>
<tr>
<td>5120.01 - 10240.00</td>
<td>M</td>
<td>15,480</td>
<td>3.00</td>
</tr>
<tr>
<td>10240.01 - 20480.00</td>
<td>N</td>
<td>21,120</td>
<td>4.00</td>
</tr>
<tr>
<td>20480.01 - 40960.00</td>
<td>O</td>
<td>26,400</td>
<td>5.00</td>
</tr>
<tr>
<td>Installed Total Impulse (N-sec)</td>
<td>Equivalent Motor type</td>
<td>Minimum Safe Distance (feet)</td>
<td>Complex Safe Dist.</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------</td>
<td>------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>160.01 - 320.00</td>
<td>H</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>320.01 - 640.00</td>
<td>I</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>640.01 - 1280.00</td>
<td>J</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>1280.01 - 2560.00</td>
<td>K</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>2560.01 - 5120.00</td>
<td>L</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>5120.01 - 10240.00</td>
<td>M</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>10240.01 - 20480.00</td>
<td>N</td>
<td>1,000</td>
<td>1,500</td>
</tr>
<tr>
<td>20480.01 - 40960.00</td>
<td>O</td>
<td>1,500</td>
<td>2,000</td>
</tr>
</tbody>
</table>
Appendix D: Additional Safety Regulations

Additional Safety Regulations may be found on the following Websites:

Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C:

http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div5&view=text&node=14:2.0.1.3.10&idno=14#14:2.0.1.3.10.3

Code of Federal Regulation Part 55:

http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=03c9459678c94e51c2fae38c3346cf93&rgn=div5&view=text&node=40:5.0.1.1.3&idno=40

NFPA 1127:

http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=1127
## Appendix E: Rocket Risk Mitigation Tables

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complete loss or severe damage of launch vehicle</td>
</tr>
<tr>
<td>60%-100%</td>
<td>4</td>
</tr>
<tr>
<td>40%-60%</td>
<td>3</td>
</tr>
<tr>
<td>20%-40%</td>
<td>2</td>
</tr>
<tr>
<td>0%-20%</td>
<td>1</td>
</tr>
</tbody>
</table>
# Failure mode and hazards during Launch

<table>
<thead>
<tr>
<th>Section</th>
<th>Failure Mode</th>
<th>Cause of Failure</th>
<th>Effect of Failure</th>
<th>Mitigation</th>
<th>Severity of Failure</th>
<th>Likelihood of Failure</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocket Motor</td>
<td>Does not ignite</td>
<td>Poor contact between igniter and propellant</td>
<td>Retry launch with a new igniter</td>
<td>Insert a backup igniter when preparing for launch, use thermite igniter if allowed</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Motor Explodes</td>
<td>Improper assembly of motor, clogging of nozzle, manufacture defect</td>
<td>Complete loss of launch vehicle</td>
<td>Team members responsible for assembling motor at launch have experience in assembling rocket motors</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Booster Section of air-frame</td>
<td>Motor retaining ring failure</td>
<td>Stress due to deployment charge of drogue chute</td>
<td>Motor ejected from air frame, failure of drogue chute deployment, hazard to ground personnel</td>
<td>Deployment charge will be conducted, improved plywood aft plate for added strength</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Fins shearing from airframe</td>
<td>Fin flutter, drag, landing impact causing stress</td>
<td>Loss of rocket stability, complete loss of launch vehicle (ascent), failure of reusable criteria (ground impact)</td>
<td>Fins stress tested for shearing using static weight hung from fin, drop test will be performed at faster than expected descent rate</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Failure of motor retainer</td>
<td>Stress due to force of motor thrust, stress due to shock of drogue chute deployment</td>
<td>Motor plows through AV compartment and destroys launch vehicle, wreckage free falls to ground</td>
<td>Motor Retainer will be stress tested to well exceed expected loads, held in place by multiple screws going through aft centering ring</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------------------------------------------------</td>
<td>-----------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>---</td>
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<td>---</td>
<td></td>
</tr>
<tr>
<td>Avionics section of air-frame</td>
<td>Failure of forward or aft bulkhead</td>
<td>Stress due to deployment of drogue and main chute, Improper assembly of avionics section</td>
<td>Booster section free-falls to ground, possible failure of main chute deployment</td>
<td>Section will be stress tested to well exceed expected loads, An eye-bolt will carry majority of expected load</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Deployment charge fails to ignite</td>
<td>Loose connection, moisture in black powder, loss of power to avionics</td>
<td>No chutes deploy, launch vehicle free-falls to ground, complete loss of launch vehicle</td>
<td>Two completely separate avionics systems will be used for redundancy, all batteries will be secured using zipties</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Payload section of air-frame</td>
<td>Payload chute anchor failure</td>
<td>Stress due to deployment of main chute coupled with payload chute deployment</td>
<td>Payload section free falls to ground, complete loss of mission</td>
<td>Anchor will be stress tested to well exceed expected loads, held in place by multiple screws going through the body tube into the bulkhead</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Recovery System</td>
<td>Main or drogue chute shredding</td>
<td>Singeing from deployment charges, stress due to shock of deployment</td>
<td>Faster than expected descent rate, damage to launch vehicle on landing</td>
<td>Flame guards will be used when packing chutes, six chords are being used on chutes to provide redundancy</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>----------------</td>
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<td>----------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
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<td>---</td>
</tr>
<tr>
<td>Premature separation of booster/avionics section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Premature separation of avionics/payload section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Main or Drogue chute getting stuck in airframe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>1</td>
<td>4</td>
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</tbody>
</table>
Appendix F: Pre-Launch Check List

SLP2019 Rocket Checklist

Sub Assemblies:

- Assemble the Avionics section. Include new 9V battery for the PerfectFlight StratologgerCF and fully charged 3.3V (and 850 mA) battery for the AltusUI TeleMega. Zip tied to mounting board. Rotatory switches OFF.
  
  Mentor Initial:___________

- Assembled Aerotech K1050 motor.
  
  Mentor Initial:___________

- Pyros; two 3-gram Black powder, and two 5-gram Black powder.
  
  Mentor Initial:___________

- Chutes; one 11-foot diameter chute (main) and one 5-foot diameter (drogue), packed to fit in the 4-inch diameter tube.
  
  Mentor Initial:___________

- Assemble the Payload section with chute packed, and attached to its respective harness.
  
  Mentor Initial:___________

Pre-Pad Assembly:

- Feed one end of a 20-foot shock chord through the Fore section, fore to aft.
- Attached one end of the fed through end of the 20-foot shock cord to the U-bolt at the forward bulkhead of the AV section, via quick-link.
- Attach two 5-gram pyros into the respective 2-pin junctions (screwed) at the top of the forward AV bulkhead.
- With one person gently pulling the other end of the 20-foot shock chord, slide the AV section (with attached 5-gram pyros) into the aft end of the Fore section until flush with the stop ring.
- Slide and bolt the aft coupler into the aft end of the Fore section, flush against the bottom of the AV aft bulkhead, using two no. 6 X ½” nuts and bolts.
- Attach two sets of splice wires to the respective 2-pin junctions (screwed) at the bottom of the Aft AV bulkhead.
- Attach one end of a 20-foot shock chord to the central screw-eye using a quick-link.
- Attach the main chute, with its 20-foot shock chord, to the forward shock chord of the Fore section using a quick-link.
- Attach the drogue chute, with its 20-foot shock chord, to the aft shock chord of the Fore section.

  <M>-----------------o-----------P-0|| AV ||o---------------o-----------<D>

  Mentor Initial:___________
o Attach one end of 40-foot shock chord to the eye-bolt at the top of the prepared K1050 motor.
o Pass the other end of the 40-foot shock chord through the motor mount of the Booster section.
o With one person gently pulling the other end of the 40-foot shock chord, insert the prepared K1050 motor into the motor mount of the Booster section, and secure using the Aeropac motor retaining system.
o Attach the end of the 40-foot shock chord to the quick-link that the drogue chute is attached to.
o Tape two 3-gram pyros to the inside of the Booster section, low, near the top of the motor mount.
o Pack the Drogue chute, with its Nymex flameproof patch, into the booster section.
o Splice both sets of the 3-gram pyros to the two sets of splice wires (2 to 2) attached to the bottom bulkhead of the AV section.
o Integrate Booster section to aft end of the Fore section, and secure using two 4-40 Nylon screws as shear pins.

\[<M>-\text{o}\rightarrow\text{P-o}|AV|o\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow\right}
Wait for proper authorization, and then carry the rocket to the appointed pad.

Mentor Initial:______________

At the pad:

- With the rail in a horizontal position, slide the rocket onto the rail being careful to properly guide the 10-10 rail buttons onto the rail. Push to the bottom stop.
- Remove the igniter from the body of the rocket (and any tape that may remain), and insert it into the aft end of the K1050 motor. Tape the leads of the igniter wires to the side of the rocket in such a way as to secure the igniter remains in the motor during the raising of the rail.
- Raise the rail to the vertical position.
- Arm the Altus TeleMega Avionic Unit by inserting a standard ¼” screw driver through the right portal and turn counter clockwise. Confirm all signals are consistent for being armed (w/2pyros), and ready.
- Arm the PerfectFlight Avionic unit by inserting a standard ¼” screw driver through the left portal and turn ¼ of a turn counter clockwise. Confirm all audible signals are consistent with being armed (w/2 pyros), and ready.

Mentor Initial:______________

- **IF ALLOWED**: attach one of the power leads to one igniter lead.
- **IF ALLOWED**: attach the other power lead to the other igniter lead, making sure no power leads or igniter leads are inadvertently touching.
- Perform a continuity test, if successful leave the launch area.
### Appendix G: Detailed Hazard Mitigation & MSDS

In addition to all the mitigation tactics listed below the team will always maintain good Environment

<table>
<thead>
<tr>
<th>Materials</th>
<th>Risk</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenolic Powder- Black</td>
<td>Ingestion Hazards, Skin Irritation, Eye Irritation, Respiratory Irritation from Dust</td>
<td>Team members will work in well-ventilated areas and wear face masks at all times to prevent inhalation and ingestion of the dust from the Phenolic Black Powder. Gloves will be worn at all times to prevent skin irritation. Goggles will be worn at all times to prevent eye irritation.</td>
</tr>
<tr>
<td>Phenolic Resin</td>
<td>Toxic Fumes, Skin Irritation, Eye Irritation</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical resistant aprons will be worn at all times to prevent Skin Irritation and contact with clothing. Goggles will be worn at all times to prevent Eye Irritation.</td>
</tr>
<tr>
<td>Copperhead igniter</td>
<td>Ingestion Hazards, Toxic Fumes, Skin Irritation, Eye Irritation, Inadvertent Ignition, Burns to skin</td>
<td>Team members will work in well-ventilated areas and wear face masks at all times to prevent inhalation and ingestion of hazardous chemicals. Gloves will be worn at all times to prevent skin irritation and burns to skin. Goggles will be worn at all times to prevent eye irritation. Igniters will be kept away from ignition sources such as flames, matches, and heat sources, and will be properly stored in Type 3 or Type 4 magazines to prevent inadvertent ignition.</td>
</tr>
<tr>
<td>First Fire Igniter</td>
<td>Ingestion Hazards, Toxic Fumes, Skin Irritation, Eye Irritation, Inadvertent Ignition, Burns to skin</td>
<td>Team members will work in well-ventilated areas and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of hazardous chemicals. Gloves will be worn at all times to prevent skin irritation and burns to skin. Goggles will be worn at all times to prevent eye irritation. Igniters will be kept away from ignition sources such as flames, matches, and heat sources, and will be properly stored in Type 3 or Type 4 magazines to prevent inadvertent ignition.</td>
</tr>
<tr>
<td>Material</td>
<td>Hazards</td>
<td>Precautions</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>First Fire Jr.</td>
<td>Ingestion Hazards, Toxic Fumes,</td>
<td>Team members will work in well-ventilated areas and wear face masks at all times to</td>
</tr>
<tr>
<td>Igniter</td>
<td>Skin Irritation, Eye Irritation,</td>
<td>prevent inhalation of toxic fumes and ingestion of hazardous chemicals. Gloves will</td>
</tr>
<tr>
<td></td>
<td>Inadvertent Ignition, Burns to</td>
<td>be worn at all times to prevent skin irritation and burns to skin. Goggles will be</td>
</tr>
<tr>
<td></td>
<td>skin</td>
<td>be worn at all times to prevent eye irritation. Igniters will be kept away from</td>
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<tr>
<td></td>
<td></td>
<td>ignition sources such as flames, matches, and heat sources, and will be properly</td>
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<tr>
<td></td>
<td></td>
<td>stored in Type 3 or Type 4 magazines to prevent inadvertent ignition.</td>
</tr>
<tr>
<td>Rocket Propellant</td>
<td>Skin Irritation, Inadvertent</td>
<td>Gloves will be worn at all times to prevent skin irritation. Propellant will be kept</td>
</tr>
<tr>
<td></td>
<td>Ignition, Burns to skin</td>
<td>away from ignition sources, such as flames, matches, igniters, heat sources, and will</td>
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<tr>
<td></td>
<td></td>
<td>be properly stored in Type 3 or Type 4 magazines to prevent inadvertent ignition.</td>
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<tr>
<td></td>
<td></td>
<td>After motor burn, the team will wait 15 minutes before disassembling the motor, while</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wearing insulated gloves to prevent burns to skin.</td>
</tr>
<tr>
<td>Epoxy Resin</td>
<td>Toxic Fumes, Skin Irritation,</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to</td>
</tr>
<tr>
<td></td>
<td>Eye Irritation</td>
<td>prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>resistant aprons will be worn at all times to prevent Skin Irritation and contact with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>clothing. Goggles will be worn at all times to prevent Eye Irritation</td>
</tr>
<tr>
<td>5-Minute Epoxy</td>
<td>Toxic Fumes, Skin Irritation,</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to</td>
</tr>
<tr>
<td>Resin</td>
<td>Eye Irritation</td>
<td>prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical</td>
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<tr>
<td></td>
<td></td>
<td>resistant aprons will be worn at all times to prevent Skin Irritation and contact with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>clothing. Goggles will be worn at all times to prevent Eye Irritation</td>
</tr>
<tr>
<td>Material</td>
<td>Hazards</td>
<td>Protective Measures</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Sinmast 4 Epoxy Mortar Mix - Normal Cure</td>
<td>Ingestion Hazards, Skin Irritation, Eye Irritation</td>
<td>Team Members will wear face masks at all times to prevent ingestion of the material. Gloves and chemical resistant aprons will be worn at all times to prevent Skin Irritation and contact with clothing. Goggles will be worn at all times to prevent Eye Irritation.</td>
</tr>
<tr>
<td>Compressed Carbon Fiber Sheets</td>
<td>Inhalation Hazards, Eye Irritation, Skin Irritation</td>
<td>Team Members will wear face masks at all times to prevent inhalation of the material. Goggles will be worn at all times to prevent Eye Irritation. Gloves will be worn at all times to prevent skin irritation.</td>
</tr>
<tr>
<td>Fiber Glass Cloth</td>
<td>Inhalation Hazards, Eye Irritation, Skin Irritation</td>
<td>Team Members will wear face masks at all times to prevent inhalation of the material. Goggles will be worn at all times to prevent Eye Irritation. Gloves will be worn at all times to prevent skin irritation.</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>Ingestion Hazards</td>
<td>Team Members will wear face masks at all times to prevent Ingestion of Material.</td>
</tr>
<tr>
<td>Polystyrene Foam</td>
<td>Ingestion Hazards, Skin Irritation, Eye Irritation</td>
<td>Team Members will wear face masks at all times to prevent Ingestion of Material. Goggles will be worn at all times to prevent eye irritation.</td>
</tr>
<tr>
<td>Duct Tape</td>
<td>Skin Irritation, Eye Irritation</td>
<td>Team members will avoid prolonged exposure of duct tape to bare skin to prevent skin irritation. Team members will not place duct tape on their eyes to prevent eye irritation.</td>
</tr>
<tr>
<td>Masking Tape</td>
<td>No Risks Stated</td>
<td></td>
</tr>
<tr>
<td>Super Glue</td>
<td>Toxic Fumes, Ingestion Hazards, Eye Irritation, Skin Irritation</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical resistant aprons will be worn at all times to prevent Skin Irritation and contact with. Goggles will be worn at all times to prevent eye irritation.</td>
</tr>
<tr>
<td>Acetone</td>
<td>Toxic Fumes, Ingestion Hazards, Eye Irritation, Skin Irritation</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical resistant aprons will be worn at all times to prevent Skin Irritation and contact with. Goggles will be worn at all times to prevent eye irritation.</td>
</tr>
<tr>
<td>Material</td>
<td>Hazards</td>
<td>Precautions</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mineral Spirits</td>
<td>Severe Eye Irritation, Skin irritation, Ingestion hazards</td>
<td>Team Members will wear face masks at all times to prevent Ingestion of the material. Gloves will be worn at all times to prevent skin irritation. Goggle will be worn at all times to prevent eye irritation</td>
</tr>
<tr>
<td>Denatured Alcohol</td>
<td>Toxic Fumes, Ingestion Hazards, Eye Irritation</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Goggles will be worn at all times to prevent eye irritation</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Inhalation Hazards</td>
<td>Team members will work in a well-ventilated area to prevent inhalation hazards</td>
</tr>
<tr>
<td>Silicone Lube</td>
<td>Ingestion Hazards, Skin Irritation, Eye Irritation, Toxic Fumes</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical resistant aprons will be worn at all times to prevent Skin Irritation and contact with clothing. Goggles will be worn at all times to prevent eye irritation</td>
</tr>
<tr>
<td>White Lithium Grease</td>
<td>Ingestion Hazards, Skin Irritation, Eye Irritation, Toxic Fumes</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Gloves and chemical resistant aprons will be worn at all times to prevent Skin Irritation and contact with clothing. Goggles will be worn at all times to prevent eye irritation</td>
</tr>
<tr>
<td>Isopropyl Rubbing Alcohol</td>
<td>Toxic Fumes, Ingestion Hazards, Eye Irritation, Inadvertent Ignition, Burns to Skin</td>
<td>Team Members will work in a well-ventilated area and wear face masks at all times to prevent inhalation of toxic fumes and ingestion of the material. Goggles will be worn at all times to prevent contact with eyes leading to eye irritation. Material will be kept away from ignition sources, such as flames, matches, igniters, heat sources. Team members will wear gloves to protect from burns to skin in the event of an inadvertent ignition</td>
</tr>
<tr>
<td>Black Powder</td>
<td>Inhalation Hazards, Eye Irritation, Inadvertent Ignition, Burns to skin</td>
<td>Team Members will wear face masks at all times to prevent Inhalation of the Black Powder. The Black Powder will be kept away from ignition sources such as flames, matches, and heat source to prevent inadvertent ignition. Gloves will be worn to prevent burns to skin. Goggles will be worn at all times to protect eyes. Equipment used with or near the Black Powder will be nonstatic producing materials to prevent inadvertent ignition.</td>
</tr>
</tbody>
</table>
Product ID: 20-3100 PHENOLIC POWDER-BLACK
MSDS Date: 01/01/1985
FSC: 9330
NIIN: 00-166-0250
MSDS Number: BDDZJ

=== Responsible Party ===
Company Name: BUEHLER LTD
Address: 41 WAUKEGAN RD
Box: 1
City: LAKE BLUFF
State: IL
ZIP: 60044-1687
Country: US
CAGE: 09410

=== Contractor Identification ===
Company Name: BUEHLER LTD.
Address: 41 WAUKEGAN RD.
Box: City: LAKE BLUFF
State: IL
ZIP: 60044-1687
Country: US
Phone: 847-295-8500
CAGE: 09410

============ Composition/Information on Ingredients =============

Ingred Name: PHENOL
CAS: 108-95-2
RTECS #: SJ3325000
Fraction by Wt: 3%
OSHA PEL: S, 5 PPM
ACGIH TLV: S, 5 PPM; 8990
EPA Rpt Qty: 1000 LBS
DOT Rpt Qty: 1000 LBS

Ingred Name: NON HAZARDOUS INGREDIENTS (AS SPECIFIED BY MFR)
Fraction by Wt: 97%

==================== Hazards Identification =====================
Effects of Overexposure: NONE SPECIFIED BY MFR. POSS. SKIN, EYE, RESPIRATORY IRRIT DUE TO DUST

================================= First Aid Measures =================================

First Aid: SKIN: WASH W/ SOAP & WATER. EYES: FLUSH W/ WATER FOR 15 MIN. AVOID INGESTION. CONSULT A DR.

================================= Fire Fighting Measures =================================

Extinguishing Media: DRY CHEMICAL, WATER, CARBON DIOXIDE
Fire Fighting Procedures: SELF CONT BREATHEING GEAR IN ENCLOSED AREA
Unusual Fire/Explosion Hazard: AVOID DUST ACCUMULATIONS OR DUST-LADEN ATMOSPHERES-DUST/AIR MIXTURES ARE EXPLOSIVE

================================= Accidental Release Measures =================================

Spill Release Procedures: VACUUM OR SWEEP WITH SAWDUST, SAND OR SWEEPING COMPOUND. AVOID GENERATING DUST.

================================= Handling and Storage =================================

Handling and Storage Precautions: AVOID TEMP EXTREMES & MOISTURE-CAN AFFECT PRODUCT PERFORMANCE. AVOID PROLONGED OR REPEATED SKIN & EYE CONTACT OR BREATHING OF VAPORS.
Other Precautions: USE ADEQUATE VENTILATION. USE GOOD PERSONAL HYGIENE.

================================= Exposure Controls/Personal Protection =================================

Respiratory Protection: NIOSH APPROVED RESPIRATORS RECOMMENDED FOR NUISANCE DUST
Ventilation: LOCAL RECOMMENDED TO REMOVE DUST & FUMES
Protective Gloves: RECOMMENDED
Eye Protection: SAFETY GLASSES
Other Protective Equipment: AS NECESSARY FOR GOOD HYGIENE & CLEAN WORK.
Supplemental Safety and Health
EXPLOSIVE LIMITS (AS POWDER) EQUALS 0.030 OZ/CU FT.

============== Physical/Chemical Properties ===============

HCC: T3  
NRC/State Lic Num: EXPLOSIVE LIMIT  
Boiling Pt: B.P. Text: NONE  
Solubility in Water: NEGLIGIBLE  
Appearance and Odor: GRANULAR - SLIGHT PHENOLIC ODOR.

============== Stability and Reactivity Data ===============

Stability Indicator/Materials to Avoid: YES  
NONE SPECIFIED BY MFR  
Hazardous Decomposition  
Products: CO₂, CO, PHENOLS, AMMONIA, FORMALDEHYDE

============== Disposal Considerations ===============

Waste Disposal Methods: BURY OR INCINERATE IN ACCORDANCE WITH LOCAL, STATE OR FEDERAL REGS.

Disclaimer (provided with this information by the compiling agencies):  
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CHEMRAY COATING CORP -- VARNISH, SPAR, PHENOLIC RESIN -- 8010-00-251-6980

=====================  Product Identification  =====================

Product ID: VARNISH, SPAR, PHENOLIC RESIN
MSDS Date: 10/27/1989
FSC: 8010
NIIN: 00-251-6980
MSDS Number: BHVZW

=== Responsible Party ===
Company Name: CHEMRAY COATING CORP
Address: 209 N MICHIGAN AVE
City: KENILWORTH
State: NJ
ZIP: 07033
Country: US
Info Phone Num: 201-245-1111
Emergency Phone Num: 800-424-9300 (CHEMTREC)
Preparer’s Name: FRED ARMSTRONG
CAGE: 33832

=== Contractor Identification ===
Company Name: CHEMRAY COATING CORP
Address: 209 N MICHIGAN AVE
Box: City: KENILWORTH
State: NJ
ZIP: 07033
Country: US
Phone: 201-245-1111
CAGE: 33832

==============  Composition/Information on Ingredients  ===============

Ingred Name: STODDARD SOLVENT
CAS: 8052-41-3
RTECS #: WJ8925000
Fraction by Wt: 41%
OSHA PEL: 500 PPM
ACGIH TLV: 100 PPM; 9293

Ingred Name: VOC = 3.07 LBS/GAL OR 368 GRAMS/LITER
RTECS #: 9999999VO
Hazard Identification

Routes of Entry: Inhalation: YES  Skin: NO  Ingestion: NO
Health Hazards Acute and Chronic: OVEREXPOSURE-NAUSEA, HEADACHE, DIZZINESS CAUSED BY OVER INHALATION. HIGH VAPOR CONCENTRATIONS (>1000 PPM) ARE IRRITATING TO THE EYES AND RESPIRATORY TRACT, ARE ANESTHETIC, AND MAY HAVE OTHER CENTRAL NERVOUS SYSTEM EFFECTS.
Effects of Overexposure: OVEREXPOSURE-NAUSEA, HEADACHE, DIZZINESS CAUSED BY OVER INHALATION. HIGH VAPOR CONCENTRATIONS (>1000 PPM) ARE IRRITATING TO THE EYES AND RESPIRATORY TRACT, ARE ANESTHETIC, AND MAY HAVE OTHER CENTRAL NERVOUS SYSTEM EFFECTS.
Medical Condition Aggravated by Exposure: NONE GENERALLY KNOWN.

First Aid Measures

First Aid: EYE CONTACT: FLUSH WITH WATER 15 MINUTES OR UNTIL IRRITATION SUBSIDES. IF IRRITATION PERSISTS, CALL PHYSICIAN. SKIN CONTACT: REMOVE CONTAMINATED CLOTHING AND WASH THOROUGHLY WITH SOAP AND WATER. INHALATION: IF OVERCOME BY VAPORS, REMOVE TO FRESH AIR, CALL PHYSICIAN. INGESTION: DO NOT INDUCE VOMITING, CALL PHYSICIAN.

Fire Fighting Measures

Flash Point Method: SCC
Flash Point: 103 F/40 C
Autoignition Temp: Autoignition Temp Text: 473 F
Lower Limits: 0.9
Upper Limits: 7
Extinguishing Media: CARBON DIOXIDE, FOAM, WATER FOG OR DRY CHEMICAL.
Fire Fighting Procedures: USE AIR SUPPLIED BREATHING EQUIPMENT. COOL ENCLOSED CONTAINERS WITH WATER SPRAY. AVOID BREATHING VAPORS OR FUMES.
Unusual Fire/Explosion Hazard: IF LEAK OR SPILL HAS IGNITED, USE WATER
SPRAY TO DISPERSE THE VAPORS FROM FIRE FIGHTERS.

================================ Accidental Release Measures ===================================

Spill Release Procedures: REMOVE ALL IGNITION SOURCES. KEEP FROM HEAT,
   SPARKS AND OPEN FLAME. ADD ABSORBENT (SAND, EARTH, SAWDUST) TO
   SPILL. VENTILATE AREA (OPEN WINDOWS, DOORS). LARGE SPILL:
   KEEP FROM ENTERING SEWERS/WATERCOU RSES BY DIKING. ADVISE
   AUTHORITIES IF DOES ENTER.

================================= Handling and Storage ========================================

Handling and Storage Precautions: STORE AWAY FROM IGNITION SOURCES, KEEP
   IN COOL, DRY, WELL VENTILATED AREAS. AVOID DIRECT SUNLIGHT AND
   EXTREME TEMPERATURES, HOT OR COLD.
Other Precautions: AVOID EYE, SKIN CONTACT, INHALATION &/OR
   INGESTION OF MISTS, SPRAY OR VAPORS. AVOID BREATHING SANDING OR BLASTING DUST.

================================= Exposure Controls/Personal Protection =======================

Respiratory Protection: USE HYDROCARBON VAPOR CANISTER OR SUPPLIED AIR
   RESPIRATOR IN CONFINED AREAS.
Ventilation: LOCAL EXHAUST: FACE VELOCITY 60FPM. SPECIAL: USE ONLY W/ADEQUATE VENTILATION. MECHANICAL: USE EXPLOSION PROOF
   EQUIPMENT.
Protective Gloves: CHEMICAL RESISTANT.
Eye Protection: SPLASH GOOGLES OR FACE SHIELD.
Other Protective Equipment: USE CHEMICAL RESISTANT APRON OR CLOTHING.

Supplemental Safety and Health

================================= Physical/Chemical Properties ================================

Boiling Pt: B.P. Text: 308F, 153C
Melt/Freeze Pt: M.P/F.P Text: O F(-17.8C)
Decomp Temp: Decomp Text: 600 F(316C)
Vapor Pres:<10 @ 68 F
Vapor Density:4.8 @ 77 F
Spec Gravity:.90 (H2O=1)
Viscosity:C-F@77F G.H.
Evaporation Rate & Reference:0.09 (BUTYL ACETATE=1)
Solubility in Water:NEGLIGIBLE
Appearance and Odor:CLEAR CARAMEL LIQUID WITH SOLVENT ODOR.
Percent Volatiles by Volume:47.7

============ Stability and Reactivity Data =============

Stability Indicator/Materials to Avoid:YES
CAN REACT WITH OXIDIZING MATERIAL WHEN HEATED TO DECOMPOSITION.
Stability Condition to Avoid:HIGH TEMPERATURES.
Hazardous Decomposition Products:CARBON MONOXIDE.

============ Disposal Considerations =============

Waste Disposal Methods:ASSURE CONFORMITY WITH APPLICABLE DISPOSAL REGULATIONS. DISPOSE OF ABSORBED MATERIAL AT AN APPROVED DISPOSAL SITE OR FACILITY. DISPOSE IN CONFORMITY WITH STATE AND FEDERAL REGULATIONS.

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AeroTech Division, RCS Rocket Motor Components, Inc.

Material Safety Data Sheet & Emergency Response Information

Prepared in accordance with 29 CFR § 1910.1200 (g)

Section 1. Product Identification

Copperhead™ igniter, FirstFire™ igniter, FirstFire Jr.™ igniter. These products contain varying percentages of Ammonium or Potassium Perchlorate, carbon black and carbon fibers dispersed in a flammable binder with lesser amounts of proprietary ingredients such as burn rate modifiers and a metal fuel.

Section 2. Physical Characteristics

Narrow copper foil strips or yellow wires coated with a small amount of black igniter composition on one end, little or no odor.

Section 3. Physical Hazards

Igniters are flammable and may give off varying amounts of Hydrogen Chloride and Carbon Monoxide gas, soot and carbon fibers when burned.

Section 4. Health Hazards

Igniter coating may be hazardous in the case of ingestion, and may be toxic to kidneys, lungs and the nervous system. Symptoms may include respiratory irritation, skin irritation, muscle tightness, vomiting, diarrhea, abdominal pain, muscular tremors, weakness, labored breathing, irregular heartbeat, convulsions. Inhalation of large amounts of combustion products may produce similar but lesser symptoms as ingestion.

Section 5. Primary Routes of Entry

Ingestion, inhalation.

Section 6. Permitted Exposure Limits

None established for manufactured product.
Section 7. Carcinogenic Potential

None known.

Section 8. Precautions for Safe Handling

Keep away from flames and other sources of heat. Do not smoke within 25 feet of product. Do not ingest. Do not breathe combustion products. Keep in original packaging until ready for use.

Section 9. Control Measures

See section 8.

Section 10. Emergency & First Aid Procedures

If ingested, induce vomiting and call a physician. If combustion products are inhaled, move to fresh air and call a physician if ill effects are noted. For mild burns use a first aid burn ointment. For severe burns immerse the burned area in cold water at once and see a physician immediately.

Section 11. Date of Preparation or Revision

October 12, 2008

Section 12. Contact Information

AeroTech Division, RCS Rocket Motor Components, Inc.
2113 W. 850 N. St.
Cedar City, UT 84721
(435) 865-7100 (Ph)
(435) 865-7120 (Fax)
Email: customerservice@aerotech-rocketry.com
Web: http://www.aerotech-rocketry.com
Emergency Response: (800) 535-5053 (US), (352) 323-3500 (Int'l)
AeroTech Division, RCS Rocket Motor Components, Inc.

Material Safety Data Sheet & Emergency Response Information

Prepared in accordance with 29 CFR § 1910.1200 (g)

Section 1. Product Identification

Model rocket motor, high power rocket motor, hobby rocket motor, composite rocket motor, rocket motor kit, rocket motor reloading kit, containing varying amounts of solid propellant with the trade names White Lightning™, Blue Thunder™, Black Jack™, Black Max™, Redline™, Warp-9™ or Mojave Green™. These products contain varying percentages of Ammonium Perchlorate, Strontium and/or Barium Nitrate dispersed in synthetic rubber with lesser amounts of proprietary ingredients such as burn rate modifiers and metal fuels. Rocket motor ejection charges contain black powder.

Section 2. Physical Characteristics

Black plastic cylinders or bags with various colored parts, little or no odor

Section 3. Physical Hazards

Rocket motors and reload kits are flammable, rocket motors may become propulsive in a fire. All propellants give off varying amounts of Hydrogen Chloride and Carbon Monoxide gas when burned, Mojave Green propellant also produces Barium Chloride.

Section 4. Health Hazards

Propellant is an irritant in the case of skin and eye contact, may be extremely hazardous in the case of ingestion, and may be toxic to kidneys, lungs and the nervous system. Symptoms include respiratory irritation, skin irritation, muscle tightness, vomiting, diarrhea, abdominal pain, muscular tremors, weakness, labored breathing, irregular heartbeat, convulsions. Inhalation of large amounts of combustion products may produce similar but lesser symptoms as ingestion.

Section 5. Primary Routes of Entry
Skin contact, ingestion, inhalation.

Section 6. Permitted Exposure Limits

None established for manufactured product.

Section 7. Carcinogenic Potential

None known.

Section 8. Precautions for Safe Handling

Disposable rubber gloves are recommended for handling Mojave Green propellant. Keep away from flames and other sources of heat. Do not smoke within 25 feet of product. Do not ingest. Do not breathe exhaust fumes. Keep in original packaging until ready for use.

Section 9. Control Measures

See section 8.

Section 10. Emergency & First Aid Procedures

If ingested, induce vomiting and call a physician. If combustion products are inhaled, move to fresh air and call a physician if ill effects are noted. In the case of skin contact, wash area immediately and contact a physician if severe skin rash or irritation develops. For mild burns use a first aid burn ointment. For severe burns immerse the burned area in cold water at once and see a physician immediately.

Section 11. Date of Preparation or Revision

October 11, 2008

Section 12. Contact Information

AeroTech Division, RCS Rocket Motor Components, Inc.
2113 W. 850 N. St.
Cedar City, UT 84721
(435) 865-7100 (Ph)
(435) 865-7120 (Fax)
Email: customerservice@aerotech-rocketry.com
Web: http://www.aerotech-rocketry.com
Emergency Response: (800) 535-5053 (US), (352) 323-3500 (Int'l)
MATERIAL SAFETY DATA SHEET

The information contained herein is based on data considered accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof.

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ELECTRON MICROSCOPY SCIENCES
321 MORRIS ROAD
P.O. BOX 251
FORT WASHINGTON, PA 19034 24 HOUR EMERGENCY PHONE NUMBER (215) 646-1566 CHEMTREC: (800) 424-9300

FOR PRODUCT AND SALES INFORMATION

CONTACT ELECTRON MICROSCOPY SCIENCES OFFICE ABOVE.

PRODUCT IDENTIFICATION

PRODUCT NAME: D.E.R.(R) 736 Epoxy Resin
INGREDIENTS: Epichlorohydrin-polyglycol reaction product

(%, unless otherwise noted)

CAS NUMBER: 041638-13-5

PERCENT: 100

This document is prepared pursuant to the OSHA Hazard Communication Standard (29 CFR 1910.1200). In addition, other substances not 'Hazardous' per this OSHA Standard may be listed. Where proprietary ingredient shows, the identity may be made available as provided in this standard.

PHYSICAL DATA

BOILING POINT: Greater than 225°C at 760 mm Hg
VAPOR PRESSURE: 5.6 mm Hg at 20°C
VAPOR DENSITY: Not applicable
SOLUBILITY IN WATER: 11.0 wt.%
SPECIFIC GRAVITY: 1.14
VISCOSITY: 30-60 cps at 25°C
APPEARANCE: Near water white liquid
ODOR: Slight ethereal.

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: 320°F

METHOD USED: PMCC, ASTM D-93

FLAMMABLE LIMITS: LFL: Not determined
UFL: Not determined
EXTINGUISHING MEDIA:

Foam, CO2, dry chemical, alcohol-resistant foam

FIRE AND EXPLOSION HAZARDS: None known

FIRE-FIGHTING EQUIPMENT: Wear positive pressure self-contained breathing apparatus.
REACTIVITY DATA

STABILITY (CONDITIONS TO AVOID):
None; but for maximum product life do not exceed 55°C (131°F) during storage.

INCOMPATIBILITY (SPECIFIC MATERIALS TO AVOID):
Base or strong acid, amines and oxidizing materials.

HAZARDOUS DECOMPOSITION PRODUCTS:
The by-products expected in incomplete pyrolysis or combustion of epoxy resins are mainly phenolics, carbon monoxide, hydrogen chloride, and water. The thermal decomposition products of epoxy resins therefore should be treated as potentially hazardous substances, and appropriate precautions should be taken.

HAZARDOUS POLYMERIZATION:
Will not occur by itself, but masses of more than 1 pound of product plus an aliphatic amine will cause irreversible polymerization with considerable heat buildup.

ENVIRONMENTAL AND DISPOSAL INFORMATION

ACTION TO TAKE FOR SPILLS/LEAKS:
Soak up in absorbent material such as sand and collect in suitable containers. Residual resin may be removed using steam or hot soapy water. Solvents are not recommended for cleanup unless the recommended exposure guidelines and safe handling practices for the specific solvent are followed. Consult appropriate solvent MSDS for handling information and exposure guidelines. Keep spark producing equipment away. For large spills, evacuate upwind of spills and contain with dike.

DISPOSAL METHOD:
DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY
OF WATER. For unused or uncontaminated material, the preferred disposal options are to send to a licensed recycler, reclaimer, or incinerator. For used or contaminated material, the preferred disposal options remain the same, although additional evaluation is required (see, for example, 40 CFR, Part 261, "Identification and Listing of Hazardous waste.") Any disposal practice must be in compliance with Federal, State, Provincial, and Local laws and regulations.

HEALTH HAZARD DATA

EYE: May cause moderate irritation with corneal injury.

SKIN CONTACT:

Short single exposure not likely to cause significant skin irritation. Prolonged exposure may cause skin irritation. Repeated exposure may cause skin burns. May cause more severe response if confined to skin or skin is abraded (scratched or cut). May cause allergic skin reaction in susceptible individuals.

SKIN ABSORPTION:

A single prolonged exposure is not likely to result in the material being absorbed through skin in harmful amounts. The LD50 for skin absorption in rabbits is >2000mg/kg.

INGESTION:

Single dose oral toxicity is low. The oral LD50 for rats is >2000 mg/kg. Amounts ingested incidental to normal handling operations are not likely to cause injury; swallowing larger amounts may cause injury.

INHALATION:

Elevated temperatures may generate vapor levels sufficient to cause irritation and other effects.

MUTAGENICITY (EFFECTS ON GENETIC MATERIAL):

Results of in vitro ("test tube") mutagenicity tests have been positive.
FIRST AID

EYES: Irrigate immediately with water for at least 15 minutes.

SKIN: Wash off in flowing water or shower.

INGESTION:
Induce vomiting if large amounts are ingested. Consult medical personnel.

INHALATION:
Remove to fresh air if effects occur. Consult a physician.

NOTE TO PHYSICIAN:
If burn is present, treat as any thermal burn, after decontamination. No specific antidote. Supportive care. Treatment based on judgement of the physician in response to reactions of the patient.

HANDLING PRECAUTIONS

EXPOSURE GUIDELINE(S): None established.

VENTILATION:
Good general ventilation should be sufficient for most conditions.

RESPIRATORY PROTECTION:
No respiratory protection should be needed. If respiratory irritation is experienced, use an approved air-purifying respirator.

SKIN PROTECTION:
For brief contact, no precautions other than clean body-
covering clothing should be needed. When prolonged or frequently repeated contact could occur, use protective clothing impervious to this material. Selection of specific items such as gloves, boots, apron or full-body suit will depend on operation.

EYE PROTECTION:

Use safety glasses. Where contact with this material is likely, chemical goggles are recommended because eye contact may cause pain even though it is unlikely to cause injury.

ADDITIONAL INFORMATION

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:

None except normal handling care. Practice good caution and personal cleanliness to avoid eye and skin contact. Avoid breathing vapors if generated.
ITW DEVCON CORP -- 5-MINUTE EPOXY RESIN -- 8040-00-264-6816

================================== Product Identification =================================

Product ID: 5-MINUTE EPOXY RESIN
MSDS Date: 12/14/1989
FSC: 8040
NIIN: 00-264-6816
MSDS Number: BLJGZ

=== Responsible Party ===
Company Name: ITW DEVCON CORP
Address: 30 ENDICOTT ST
City: DANVERS
State: MA
ZIP: 01923
Country: US
Info Phone Num: 508-777-1100
Emergency Phone Num: 800-424-9300 CHEMTREC
CAGE: EO352

=== Contractor Identification ===
Company Name: DEVCON CORP
Address: 30 ENDICOTT ST
Box: City: DANVERS
State: MA
ZIP: 01923-3753
Country: US
Phone: 1-508-777-1100
CAGE: 16059
Company Name: ITW DEVCON CORP
Address: 30 ENDICOTT ST
City: DANVERS
State: MA
ZIP: 01923
Country: US
Phone: 508-777-1100
CAGE: EO352

================================= Composition/Information on Ingredients ======================

Ingred Name: BISPHENOL A DIGLYCIDYL ETHER RESIN (POTENTIAL SKIN SENSITIZER)
CAS: 25068-38-6
RTECS #: KD4380000
Fraction by Wt: >60%
Other REC Limits: NONE SPECIFIED

Ingred Name: VOC: 0 LBS/GAL (EPA REFERENCE METHOD 24)
RTECS #: 9999999VO
Other REC Limits: NONE SPECIFIED

=================================  Hazards Identification  ===================

LD50 LC50 Mixture: ORAL LD50 RAT: 11,400 MG/KG; DERM LD50 *
Routes of Entry: Inhalation: NO  Skin: YES  Ingestion: YES
Reports of Carcinogenicity: NTP: NO   IARC: NO   OSHA: NO
Health Hazards Acute and Chronic: PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE SENSITIZATION WITH ITCHING, SWELLING OR RASHES ON LATER EXPOSURE.
Explanation of Carcinogenicity: *RABB: >20,000 MG/KG; INHALATION LC50 RAT: NO DEATHS IN SATURATED AIR; EXPOSURE TIME: 8 HRS.
Effects of Overexposure: EYES: MILD IRRITATION. SKIN: MILD IRRITATION. INHALATION. THE LOW VAPOR PRESSURE OF THE RESIN MAKES INHALATION UNLIKELY IN NORMAL USE. INGESTION: ACUTE ORAL TOXICITY IS LOW. MAY CAUSE GASTRIC DISTRESS.
Medical Cond Aggravated by Exposure: ALLERGIES, ECZEMA OR OTHER SKIN DISORDERS.

================================= First Aid Measures  =================================

First Aid: EYES: FLUSH W/CLEAN WATER-15 MIN. WHILE GENTLY HOLDING EYELIDS OPEN. GET IMMED MEDICAL ATTENTION. SKIN: WASH THOROUGHLY W/SOAP & WARM WATER. CONSULT PHYSICIAN IF IRRIT DEVELOPS. INHALATION: REMOVE TO FRESH AIR. GIVE OXYGEN IF BREATHING IS DIFFICULT. GET MEDICAL ATTENTION IF SYMPTOMS PERSIST.
INGESTION: DO NOT INDUCE VOMITING. GIVE 2 GLASSES WATER TO DILUTE (UNLESS UNCONSCIOUS). GET MEDICAL ATTEN.

=================================  Fire Fighting Measures  ================

Flash Point Method: PMCC
Flash Point: >400F, >204C
Lower Limits: N/D
Upper Limits: N/D
Extinguishing Media: CO2, DRY CHEMICAL, FOAM.
Fire Fighting Procedures: FIREFIGHTERS SHOULD WEAR SELF-CONTAINED BREATTHING APPARATUS AND PROTECTIVE CLOTHING.
Unusual Fire/Explosion Hazard: NONE

Accidental Release Measures

Spill Release Procedures: PREVENT SKIN AND EYE CONTACT. LARGE SPILLS MAY BE ABSORBED ON INERT MATERIAL SUCH AS SAND OR VERMICULITE. SCRAPE SPILL UP INTO NONPOROUS CONTAINERS. CLEAN SPILL AREA WITH STRONG DETERGENT AND WATER; USE SOLVENTS ONLY WITH APPROPRIATE CAUTION.

Handling and Storage

Handling and Storage Precautions: STORE IN A COOL, DRY PLACE. HANDLE MIXED RESIN & HARDENER IN ACCORDANCE W/POTENTIAL HAZARD OF THE CURING AGENT USED. DISCARD CONTAM LEATHER ARTICLES.
Other Precautions: REMOVE CONTAMINATED CLOTHING AND PROTECTIVE GEAR;
CLEAN THOROUGHLY BEFORE USING AGAIN. IF CURED MATERIAL IS SANDED OR MACHINED, USE ADEQUATE PRECAUTIONS AGAINST NUISANCE PARTICulates.

Exposure Controls/Personal Protection

Respiratory Protection: NONE REQUIRED AT NORMAL HANDLING TEMPERATURES.
Ventilation: LOCAL EXHAUST IS RECOMMENDED FOR CONFINED AREAS. GENERAL MECHANICAL VENTILATION IS ADEQUATE FOR NORMAL USE.
Protective Gloves: IMPERVIOUS GLOVES.
Eye Protection: SAFETY GLASSES WITH SIDE SHIELDS.
Other Protective Equipment: OTHER GEAR AS REQUIRED.
Work Hygienic Practices: WASH THOROUGHLY AFTER USING, PARTICULARLY BEFORE EATING OR SMOKING.
Supplemental Safety and Health

================================== Physical/Chemical Properties ==================================

HCC:N1
Boiling Pt:B.P. Text:N/D
Melt/Freeze Pt:M.P/F.P Text:N/D
Vapor Pres:NIL @ 70 F
Vapor Density:>1
Spec Gravity:1.2
pH:7 (5%)
Evaporation Rate & Reference:<1 (BUAC = 1)
Solubility in Water:NIL
Appearance and Odor:THICK, AMBER LIQUID WITH LITTLE ODOR.

================================== Stability and Reactivity Data =================================

Stability Indicator/Materials to Avoid:YES
STRONG ACIDS AND STRONG OXIDIZING AGENTS.
Stability Condition to Avoid:OPEN FLAME AND EXTREME HEAT.
Hazardous Decomposition Products:OXIDES OF CARBON, ALDEHYDES AND ACIDS
FROM INCOMPLETE COMBUSTION.
Conditions to Avoid Polymerization:HEAT IS GENERATED WHEN THIS RESIN IS
MIXED WITH AMINES OR EPOXY HARDENERS; BE CAREFUL WHEN MIXING.

================================== Disposal Considerations ==================================

Waste Disposal Methods:REMOVE TO A WASTE FACILITY OPERATING IN COMPLIANCE WITH STATE AND LOCAL REGULATIONS.

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SPECIALTY COMPOUNDS INC -- SINMAST 4 EPOXY MORTAR MIX - NORMAL CURE -- 5610-00N078857

========================= Product Identification =========================

Product ID:SINMAST 4 EPOXY MORTAR MIX - NORMAL CURE
MSDS Date:08/01/1995
FSC:5610
NIIN:00N078857
MSDS Number: CGGQS

=== Responsible Party ===
Company Name:SPECIALTY COMPOUNDS INC
Address:3300 EAST 84TH PLACE
City:MERRILVILLE
State:IN
ZIP:46410
Country:US
Info Phone Num:219-947-1070
Emergency Phone Num:800-255-3924
CAGE:7T163

=== Contractor Identification ===
Company Name:SPECIALTY COMPOUNDS INC
Address:3300 E 84TH PL
Box:City:MERRILLVILLE
State:IN
ZIP:46410-6551
Country:US
Phone:219-947-1070
CAGE:7T163

============== Composition/Information on Ingredients ===============

Ingred Name:COMPONENT "A" (CONSISTING OF INGREDIENTS 2 & 3)
RTECS #:9999999ZZ
OSHA PEL:N/K
ACGIH TLV:N/K

Ingred Name:BISPHENOL A-EPICHLOROHYDRIN COPOLYMER;
(BISPHENOL A
   EPICHLOROHYDRIN EPOXY RESIN)
CAS:25068-38-6
RTECS #:SL6475000
Fraction by Wt: 90%
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: PROPANE, 1-BUTOXY-2,3-EPoxy-; (BUTYL GLYCIDYL ETHER) (BGE)
CAS: 2426-08-6
RTECS #: TX4200000
Fraction by Wt: 10%
OSHA PEL: 50 PPM
ACGIH TLV: 25 PPM

Ingred Name: COMPONENT "B" (CONSISTING OF INGREDIENTS 5 - 8)
RTECS #: 9999999ZZ
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: TOFA REACT WITH TEPA
CAS: 68953-36-6
Fraction by Wt: 55%
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: DIETHYLENETRIAMINE
CAS: 111-40-0
RTECS #: IE1225000
Fraction by Wt: 15%
OSHA PEL: 1 PPM
ACGIH TLV: 1 PPM, S

Ingred Name: 1,2-ETHANEDIAMINE, N-(2-AMINOETHYL)-N’-(2-
(2-AMINOETHYL)AMINO)ETHYL)-; (TETRAETHYLENEPENTAMINE)
CAS: 112-57-2
RTECS #: KH8585000
Fraction by Wt: 15%
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: PHENOL, 4,4’-ISOPROPYLENEDI-; (BISPHENOL A) (SARA 313)
CAS: 80-05-7
RTECS #: SL6300000
Fraction by Wt: 10%
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: SUPP DATA: WHEN PRODUCT COMES IN CONTACT W/NITROUS ACID,
NITRITES OR ATMOSPHERES W/HIGH NITROUS OXIDE CONCENTRATIONS.
RTECS #:9999999ZZ

Ingred Name: SPILL PROC: OR DISP. EVACUATE ALL PERS UPWIND FROM SPILL.
   PVNT SPILL PROD FROM ENTERING STREAMS/DRINKING WATER (ING 11)
RTECS #:9999999ZZ

Ingred Name: ING 10: SUPPLIES. NOTIFY LOCAL HEALTH AUTHORITIES & OTHER
   APPROPRIATE AGENCIES IF SUCH CONTAMINATION SHOULD OCCUR.
RTECS #:9999999ZZ

Ingred Name: PROT GLOVES: SITUATIONS, WEAR IMPERMEABLE GLOVES W/CUFFS TO
   PVNT SPREAD OF MATL ABOVE WRISTS. EXAMINE PROT GLOVES (ING 13)
RTECS #:9999999ZZ

Ingred Name: ING 12: BEFORE USING. DISCARD IF THERE IS EVIDENCE OF HOLES
   OR CRACKS.
RTECS #:9999999ZZ

================================== Hazards Identification ==========================

LD50 LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation: NO  Skin: YES  Ingestion: YES
Reports of Carcinogenicity: NTP: NO  IARC: NO  OSHA: NO
Health Hazards Acute and Chronic: EYE CONTACT: MODERATELY IRRITATING.
   SKIN CONTACT: MODERATELY IRRITATING - POSSIBLE SENSITIZATION.
   INHALATION: DUE TO LOW VOLATILITY, NOT LIKELY TO BE INHALED.
   INGESTION: CAN CAUSE BLEEDING IN GASTROINTESTINAL TRACT.
Explanation of Carcinogenicity: NOT RELEVANT
Effects of Overexposure: SEE HEALTH HAZARDS.
Medical Cond Aggravated by Exposure: NONE SPECIFIED BY MANUFACTURER.

================================== First Aid Measures =============================

First Aid: EYES: FLUSH W/PLENTY OF WATER FOR AT LST 15 MINS HOLDING LIDS
OPEN. GET MED ATTN. SKIN: REMOVE PROD FROM SKIN. FLUSH AFFECTED AREA
W/WATER. REMOVE CONTAM CLTHG & GLOVES. FOLLOW BY WASHING W/SOAP & WATER. IF IRRIT PERSISTS GET MED ATTN. INHAL: REMOVE TO FRESH AIR & PROVIDE OXYG IF BRTHG IS DFCLT. GET MED ATTN. INGEST: DO NOT INDUCE VOMIT. ADMIN 3-4 GLASSES OF MILK/WATER. OBTAIN MED CARE IMMEDIATELY.

----------------------------- Fire Fighting Measures -----------------------------

Flash Point Method: PMCC
Flash Point: 156F, 69C
Extinguishing Media: WATER FOG, CO2, DRY CHEMICAL OR FOAM. MATERIAL WILL NOT BURN UNLESS PREHEATED.
Fire Fighting Procedures: USE NIOSH APPROVED SCBA & FULL PROTECTIVE EQUIPMENT. COOL FIRE W/WATER FOG.
Unusual Fire/Explosion Hazard: NONE SPECIFIED BY MANUFACTURER.

----------------------------- Accidental Release Measures -----------------------------

Spill Release Procedures: SHUT OFF/REMOVE ALL IGNIT SOURCES. CONSTRUCT DIKE TO PVNT SPREADING. PERS SHOULD BE EQUIPPED W/ NIOSH APPRVD SCBA & BUTYL RUBBER PROT CLTHG. COVER MINOR SPILLS W/SODIUM BISULFITE & REDUCE VAPS. SPRAY W/WATER. PLACE IN METAL CNTNRS FOR RECOVERY(ING 10)
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.

----------------------------- Handling and Storage -----------------------------

Handling and Storage Precautions: CORR. KEEP AT ROOM TEMP, DRY, VENTED STOR IN CLSD CNTNRS. KEEP AWAY FROM OXIDIZERS, HEAT/FLAMES. STORE IN STEEL CNTNRS. AVOID CONT W/SKIN OR EYES.
Other Precautions: HANDLE IN WELL VENTED WORK SPACE. AVOID BRTHG VAPS. ADHERE TO WORK PRACTICE RULES ESTABLISHED BY GOVT REGS
(E.G. OSHA).

DO NOT USE SODIUM NITRITE/OTHER NITROSATING AGENTS IN FORMULATIONS.
CANCER-CAUSING NITROSAMINES COULD BE FORMED.

============= Exposure Controls/Personal Protection =============

Respiratory Protection: IN POORLY VENTED AREAS, A NIOSH APPROVED CARTRIDGE
MASK APPROVED FOR ORG VAPS IS RECOMMENDED UNDER FOLLOWING CONDITIONS:
SITUATIONS, WHEN PROD VAP CONC IS >20 PPM FOR PERIOD >15 MINS,
DURING REPAIR & CLEANING OF EQUIPMENT, DURING TRANSFER/DISCHARGE (SUPDAT)

Ventilation: ADEQUATE GENERAL & LOCAL EXHAUST.
Protective Gloves: NITRILE RUBBER GLOVES. IN EMERGENCY SITUATIONS, WHEN PROD VAP CONC IS >20 PPM FOR PERIOD >15 MINS,
DURING REPAIR & CLEANING OF EQUIPMENT, DURING TRANSFER/DISCHARGE (SUPDAT)

Eye Protection: ANSI APPROVED CHEMICAL WORKERS GOGGS & (SUPDAT)

Other Protective Equipment: EYE WASH FOUNTAIN & DELUGE SHOWER WHICH MEET ANSI DESIGN CRITERIA.

RUBBER BOOTS.

WORK HYGIENIC PRACTICES: CONTACT LENSES SHOULD NOT BE WORN. WASH AT END
OF EACH WORK SHIFT & BEFORE EATING, SMOKING/USING TOILET.
LAUNDER (SUPDAT)

Supplemental Safety and Health

PH: ALKALINE. WASTE DISP METH: LONG TERM ENVIRONMENTAL HAZARDS, THEREFORE LANDFILL DISPOSAL MUST BE CONSIDERED LESS ACCEPTABLE THAN INCINERATION. RESPIRATORY PROTECTION & USE OF PROD. EYE PROTECTIVE FULL LENGTH FACE SHIELD. HYGIENIC PRACTICE: OR DISCARD CONTAMINATED CLOTHING.

CLOTHES. DISCARD CONTAMINATED LEATHER ARTICLES INCLUDING SHOES. MATERIALS TO AVOID: ARE KNOWN TO BE CARCINOGENIC, MAY BE FORMED (ING 9)

============= Physical/Chemical Properties ==============

pH: SUPDAT
Appearance and Odor: CLEAR, LIGHT AMBER, FLOWABLE LIQUID; AMMONIACAL ODOR.

============= Stability and Reactivity Data =============
Stability Indicator/Materials to Avoid: YES
CAN REACT VIGOROUSLY W/STRONG OXIDIZING AGENTS, STRONG LEWIS/MINERAL
ACIDS. CAUT: N-NITROSAMINES, MANY OF WHICH (SUPDAT)
Stability Condition to Avoid: NONE SPECIFIED BY MANUFACTURER.
Hazardous Decomposition Products: N-NITROSAMINES MAY BE FORMED.

==================== Disposal Considerations ====================

Waste Disposal Methods: COMPLY W/ALL FED, STATE & LOC REGS. INCIN IS ACCEPT & PREF METH OF DISP. INCIN IN ADMIXT W/FUEL EQUIPPED W/SCRUBBER TO REMOVE NITROGEN OXIDES & CARBON MONOXIDE.
DISP OF IN
APPRVD LANDFILL IF ALLOWED L OCALLY. WASTE FROM THIS PROD MAY
PRESENT (SUPDAT)

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Product ID: COMPRESSED CARBON FIBER SHEET, STYLE MTC-9850
MSDS Date: 08/11/1993
FSC: 5330
NIIN: 00N064992
MSDS Number: BZKXB
*** Responsible Party ***
Company Name: GARLOCK INC
Address: 1666 DIVISION ST
City: PALMYRA
State: NY
ZIP: 14522
Country: US
Info Phone Num: 315-597-4811
Emergency Phone Num: 315-597-4811
Preparer's Name: HAROLD R HUGHES
CAGE: 76380
*** Contractor Identification ***
Company Name: GARLOCK INC
Address: 1666 DIVISION ST
Box: City: PALMYRA
State: NY
ZIP: 14522
Country: US
Phone: 315-597-4811
CAGE: 76380
Company Name: GARLOCK INC MECHANICAL PACKING DIV
Address: 1666 DIVISION ST
City: PALMYRA
State: NY
ZIP: 14522-9343
Country: US
Phone: 315-597-4811
CAGE: 73680

================= Composition/Information on Ingredients =================

Ingred Name: MINERAL WOOL; (ROCK WOOL (MAN MADE MINERAL FIBER))
RTECS #: PY8070000
Fraction by Wt: 2-6%
OSHA PEL:N/K
ACGIH TLV:10 MG/M3 (TWA) (MFR)

Ingred Name:SILICA, CRYSTALLINE - QUARTZ (CRYSTALLINE SILICA - NOT A HAZARD UNLESS AIRBORNE)
CAS:14808-60-7
RTECS #:VV7330000
Fraction by Wt: <2.5%
OSHA PEL:SEE TABLE Z-3
ACGIH TLV:0.1 MG/M3 RDUST;9495

Ingred Name:GRAPHITE; (NATURAL GRAPHITE - NOT A HAZARD UNLESS AIRBORNE)
CAS:7782-42-5
RTECS #:MD9659600
Fraction by Wt: 2-5%
OSHA PEL:15 MPPCF; Z-3
ACGIH TLV:2 MG/M3 RDUST; 9495

Ingred Name:FIBERS, SYNTHETIC; (SYNTHETIC FIBERS)
OSHA PEL:N/K
ACGIH TLV:N/K

Ingred Name:BINDER SYSTEM; (ELASTOMERIC BINDERS)
OSHA PEL:N/K
ACGIH TLV:N/K

Ingred Name:STYRENE-BUTADIENE; (STYRENE-BUTADIENE ELASTOMER)
OSHA PEL:N/K
ACGIH TLV:N/K

================================== Hazards Identification =================================

LD50 LC50 Mixture:NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation:YES  Skin:NO  Ingestion:NO
Reports of Carcinogenicity:NTP:YES   IARC:YES   OSHA:NO
Health Hazards Acute and Chronic:PRODUCT DOES NOT POSE A HEALTH HAZARD
   UNDER ORDINARY CONDITIONS OF USE. A HAZARD WOULD ARISE ONLY IF THE
   PRODUCT WAS SUBJECT TO MECHANICAL ACTIONS WHICH COULD CAUSE FIBERS
   AND/OR DUST TO RELEASED FROM THE ELASTOMER MATRIX.

INHALATION OF

117
SUFFICIENT QUANTITIES OF FIBERS AND/OR DUST COULD CAUSE (EFTS OF OVEREXP)
Explanation of Carcinogenicity:CRYSTALLING SILICA:NTP 7TH ANNUAL RPT ON CARCINS, 1994: ANTIC TO BE CARCIN. IARC MONOGRAPHS, SUPP. VOL 7, PG 341(SUPDAT)
Effects of Overexposure:HLTH HAZ:RESPIRATORY PROBLEMS AND HAS THE POTENTIAL TO CAUSE LASTING LUNG DAMAGE.
Medical Cond Aggravated by Exposure:BREATHING AIRBORNE FIBERS OR PARTICULATES MAY AGGRAVATE ANY EXISTING LUNG DISORDERS OR BRONCHITIS.

============= First Aid Measures =============
First Aid:INGEST:CALL MD IMMEDIATELY . EYES:IMMEDIATELY FLUSH W/POTABLE WATER FOR A MINIMUM OF 15 MINUTES, SEEK ASSISTANCE FROM MD . SKIN:FLUSH W/COPIOUS AMOUNTS OF WATER. CALL MD . INHAL:IF OVERCOME BY THERMAL DECOMPOSITION PRODUCTS FROM A FIRE, MOVE TO FRESH AIR. IF VICTIM IS UNCONSCIOUS, EXHIBITS BREATHING DIFFICULTY OR IF RECOVERY IS NOT PROMPT, CONTACT A PHYSICIAN FOR TREATMENT.

============== Fire Fighting Measures ===============

============== Accidental Release Measures ===============
Spill Release Procedures:NO SPECIAL ACTION FOR SOLID PIECES OF PRODUCT. VACUUM UP ANY DUST FROM OPERATIONS SUCH AS GASKET CUTTING. ALTERNATELY, DAMPEN AREA BEFORE WIPING OR SWEEPING. DO NOT DRY WIPE
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.

Handling and Storage Precautions: STORE IN CLEAN DRY PLACE AWAY FROM STRONG OXIDIZING AGENTS. DO NOT GRIND OR MACHINE PRODUCT. NORMAL WASH UP AFTER HANDLING IS RECOMMENDED. Other Precautions: WHEN REMOVING USED GASKETS, AVOID EXCESSIVE MECHANICAL ACTIONS AND PLACE RESIDUE IN A PLASTIC BAG FOR DISPOSAL.


Solubility in Water: INSOLUBLE Appearance and Odor: BLACK SHEET OR GASKETS - SLIGHT ODOR.

Stability Indicator/Materials to Avoid: NO AVOID STORAGE WITH STRONG OXIDIZING AGENTS. Stability Condition to Avoid: DIRECT FLAME WILL IGNITE PRODUCT.
Hazardous Decomposition Products: IN A FIRE: CARBON MONOXIDE UNDER CERTAIN CIRCUMSTANCES, POSSIBLY ACRYLONITRILE MONOMER FUMES AND POSSIBLY SOME (SUPDAT)

================================= Disposal Considerations =================================

Waste Disposal Methods: NORMAL LANDFILL. COMPLY WITH ANY LOCAL DISPOSAL REGULATIONS. DISPOSAL MUST BE IN ACCORDANCE WITH FEDERAL, STATE AND LOCAL REGULATIONS.

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CLARK-SCHWEBEL FIBER GLASS CORP -- FIBER GLASS CLOTH -- 8305-01-276-9043

======================  Product Identification  ======================

Product ID: FIBER GLASS CLOTH
MSDS Date: 06/28/1989
FSC:8305
NIIN:01-276-9043
MSDS Number: BWRFR

=== Responsible Party ===
Company Name: CLARK-SCHWEBEL FIBER GLASS CORP
Box:2627
City:ANDERSON
State:SC
ZIP:29622
Country:US
Info Phone Num:803-224-3506
Emergency Phone Num:800-424-9300 (CHEMTREC)
CAGE:1H193

=== Contractor Identification ===
Company Name: CLARK-SCHWEBEL FIBER GLASS CORP
Box:City:ANDERSON
State:SC
ZIP:29622
Country:US
Phone:803-224-3506
CAGE:1H193

======================  Composition/Information on Ingredients  ======================

Ingred Name: GLASS OXIDE
Fraction by Wt: >99%
OSHA PEL: 15 MG/M3 (MFR)
ACGIH TLV: 5 MG/M3 (MFR)

Ingred Name: METHACRYLATO CHROMIC CHLORIDE
Fraction by Wt: <1%
OSHA PEL: N/K
ACGIH TLV: N/K

======================  Hazards Identification  ======================

121
LD50 LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation: YES  Skin: NO  Ingestion: NO
Reports of Carcinogenicity: NTP: NO  IARC: NO  OSHA: NO
Health Hazards Acute and Chronic: ACUTE: IF IN EYES OR ON SKIN, MAY CAUSE MILD IRRITATION. IF INHALED, MAY CAUSE UPPER RESPIRATORY TRACT IRRITATION. CHRONIC HEALTH EFFECTS: NONE MENTIONED.
Explanation of Carcinogenicity: NOT RELEVANT
Effects of Overexposure: SEE HEALTH HAZARDS.
Medical Cond Aggravated by Exposure: NONE.

=======================  First Aid Measures  ========================

First Aid: INGEST: CALL MD IMMEDIATELY . EYES: FLUSH WITH WATER FOR AT LEAST 15 MINUTES WHILE LIFTING UPPER & LOWER EYELIDS. IF IRRITATION PERSISTS, GET MEDICAL ATTENTION. SKIN: WASH THOROUGHLY WITH SOAP AND COOL WATER. INHAL: IF INHALED AND AFFECTED, REMOVE INDIVIDUAL TO FRESH AIR. IF IRRITATION PERSISTS, GET MEDICAL ATTENTION.

======================  Fire Fighting Measures  =======================

Flash Point: NONE
Extinguishing Media: USE APPROPRIATE EXTINGUISHING MEDIA FOR PRIMARY SOURCE OF FIRE. PRODUCT IS NOT COMBUSTIBLE.
Fire Fighting Procedures: USE NIOSH/MSHA APPROVED SCBA AND FULL PROTECTIVE EQUIPMENT .
Unusual Fire/Explosion Hazard: NONE.

==================  Accidental Release Measures  ===================

Spill Release Procedures: NO SPECIAL PRECAUTIONS.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.

======================  Handling and Storage  =======================

Handling and Storage Precautions: FIBER GLASS CLOTH IS DENSE AND EVEN SMALL ROLLS ARE HEAVY. USE LIFT DEVICES TO PREVENT INJURIES. DO NOT
ALLOW CLOTH TO CRUSH LIMBS OR EXTREMITIES.
Other Precautions:NONE KNOWN.

============ Exposure Controls/Personal Protection =============

Respiratory Protection: IF AIRBORNE FIBERGLASS CONCENTRATIONS EXCEED
PERMISSIBLE EXPOSURE LEVELS, NIOSH/MSHA APPROVED RESPIRATORY
PROTECTION FOR NUISANCE DUST IN ACCORDANCE WITH OSHA 1910.134
SHOULD BE USED. NONE NORMALLY REQUIRED.
Ventilation: USE LOCAL EXHAUST VENTILATION IF NECESSARY TO MAINTAIN
AIRBORNE LEVELS TO BELOW ESTABLISHED LIMITS.
Protective Gloves: IMPERVIOUS GLOVES.
Eye Protection: ANSI APPRVD CHEM WORKERS GOGGLES.
Other Protective Equipment: IN SOME CIRCUMSTANCES, IT MAY BE ADVISABLE
TO WEAR LONG SLEEVED, LOOSE FITTING CLOTHING.
Work Hygienic Practices: USE RECOM SFTY EQUIP. WASH W/ SOAP & WATER AFTER
HNDLG. WASH WORK CLOTHES SEPARATELY FROM OTHER CLTHG.
WIPE OUT
(SUPDAT)
Supplemental Safety and Health
HYGIENE PRACT: WASHING MACHINE.

============= Physical/Chemical Properties =============

Spec Gravity: 2.54 (H*2O=1)
Solubility in Water: INSOLUBLE
Appearance and Odor: WHITE TO LIGHT GREEN, ODORLESS CLOTH.
Percent Volatiles by Volume: NONE

============= Stability and Reactivity Data =============

Stability Indicator/Materials to Avoid: YES
STRONG BASES AND ACIDS (OXIDIZING MINERAL, ESPECIALLY OXALIC AND
HYDROFLUORIC ACID).
Stability Condition to Avoid: NONE.
Hazardous Decomposition Products: GLASS CLOTHG: NONE. SMALL AMOUNTS OF
OXIDES OF CARBON AND NITROGEN MAY BE EVOLVED IF EXPOSED TO FIRE.
Waste Disposal Methods: AN INERT, SOLID WASTE. DISPOSE OF IN A LANDFILL IN ACCORDANCE WITH LOCAL, STATE AND FEDERAL REGULATIONS.

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SCIENTIFIC POLYMER PRODUCTS, INC -- POLYSTYRENE, 400 -- 6810-00N047324

================================== Product Identification =================================

Product ID: POLYSTYRENE, 400
MSDS Date: 03/01/1991
FSC: 6810
NIIN: 00N047324
MSDS Number: BTQVW

=== Responsible Party ===
Company Name: SCIENTIFIC POLYMER PRODUCTS, INC
Address: 6265 DEAN PARKWAY
City: ONTARIO
State: NY
ZIP: 14519
Country: US
Info Phone Num: 716-265-0413
Emergency Phone Num: 716-265-0413
CAGE: 0MW60

=== Contractor Identification ===
Company Name: SCIENTIFIC POLYMER PRODUCTS, INC
Address: 6265 DEAN PARKWAY
Box: City: ONTARIO
State: NY
ZIP: 14519
Country: US
Phone: 716-265-0413
CAGE: 0MW60

================================ Composition/Information on Ingredients ====================

Ingred Name: SYTRENE POLYMER; (POLYSTYRENE)
CAS: 9003-53-6
RTECS #: WL6475000
Fraction by Wt: 99.9%
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: ADDITIVES
Fraction by Wt: <0.1%
OSHA PEL: N/K
ACGIH TLV:N/K

=============================== Hazards Identification ================================

LD50 LC50 Mixture:NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation:NO Skin:NO Ingestion:NO
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:NONE SPECIFIED BY MANUFACTURER.
Explanation of Carcinogenicity:NOT RELEVANT.
Effects of Overexposure:NONE SPECIFIED BY MANUFACTURER.
Medical Cond Aggravated by Exposure:NONE SPECIFIED BY MANUFACTURER.

=============================== First Aid Measures ================================

First Aid:INGEST:CALL MD IMMEDIATELY. INHAL:REMOVE FROM EXPOSURE. IF
  BREATHING STOPS, BEGIN MOUTH TO MOUTH. EYES:FLUSH WITH WATER FOR AT
  LEAST 15 MINUTES. SKIN:WASH AFFECTED AREA WITH SOAP AND WATER. REM
  OVE DIRTY CLOTHING. IN ALL CASES, IF IRRITATION DEVELOPS, SEEK MEDICAL ASSISTANCE.

=============================== Fire Fighting Measures ================================

Flash Point Method:COC
Flash Point:977F,525C
Extinguishing Media:DRY CHEMICAL, CO2, WATER.
Fire Fighting Procedures:USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT.
Unusual Fire/Explosion Hazard:DECOMPOSITION MAY RESULT IN RELEASE OF
  CO2 AND ORGANICS OF UNKNOWN CHEMICAL COMPOSITION.
  FLAMMABLE DUST
  WHEN FINELY DIVIDED & SUSPENDED IN AIR.

=============================== Accidental Release Measures ================================

Spill Release Procedures:Sweep up spill and place in containers for
  salvage or disposal.
Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.
Handling and Storage Precautions: TREAT AS A COMBUSTIBLE SOLID. STORE AWAY FROM OXIDIZING MATLS IN A COOL, DRY PLACE WITH ADEQUATE VENTILATION.

Other Precautions: KEEP AWAY FROM HEAT AND OPEN FLAMES. KEEP CONTAINERS TIGHTLY CLOSED. NOTE: THIS MATERIAL IS INTENDED FOR LABORATORY USE ONLY. IT IS NOT INTENDED FOR DRUG, HOUSEHOLD OR OTHER USES.

Respiratory Protection: NIOSH/MSHA APPROVED RESPIRATOR APPROPRIATE FOR EXPOSURE OF CONCERN.

Ventilation: LOCAL EXHAUST ADEQUATE.

Protective Gloves: IMPERVIOUS GLOVES.

Eye Protection: ANSI APPRVD CHEM WORKER GOGGLES.

Other Protective Equipment: ANSI APPRVD EMERGENCY EYE WASH & DELUGE SHOWER.

Work Hygienic Practices: GOOD HYGIENE PRACTICES SHOULD BE STRICTLY FOLLOWED.

Supplemental Safety and Health NONE SPECIFIED BY MANUFACTURER.

Melt/Freeze Pt: M.P/F.P Text: >212F, >100C
Spec Gravity: 1.05
Solubility in Water: INSOLUBLE
Appearance and Odor: COLORLESS, ODORLESS PELLET

Stability Indicator/Materials to Avoid: YES
STRONG OXIDIZING AGENTS.
Hazardous Decomposition Products: CO AND ORGANICS OF UNKNOWN CHEMICAL COMPOSITION.
Waste Disposal Methods: IN ACCORDANCE WITH FEDERAL, STATE AND LOCAL REGULATIONS.

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DOW CHEMICAL CO -- 05536 DOW GRAYBOARD EXTRUDED POLYSTYRENE FOAM INSULATION -- 5640-00F024892

====================  Product Identification  =====================

Product ID: 05536 DOW GRAYBOARD EXTRUDED POLYSTYRENE FOAM INSULATION
MSDS Date: 06/13/1990
FSC: 5640
NIIN: 00F024892
MSDS Number: BNYRD

=== Responsible Party ===
Company Name: DOW CHEMICAL CO
Address: 2030 DOW CENTER
City: MIDLAND
State: MI
ZIP: 48674
Country: US
Info Phone Num: (517) 636-4410
Emergency Phone Num: (517) 636-4410
CAGE: 0BG07

=== Contractor Identification ===
Company Name: DOW CHEMICAL CO THE
Address: 1801 DOW CTR
City: MIDLAND
State: MI
ZIP: 48674-1801
Country: US
Phone: 517-636-4400 / 800-258-2436
CAGE: 0BG07
Company Name: DOW CHEMICAL U.S.A.
City: MIDLAND
State: MI
ZIP: 48674
Country: US
Phone: 517-636-4400
CAGE: 71983

============  Composition/Information on Ingredients  =============

Ingred Name: ETHENE-1-OCTENE COPOLYMER; POLYETHYLENE
CAS: 26227-73-8
Fraction by Wt: 0-10%

Ingred Name: STYRENE POLYMER, POLYSTYRENE
CAS: 9003-53-6
RTECS #: WL6475000
Fraction by Wt: BALANCE

Ingred Name: DICHLORODIFLUOROMETHANE, FREON 12
CAS: 75-71-8
RTECS #: PA8200000
Fraction by Wt: 0-7.5%
Other REC Limits: 1000 PPM
OSHA PEL: 4950 MG/CUM
ACGIH TLV: 4950 MG/CUM
EPA Rpt Qty: 5000 LBS
DOT Rpt Qty: 5000 LBS
Ozone Depleting Chemical: 1

Ingred Name: ETHANE, 1-CHLORO-1,1-DIFLUORO-, CHLORODIFLUOROETHANE (DOT), FREON 142, DIFLUOROROMONOCHLOROETHANE
CAS: 75-68-3
RTECS #: KH7650000
Fraction by Wt: 0-10%
Ozone Depleting Chemical: 2

Ingred Name: POLYETHYLENE, POLYETHYLENE RESIN (HOMOPOLYMER)
CAS: 9002-88-4
RTECS #: TQ3325000
Fraction by Wt: 0-10%

Ingred Name: HEXABROMOCYCLODODECANE *92-2*
CAS: 3194-55-6
Fraction by Wt: 0-2%

Ingred Name: 1,2,3,4,5-PENTABROMO-6-CHLOROCYCLOHEXANE *92-2*
CAS: 87-84-3
Fraction by Wt: 0-2%

Ingred Name: ETHYL CHLORIDE, CHLOROETHANE
CAS: 75-00-3
RTECS #: KH7525000
Fraction by Wt: 0-4.5%
Other REC Limits: 2600 MG/CUM
OSHA PEL: 1000 PPM
ACGIH TLV: 1000 PPM
EPA Rpt Qty: 100 LBS
DOT Rpt Qty: 100 LBS

Hazard Identification

Routes of Entry: Inhalation: YES  Skin: YES  Ingestion: YES

Reports of Carcinogenicity: NTP: NO  IARC: NO  OSHA: NO

Health Hazards Acute and Chronic: EYES: IRRITATION OR CORNEAL INJURY.
   SKIN: MECHANICAL INJURY. INGESTION: LIVER & KIDNEY EFFECTS, INCREASE IN TISSUE LEVELS OF BROMINE, PHYSICAL INJURY, CHOKING.
   INHALATION: SEVERE RESPIRATORY EFFECTS, UPPER RESPIRATORY TRACT IRRITATION, CNS DEPRESSION, ANESTHETIC EFFECTS, IRREGULAR HEARTBEATS & CARDIAC SENSITIZATION.

Explanation of Carcinogenicity: NONE

Effects of Overexposure: EYES: IRRITATION OR CORNEAL INJURY. SKIN: MECHANICAL INJURY. INGESTION: LIVER & KIDNEY EFFECTS, INCREASE IN TISSUE LEVELS OF BROMINE, PHYSICAL INJURY, CHOKING.

INHALATION:
   SEVERE RESPIRATORY EFFECTS, UPPER RESPIRATORY TRACT IRRITATION, CNS DEPRESSION, ANESTHETIC EFFECTS, IRREGULAR HEARTBEATS & CARDIAC SENSITIZATION.

First Aid Measures

First Aid: EYES: IRRIGATE W/WATER FOR 5 MIN. INHALATION: REMOVE TO FRESH AIR. SKIN/INGESTION: OBTAIN MEDICAL ATTENTION IN ALL CASES.

Fire Fighting Measures

Flash Point Method: PMCC
Flash Point: 670F
Extinguishing Media: WATER FOG
Fire Fighting Procedures: WEAR POSITIVE-PRESSURE SCBA. APPLY LARGE VOLUME OF WATER DIRECTLY ON FLAME OR BURNING SURFACE. Unusual Fire/Explosion Hazard: EMITS DENSE, BLACK SMOKE WHEN BURNED.
   GRINDING OR CUTTING MAY LEAD TO A BUILDUP OF DUST
SUSPENDED IN AIR
   WHICH CAN CAUSE A DUST EXPLOSION IF IGNITED.

================================ Accidental Release Measures =================================

Spill Release Procedures:PICK UP, OR IF DUST/SMALL PIECES, SWEEP UP &
   PLACE IN SUITABLE CONTAINER FOR DISPOSAL.

================================ Handling and Storage =================================

Handling and Storage Precautions:DON'T STORE OR USE IN CONFINED,
   VIRTUALLY AIRTIGHT SPACES TO PREVENT BUILDUP OF
   COMBUSTIBLE VAPORS.
Other Precautions:USE ONLY AS DIRECTED BY THE SPECIFIC
   INSTRUCTIONS FOR
   THIS PRODUCT. PROVIDE ADEQUATE VENTILATION, & APPROPRIATE
   DUST
   HANDLING SYSTEMS.

================================== Exposure Controls/Personal Protection ==================

Respiratory Protection:USE AN APPROVED AIR-PURIFYING/APPROVED
   DUST
   RESPIRATOR.
Ventilation:GENERAL/LOCAL EXHAUST
Eye Protection:GLASSES/CHEMICAL GOGGLES
Supplemental Safety and Health
   GAS FIRED RECIRCULATING AIR FURNACES/HEATERS, GAS WATER
   HEATERS CAN BE
   SUBJECTED TO RUST/CORROSION PROBLEMS. THIS INSULATION
   CONTAINS A
   FLAME RETARDANT ADDITIVE TO INHIBIT ACCIDENTAL IGNITION FROM
   FIRE
   SOURCES. PRODUCT MAY CONTAIN EITHER 9002-88-4 OR 26221-73-8.

================================= Physical/Chemical Properties =========================

Spec Gravity:0.027 TO 0.064
Solubility in Water:INSOLUBLE
Appearance and Odor:RIGID CELLULAR FOAM BOARD, NO ODOR.

================================ Stability and Reactivity Data ===========================

Stability Indicator/Materials to Avoid:YES
AROMATIC HYDROCARBONS, HIGHER (>C5) ALIPHATIC HYDROCARBONS, ESTERS, AMINES, HIGHER ALDEHYDES.

Stability Condition to Avoid: FIRE, HIGH TEMPS. TEMPERATURES OVER 572F WILL RELEASE COMBUSTIBLE GASES.

Hazardous Decomposition Products: CO, CO2, HYDROGEN BROMIDE/CHLORIDE/FLUORIDE & SMALL AMOUNTS OF AROMATIC HYDROCARBONS SUCH AS STYRENE & ETHYLBENZENE.

Conditions to Avoid Polymerization: FLAME OR OTHER IGNITION SOURCES

==================== Disposal Considerations ====================

Waste Disposal Methods: BURY IN AN APPROVED LANDFILL, OR BURN IN AN ADEQUATE INCINERATOR W/EXCESS OXYGEN, IN ACCORDANCE W/LOCAL, STATE & FEDERAL REGULATIONS.

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KING ADHESIVES CORP -- 11-282 DUCT TAPE ADHESIVE -- 8040-00F038125

================================= Product Identification =================================

Product ID:11-282 DUCT TAPE ADHESIVE
MSDS Date:02/07/1992
FSC:8040
NIIN:00F038125
MSDS Number: BWKRB

=== Responsible Party ===
Company Name: KING ADHESIVES CORP
Address: 5231 NORTHRUP AVE
City: ST LOUIS
State: MO
ZIP: 63110-5000
Country: US
Info Phone Num: 314-772-9953/800-233-8171
Emergency Phone Num: 314-772-9953/800-233-8171
CAGE: KINGG

=== Contractor Identification ===
Company Name: KING ADHESIVES CORP
Address: 5231 NORTHRUP AVE
Box: City: ST LOUIS
State: MO
ZIP: 63110-5000
Country: US
Phone: 314-772-9953/800-233-8171
CAGE: KINGG

================================= Composition/Information on Ingredients =================================

Ingred Name: NON HAZARDOUS INGREDIENTS

================================= Hazards Identification =================================

Routes of Entry: Inhalation: NO   Skin: NO   Ingestion: NO
Reports of Carcinogenicity: NTP: NO   IARC: NO   OSHA: NO
Health Hazards Acute and Chronic: EYES: IRRITATION, DAMAGE TO MUCOUS LININGS. SKIN: IRRITATION. INHALATION: NASAL & RESPIRATORY IRRITATION. INGESTION: GI IRRITATION.
Explanation of Carcinogenicity: NONE
Effects of Overexposure: REDNESS, TEARING, BLURRED VISION,
IRRITATION.

================================ First Aid Measures
================================

First Aid: EYES: FLUSH W/WATER FOR 15 MINS. INHALATION: REMOVE TO FRESH AIR. INGESTION: DON'T INDUCE VOMITING. OBTAIN MEDICAL ATTENTION IN ALL CASES.

================================ Fire Fighting Measures
================================

Flash Point Method: TCC
Flash Point: >203F
Extinguishing Media: FOAM, CO2, DRY CHEMICAL, WATER FOG
Fire Fighting Procedures: WEAR SELF CONTAINED BREATHING APPARATUS W/FULL FACE PIECE OPERATED IN A PRESSURE DEMAND/OTHER POSITIVE PRESSURE MODE. DRY FILM WILL BURN.

================================ Accidental Release Measures
================================

Spill Release Procedures: DIKE AREA TO PREVENT FROM SPREADING. COLLECT MATERIAL IN SALVAGE CONTAINER. MATERIAL WILL FLOW.

================================ Handling and Storage
================================

Handling and Storage Precautions: DON'T STORE IN TEMP >125F/BELOW FREEZING. WHEN HANDLING MATERIAL, ALWAYS FOLLOW PERSONAL PROTECTION INSTRUCTION & NEVER TRANSFER.

============= Exposure Controls/Personal Protection ===============

Respiratory Protection: NONE REQUIRED
Ventilation: GENERAL MECHANICAL
Protective Gloves: IMPERVIOUS ARE RECOMMENDED
Eye Protection: SAFETY GLASSES
Work Hygienic Practices: REMOVE/LAUNDER CONTAMINATED CLOTHING BEFORE REUSE.
Supplemental Safety and Health
Boiling Pt: B.P. Text: 212°F
Vapor Density: >1
Spec Gravity: 1.03
Evaporation Rate & Reference: SLOWER THAN ETHER
Solubility in Water: COMPLETE
Appearance and Odor: WHITE COLORED THIN VISCOSITY LIQUID W/BLAND ODOR
Percent Volatiles by Volume: 45-53

Stability Indicator/Materials to Avoid: YES
SULFURIC ACID/ALKALI MATERIALS/SODIUM/METAL HYDRIDES.
Stability Condition to Avoid: FREEZING, TEMP <125°F.
Hazardous Decomposition Products: CO2, CO, CARBON, ACETIC ACID/ACETALDEHYDE

Waste Disposal Methods: DISPOSE OF IAW/FEDERAL, STATE & LOCAL REGULATIONS.

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SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: SCOTCH BRAND #232 HIGH PERFORMANCE MASKING TAPE

MANUFACTURER: 3M
DIVISION: Industrial Tape And Specialties Division
ADDRESS: 3M Center
St. Paul, MN  55144-1000
EMERGENCY PHONE: 1-800-364-3577 or (651) 737-6501 (24 hours)

Issue Date: 01/11/2005
Supercedes Date: 07/24/2003
Document Group: 07-0454-4

Product Use:
Intended Use: Used in medium temperature paint bake operations.
Limitations on Use: 250ºF for up to one hour.

SECTION 2: INGREDIENTS

<table>
<thead>
<tr>
<th>Ingredient C.A.S. No.</th>
<th>% by Wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATURATED PAPER BACKING MIXTURE</td>
<td>35 - 50</td>
</tr>
<tr>
<td>RUBBER / RESIN ADHESIVE MIXTURE</td>
<td>5 - 20</td>
</tr>
</tbody>
</table>

SECTION 3: HAZARDS IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Specific Physical Form: Roll of Tape
Odor, Color, Grade: Tan color paper with unpigmented adhesive

General Physical Form: Solid

Immediate health, physical, and environmental hazards: The environmental properties of this product present a low environmental hazard. This product, when used under reasonable conditions and in accordance with the 3M directions for use, should not present a health hazard. However, use or processing of the product in a manner not in accordance with the product’s directions for use may affect the performance of the product and may present potential health and safety hazards.

3.2 POTENTIAL HEALTH EFFECTS

Eye Contact:
No health effects are expected.

Skin Contact:
No health effects are expected.

Inhalation:
No health effects are expected.

Ingestion:
No health effects are expected.
3.3 POTENTIAL ENVIRONMENTAL EFFECTS
This substance does not leach metals or other RCRA (Resource Conservation and Recovery Act) listed TCLP (Toxic Characteristic Leaching Procedure) hazardous substances at concentrations that would make the product a hazardous waste.

SECTION 4: FIRST AID MEASURES
4.1 FIRST AID PROCEDURES
The following first aid recommendations are based on an assumption that appropriate personal and industrial hygiene practices are followed.

Eye Contact: No need for first aid is anticipated.
Skin Contact: No need for first aid is anticipated.
Inhalation: No need for first aid is anticipated.
If Swallowed: No need for first aid is anticipated.

SECTION 5: FIRE FIGHTING MEASURES
5.1 FLAMMABLE PROPERTIES
Autoignition temperature 451 °F
Flash Point No Data Available
Flammable Limits - LEL Not Applicable
Flammable Limits - UEL Not Applicable

5.2 EXTINGUISHING MEDIA Ordinary combustible material. Use fire extinguishers with class A extinguishing agents (e.g., water, foam). Use fire extinguishers with class B extinguishing agents (e.g., dry chemical, carbon dioxide).

5.3 PROTECTION OF FIRE FIGHTERS
Special Fire Fighting Procedures: See Hazardous Decomposition section for products of combustion. Nonflammable. Wear full protective equipment (Bunker Gear) and a self-contained breathing apparatus (SCBA).
Unusual Fire and Explosion Hazards: Not applicable. No unusual fire or explosion hazards are anticipated. Non-flammable: ordinary combustible material.

Note: See STABILITY AND REACTIVITY (SECTION 10) for hazardous combustion and thermal decomposition information.

SECTION 6: ACCIDENTAL RELEASE MEASURES
Accidental Release Measures: Collect as much of the spilled material as possible. Reclaim undamaged product.

SECTION 7: HANDLING AND STORAGE
7.1 HANDLING
Do not ingest. Do not breathe thermal decomposition products. Avoid skin contact with hot material. Avoid eye contact with vapors, mists, or spray. This product is considered to be an article which does not release or otherwise result in exposure to a hazardous chemical under normal use conditions. Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures.
to below Occupational Exposure Limits. If ventilation is not adequate, use respiratory protection equipment.

7.2 STORAGE
Store out of direct sunlight. Not applicable. Store under normal warehouse conditions.

SECTION 8: EXPOSURE CONTROLS/PERSOANL PROTECTION

8.1 ENGINEERING CONTROLS
Not applicable. Provide appropriate local exhaust for molten or extruded material. Provide appropriate local exhaust when product is heated. General ventilation adequate below 400 °C. Local exhaust recommended above 400 °C.

8.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

8.2.1 Eye/Face Protection
Avoid eye contact. Not applicable. Avoid eye contact with vapors, mists, or spray.

8.2.2 Skin Protection
Wear appropriate gloves, such as Nomex, when handling this material to prevent thermal burns. Not applicable. Avoid skin contact. Avoid prolonged or repeated skin contact. Avoid skin contact with hot material. Gloves are not required. Select and use gloves and/or protective clothing to prevent skin contact based on the results of an exposure assessment. Consult with your glove and/or protective clothing manufacturer for selection of appropriate compatible materials.

8.2.3 Respiratory Protection
Under normal use conditions, airborne exposures are not expected to be significant enough to require respiratory protection. 8.2.4 Prevention of Swallowing
Not applicable. Do not ingest.

8.3 EXPOSURE GUIDELINES
None Established

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Specific Physical Form: Roll of Tape
Odor, Color, Grade: Tan color paper with unpigmented adhesive
General Physical Form: Solid
Autoignition temperature 451 °F
Flash Point No Data Available
Flammable Limits - LEL Not Applicable
Flammable Limits - UEL Not Applicable
Boiling point Not Applicable
Density 0.84 - 0.88 g/ml
Vapor Density Not Applicable
Vapor Density Negligible
Vapor Pressure Not Applicable
Vapor Pressure Negligible
Specific Gravity Approximately 0.85 g/ml
pH  Not Applicable
Melting point  Not Applicable
Solubility In Water  Not Applicable
Solubility in Water  Negligible
Evaporation rate  Not Applicable
Hazardous Air Pollutants  No Data Available
Volatile Organic Compounds  <=0.2 %
Percent volatile  Not Applicable
VOC Less H2O & Exempt Solvents  <=0.2 %
Viscosity  Not Applicable

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable.
Materials and Conditions to Avoid: None known
Additional Information: Excessive heat
Hazardous Polymerization: Hazardous polymerization will not occur.
Hazardous Decomposition or By-Products
Substance Condition
Hydrocarbons  Not Specified
Carbon monoxide  Not Specified
Carbon dioxide  Not Specified

Hazardous Decomposition: Under recommended usage conditions, hazardous decomposition products are not expected. Hazardous decomposition products may occur as a result of oxidation, heating, or reaction with another material.

SECTION 11: TOXICOLOGICAL INFORMATION

Please contact the address listed on the first page of the MSDS for Toxicological Information on this material and/or its components.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION
Not determined. Not applicable.
CHEMICAL FATE INFORMATION
Not determined. Not applicable.

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method: Reclaim if feasible. If product can’t be reclaimed, dispose of waste product in a sanitary landfill.
Alternatively, incinerate the waste product in an industrial, commercial, or municipal incinerator. Dispose of waste product in a sanitary landfill. As a disposal alternative, incinerate in an industrial or commercial facility.

EPA Hazardous Waste Number (RCRA): Not regulated
Since regulations vary, consult applicable regulations or authorities before disposal.

SECTION 14: TRANSPORT INFORMATION

Please contact the emergency numbers listed on the first page of the MSDS for Transportation Information for this
SECTION 15: REGULATORY INFORMATION

US FEDERAL REGULATIONS
Contact 3M for more information.

311/312 Hazard Categories:
Fire Hazard - No  Pressure Hazard - No  Reactivity Hazard - No  Immediate Hazard - No  Delayed Hazard – No

STATE REGULATIONS
Contact 3M for more information.

CHEMICAL INVENTORIES
The components of this product are in compliance with the chemical notification requirements of TSCA.
All applicable chemical ingredients in this material are listed on the European Inventory of Existing Chemical Substances (EINECS), or are exempt polymers whose monomers are listed on EINECS.
This product is an article as defined by TSCA regulations, and is exempt from TSCA Inventory listing requirements.
Contact 3M for more information.

INTERNATIONAL REGULATIONS
Contact 3M for more information.

WHMIS: Hazardous

This MSDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: OTHER INFORMATION

NFPA Hazard Classification
Health: 0  Flammability: 1  Reactivity: 0  Special Hazards: None
National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

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within the user's knowledge and control, it is essential that the user evaluate the 3M product to determine whether it is fit for a particular purpose and suitable for user's method of use or application. 3M provides information in electronic form as a service to its customers. Due to the remote possibility that electronic transfer may have resulted in errors, omissions or alterations in this information, 3M makes no representations as to its completeness or accuracy. In addition, information obtained from a database may not be as current as the information in the MSDS available directly from 3M.
SUPER GLUE CORP -- SUPER GLUE -- 8040-00N056030
==================  Product Identification  ==================

Product ID: SUPER GLUE
MSDS Date: 08/18/1993
FSC: 8040
NIIN: 00N056030
MSDS Number: BWBXW

=== Responsible Party ===
Company Name: SUPER GLUE CORP
Address: 184-08 JAMACA AVE
City: HOLLIS
State: NY
ZIP: 11423
Country: US
Info Phone Num: 718-454-4747
Emergency Phone Num: 800-424-9300 (CHEMTREC)
CAGE: 0ACS9

=== Contractor Identification ===
Company Name: SUPER GLUE CORP
Address: 184-08 JAMAICA AVE
Box: City: HOLLIS
State: NY
ZIP: 11423
Country: US
Phone: 800-221-4478
CAGE: 0ACS9

============  Composition/Information on Ingredients  =============

Ingred Name: 2-PROPENOIC ACID, 2-CYANO-, ETHYL ESTER; (ETHYL CYANOACRYLATE)
CAS: 7085-85-0
RTECS #: UD3330000
Fraction by Wt: 60-100%
OSHA PEL: N/K
ACGIH TLV: N/K

Ingred Name: HYDROQUINONE (SARA III)
CAS: 123-31-9
RTECS #: MX3500000
Fraction by Wt: 0-1%
OSHA PEL:2 MG/M3  
ACGIH TLV:2 MG/M3  
EPA Rpt Qty:1 LB  
DOT Rpt Qty:1 LB  

Ingred Name:POLYMETHYLMETHACRYLATE  
CAS:9011-14-7  
RTECS #:TR04000000  
Fraction by Wt: 10-30%  
OSHA PEL:N/K  
ACGIH TLV:N/K  

Ingred Name:SUPDAT:(DO NOT PULL) LIPS APART. IT IS ALMOST IMPOSSIBLE TO SWALLOW CYANOACRYLATE AS ADHESIVE SOLIDIFIES UPON (ING 5)  
RTECS #:9999999ZZ  

Ingred Name:ING 4:CONT W/SALIVA & MAY ADHERE TO INSIDE OF MOUTH. SALIVA WILL LIFT ADHESIVE IN 1-2 DAYS, AVOID SWALLOWING (ING 6)  
RTECS #:9999999ZZ  

Ingred Name:ING 5:ADHESIVE AFTER DETACHMENT.  
RTECS #:9999999ZZ  

============ Hazards Identification ==============  
LD50 LC50 Mixture:LD50:(ORAL) 12.2 CC/KG  
Routes of Entry: Inhalation:YES  Skin:NO  Ingestion:YES  
Reports of Carcinogenicity:NTP:NO    IARC:NO    OSHA:NO  
Health Hazards Acute and Chronic:ACUTE:IRRITATES EYES, MUCOUS MEMBRANES. CHRONIC:NO RESIDUAL AFFECTS OF ACUTE PROPERTIES.  
Explanation of Carcinogenicity:NOT RELEVANT.  
Effects of Overexposure:SEE HEALTH HAZARDS.  
Medical Cond Aggravated by Exposure:PRE-EXISTING SKIN, EYE AND RESPIRATORY DISORDERS MAY BE AGGRAVATED BY EXPOSURE.  

============== First Aid Measures ===============  
First Aid:EYE:TEARING FROM EYE IRRIT. REMOVE TO FRESH AIR. FLUSH AREAS OF CONT W/WATER FOR @ LEAST 15 MINS. ADHESIVE WILL DISASSOCIATE FROM EYE/EYELIDS OVER TIME, USUALLY W/IN SEVERAL HRS.
TEMPORARY WEARING OF EYES/DISTURB VISION MAY BE EXPERIENCED UNTIL CLEARANCE IS ACHIEVED. SKIN: IMMERSE BONDED AREAS IN WARM, SOAPY WATER. PEEL/ROLL SKIN APART. REMOVE SECURED ADHESIVE WITH SEVERAL APPLICATIONS OF WARM, SOAPY (SUPDAT)

-------------------- Fire Fighting Measures --------------------

Flash Point Method: TCC
Flash Point: 176°F, 80°C
Extinguishing Media: FLUSH WITH LARGE AMOUNTS OF WATER OR DRY CHEMICAL EXTINGUISHER.
Fire Fighting Procedures: NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT. FUMES MAY BE IRRITATING IF NOT BURNING & REQUIRE AIR SUPPLY WITH GOGGLES WHILE APPLYING LARGE AMOUNTS OF WATER/DRY (SUPDAT)
Unusual Fire/Explosion Hazard: NONE. COMBUSTIBLE REQUIRING THE ABOVE PROCEDURES.

-------------------- Accidental Release Measures --------------------

Spill Release Procedures: POLYMERIZE WITH WATER. SOLID MATERIAL MAY BE SCRAPPED FROM SURFACE.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.

-------------------- Handling and Storage --------------------

Handling and Storage Precautions: AVOID MOISTURE, DIRECT UV/SUNLIGHT AND DO NOT STORE ABOVE 25°C. KEEP CONTAINERS TIGHTLY CLOSED WHEN NOT IN USE.
AVOID BREATHING VAPORS, CONT WITH EYES/SKIN.
Other Precautions: DO NOT STORE AT -5°C WHICH FREEZES PRODUCT TO USELESS STATE. PRODUCT NOT DAMAGED BY FREEZING.

-------------------- Exposure Controls/Personal Protection --------------------

Respiratory Protection: NORMALLY NOT NECESSARY. A NIOSH/MSHA
APPROVED

ORGANIC VAPOR CANISTER MAY BE USED.

Ventilation: LOCAL EXHAUST: TO PREVENT EYE IRRITATION. MECHANICAL (GENERAL): LARGE AMOUNT: USED TO 2PPM.

Protective Gloves: VINYL (POLYETHYLENE) NON-STICKING GLOVES.

Eye Protection: SAFETY GLASSES & SIDE SHIELD.

Other Protective Equipment: RUBBER APRON TO PROTECT CLOTHING.

Work Hygienic Practices: SOAP AND WATER HELPS REMOVE ADHESIVE FROM SKIN.

Supplemental Safety and Health

SOL IN H*20: INSOLUBLE, MATL REACTS TO HARDENED MASS FOR NON-HAZ WASTE.

FIRE FIGHT PROC: CHEM EXTING. FIRST AID PROC: WATER. INHAL: IRRIT OF MUC MEMB/COUGHING. REMOVE TO FRESH AIR. INGEST: LIPS MAY BECOME STUCK TOGETHER: APPLY COPIOUS AMTS OF WARM WATER & ENCOURAGE SWETTING/PRESS FROM SALIVA INSIDE MOUTH. PEEL/ROLL (ING 4)

Physical/Chemical Properties

Boiling Pt: B.P. Text: 149F, 65C
Vapor Pres: 1 @ 20C
Spec Gravity: 1.05 (H*20=1)
Evaporation Rate & Reference: NOT KNOWN
Solubility in Water: SUPP DATA
Appearance and Odor: TRANSPARENT WATER-WHITE TO STRAW COLORED LIQUID WITH STIMULATIVE ODOR

Stability and Reactivity Data

Stability Indicator/Materials to Avoid: YES
POLYMERIZED BY WATER, ALCOHOL, AMINES, ALKALINE MATERIALS AND DIRECT UV.
Stability Condition to Avoid: EXCESSIVE HEAT ABOVE 176F, MOISTURE AND ALKALINES. STABLE UP TO 122F. STORE IN COOL DRY PLACE.

Hazardous Decomposition Products: COMBUSTIBLE BY-PRODUCTS OF CARBON MONOXIDE/DIOXIDE.

Disposal Considerations

Waste Disposal Methods: INCINERATE SOLID COMBUSTIBLE WASTE OR
DUMP AS CHEMICAL WASTE ACCORDING TO LOCAL, STATE AND FEDERAL REGULATIONS.

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MATERIAL SAFETY DATA SHEET

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(215) 646-1566 CHEMTREC: (800) 424-9300

FOR PRODUCT AND SALES INFORMATION
CONTACT ELECTRON MICROSCOPY SCIENCES OFFICE ABOVE.

PRODUCT IDENTIFICATION

PRODUCT NAME: Acetone
CAS NO.: 67-64-1
COMMON NAMES/SYNONYMS: 2-Propanone Dimethyl Ketal, Dimethyl Ketone
FORMULA: C3H6O
MOLECULAR WEIGHT: 58.08

NFPA RATING (MANUFACTURER): HAZARD RATING SCALE:

<table>
<thead>
<tr>
<th>HEALTH</th>
<th>0 = NONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRE</td>
<td>1 = MINIMAL</td>
</tr>
<tr>
<td>Reactivity</td>
<td>2 = MODERATE</td>
</tr>
<tr>
<td>SPECIAL</td>
<td>3 = SERIOUS</td>
</tr>
</tbody>
</table>
HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CAS NO.</th>
<th>%</th>
<th>PEL</th>
<th>TLV</th>
<th>LIMIT</th>
<th>HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>67-64-1</td>
<td>&gt;99</td>
<td>750</td>
<td>750</td>
<td>1,000</td>
<td>Flammable/Irritant</td>
</tr>
</tbody>
</table>

(ACGIH STEL)

PHYSICAL/CHEMICAL CHARACTERISTICS

- BOILING POINT: 133°F
- MELTING POINT: 142°F
- SPECIFIC GRAVITY (WATER=1): 0.79
- VAPOR PRESSURE, mm Hg: 184
- pH: No data found
- VAPOR DENSITY (AIR=1): 2.0
- WATER SOLUBILITY: 100%
- EVAPORATION RATE (BUTYL ACETATE=1): 5.6
- % VOLATILE (BY VOLUME): 100
- APPEARANCE AND ODOR: Clear, colorless liquid; sweet odor.

FIRST AID MEASURES

INHALATION: Remove to fresh air. Give artificial respiration if not breathing. Get immediate medical attention.

EYE CONTACT: Immediately flush eyes with lots of running water for 15 minutes, lifting the upper and lower eyelids occasionally. Get immediate attention.

SKIN CONTACT: Immediately wash skin with lots of soap and water. Remove contaminated clothing and shoes; wash before reuse. Get medical attention if irritation persists after washing.

INGESTION: Do not induce vomiting. If conscious, give lots of water. Get immediate medical attention. Do not give anything by mouth to an unconscious or convulsing person.

NOTES TO PHYSICIAN: The danger of aspiration must be weighed against toxicity when considering emptying the stomach. Stomach contents should be emptied quickly in a manner which avoids the vomitus from entering the lungs.
HEALTH HAZARD INFORMATION

PRIMARY ROUTES OF EXPOSURE: Inhalation, skin or eye contact.

SIGNS AND SYMPTOMS OF EXPOSURE:

INHALATION: Prolonged or repeated exposure or breathing very high concentration may cause headaches, nausea, vomiting, dizziness, other central nervous system effects, convulsions, and in extreme cases, unconsciousness and death.

EYE CONTACT: Vapors will irritate the eyes. Liquid and mists will irritate and may burn the eyes.

SKIN CONTACT: Brief contact may dry the skin. Prolonged or repeated contact may irritate the skin causing dermatitis.

INGESTION: Swallowing large quantities causes headaches, nausea, vomiting, and perhaps unconsciousness. Can also cause liver and kidney injury.

CHRONIC EFFECTS OF EXPOSURE: No specific information available.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:

Preexisting eye or skin disorders may be aggravated by acetone exposure. Also, use of alcoholic beverages enhances toxic effects.

TOXICITY DATA

ORAL: Rat LD50 = 9750 MG/KG
DERMAL: Rabbit LD50 = 20 G/KG
INHALATION: Rat LC50 = 16,000 PPM/4 HR

CARCINOGENICITY: This material is not considered to be a carcinogen by the National Toxicology Program, the International Agency for Research on Cancer, or The Occupational Safety and Health Administration.

OTHER DATA: Development of cataracts has been reported in laboratory animals after prolonged repeated skin exposure.
PERSONAL PROTECTION

VENTILATION: Local mechanical exhaust ventilation capable of maintaining emissions at the point of use below the PEL.

RESPIRATORY PROTECTION: If use conditions generate vapors or mists, wear a NIOSH-approved respirator appropriate for those emission levels.

Appropriate respirators may be a full facepiece or half mask air-purifying cartridge respirator equipped for organic vapors/mists, a self-contained breathing apparatus in the pressure demand mode, or a supplied-air respirator.

EYE PROTECTION: Chemical goggles unless a full facepiece respirator is also worn. It is generally recognized that contact lenses should not be worn when working with chemicals because contact lenses may contribute to the severity of an eye injury.

PROTECTIVE CLOTHING: Long-sleeved shirt, trousers, safety shoes, rubber gloves, and rubber apron.

OTHER PROTECTIVE MEASURES: An eyewash and safety shower should be nearby and ready for use.

FIRE AND EXPLOSION INFORMATION

FLASH POINT: -15oF METHOD USED: TCC
FLAMMABLE LIMITS IN AIR: LOWER: 2% UPPER: 13%
AUTOIGNITION TEMPERATURE: No data found
EXTINGUISHING MEDIA: Use water spray, dry chemical, CO2 or alcohol foam.

SPECIAL FIREFIGHTING PROCEDURES: Fire fighters should wear self-contained breathing apparatus and full protective clothing. Use water spray to cool nearby containers and structures exposed to fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Acetone is extremely flammable. Extinguish all nearby sources of ignition. Avoid accumulation of water or acetone vapors because aqueous solutions containing more than 2.5% acetone vapors are flammable. Vapors formed from this
product are heavier than air and may travel along the surface to a distant sources of ignition and flashback. Explosive vapor-air mixtures may be formed above the flash point or between the lower and upper flammable limits.

HAZARDOUS REACTIVITY

STABILITY: Stable
POLYMERIZATION: Will not occur
CONDITIONS TO AVOID: Heat, Sparks, and Open Flames.
MATERIALS TO AVOID: Oxidizers, acids, alkalis, chlorinated compounds.

HAZARDOUS DECOMPOSITION PRODUCTS: May liberate carbon monoxide, carbon dioxide, and unidentified organic compounds in black smoke.

SPILL, LEAK AND DISPOSAL PROCEDURES

Action to take for spills or leaks: wear protective equipment including rubber boots, rubber gloves, rubber apron, and a self-contained breathing apparatus in the pressure demand mode or a supplied-air respirator. If the spill or leak is small, a full facepiece air-purifying cartridge respirator equipped for organic vapors may be satisfactory. In any event, always wear eye protection. Extinguish all ignition sources and ensure that all handling equipment is electrically grounded. For small spills or drips, mop or wipe up and dispose of in DOT-approved waste containers. For large spills, contain by diking with soil or other non-combustible absorbent materials and then pump into DOT-approved waste containers; or absorb with non-combustible sorbent material, place residue in DOT-approved waste containers. Keep out of sewers, storm drains, surface waters, and soil.

Comply with all applicable governmental regulations on spill reporting, and handling and disposal of waste.

DISPOSAL METHODS: Dispose of contaminated product and materials used in cleaning up spills or leaks in a manner approved for this material. Consult with appropriate Federal, State and local regulatory agencies.

NOTE: Empty containers can have residues, gases and mists and are subject to proper waste disposal, as above.
SPECIAL PRECAUTIONS

HANDLING AND STORAGE PRECAUTIONS: Keep away from heat, sparks, and flames. Store in a cool, dry, well-ventilated place away from incompatible materials. Vent container frequently, and more often in warm weather, to relieve pressure. Electrically ground all equipment when handling this product and use only non-sparking tools. Keep container tightly closed when not in use.

Do not use pressure to empty container. Wash thoroughly after handling. Do not get in eyes, on skin, or on clothing.

REPAIR AND MAINTENANCE PRECAUTIONS: Do not cut, grind, weld, or drill on or near this container.

OTHER PRECAUTIONS: Containers, even those that have been emptied, will retain product residue and vapors. Always obey hazard warnings and handle empty containers as if they were full.

OTHER REGULATORY INFORMATION

SECTION 313 - This product is a toxic chemical subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

PROPOSITION 65 (WITH CHEMICALS LISTED) - This product contains the following chemical(s) considered by the state of California's safe drinking water and Toxic Enforcement Act of 1986 (Proposition 65) as causing cancer or reproductive toxicity and for which warnings are required:

<table>
<thead>
<tr>
<th>CHEMICALS</th>
<th>CAS NO.</th>
<th>% WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>71-43-2</td>
<td>30 PPM</td>
</tr>
</tbody>
</table>

MASSACHUSETTS - Under the Massachusetts right-to-know law, hazardous substance and extraordinarily hazardous substances components present in this product which requires reporting are:

<table>
<thead>
<tr>
<th>HAZARDOUS SUBSTANCE</th>
<th>CAS NO.</th>
<th>CONC.( &gt;1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>67-64-1</td>
<td>100</td>
</tr>
</tbody>
</table>

PENNSYLVANIA - Under the Pennsylvania right-to-know law, hazardous substances and special hazardous substances components present in
this product which require reporting are:

<table>
<thead>
<tr>
<th>HAZARDOUS SUBSTANCE</th>
<th>CAS NO.</th>
<th>CONC. (&gt;1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>67-64-1</td>
<td>100</td>
</tr>
</tbody>
</table>

CALIFORNIA SCAQMD: Rule 443.1 VOC'S
VOC: 790 G/L  Vapor Pressure: 184 MMHG AT 68oF.

TSCA: THE INGREDIENTS OF THIS PRODUCT ARE ON THE TSCA INVENTORY.
MATERIAL SAFETY DATA SHEET

The information contained herein is based on data considered accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to obtained from the use thereof.

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_________________________________________________________________

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_________________________________________________________________

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_________________________________________________________________

PRODUCT IDENTIFICATION

_________________________________________________________________

PRODUCT NAME: EM Glass
CHEMICAL NAME: Merckoglas(R) Liquid Cover Glass

CHEMICAL FAMILY: Organic substances in toluene

FORMULA: Organic substances in toluene

MOLECULAR WEIGHT: N/A

COMPONENT CAS # APPR %
Toluene 108-88-3 N/A

Also contains organic substances not disclosed by the manufacturer.

________________________________________________________________

HAZARDS IDENTIFICATION

________________________________________________________________

EMERGENCY OVERVIEW:

Flammable liquid and vapor.
Harmful or fatal if swallowed.
Vapor harmful.
May be irritating to skin, eyes and mucous membranes.
May cause damage to central nervous system, liver, kidneys and lungs.

APPEARANCE: Colorless, viscous liquid.

POTENTIAL HEALTH EFFECTS (ACUTE AND CHRONIC)

Symptoms of Exposure:

Quantitative data on the toxicity of this product is not available.
Expected properties on the grounds of the components:
Harmful or fatal if swallowed. Vapor harmful if inhaled.

Symptoms: Headache, dizziness, hallucinations, distorted perceptions, changes in motor activity, nausea, diarrhea, respiratory irritation, central nervous system depression, unconsciousness, liver, kidney and lung damage. Contact can
cause severe eye irritation. May cause skin irritation.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Data not available.

ROUTES OF ENTRY: Inhalation, ingestion.

CARCINOGENICITY: The material is not listed (IARC, NTP, OSHA) as cancer causing agent.

FIRST AID MEASURES

EMERGENCY FIRST AID:

GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE.

SKIN: Wash thoroughly with soap and water.

EYES: Immediately flush thoroughly with water for at least 15 minutes.

INHALATION: Remove to fresh air; give artificial respiration if breathing has stopped.

INGESTION: If conscious, drink water and induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.

FIRE FIGHTING MEASURES

FLASH POINT (F): 47oF
FLAMMABLE LIMITS LEL (%): N/A
FLAMMABLE LIMITS UEL (%): N/A

EXTINGUISHING MEDIA: Dry chemical, C02, or "alcohol" foam.

FIREFIGHTING PROCEDURES: Wear self-contained breathing apparatus and protective clothing.

FIRE & EXPLOSION HAZARDS: Dangerous fire and explosion hazard. Vapor can travel distances to ignition source and flash back.
ACCIDENTAL RELEASE MEASURES

SPILL RESPONSE:

Evacuate the area of all unnecessary personnel. Wear suitable protective equipment listed under Exposure/Personal Protection. Eliminate any ignition sources until the area is determined to be free from explosion or fire hazards. Contain the release and eliminate its source, if this can be done without risk. Take up and containerize for proper disposal as described under Disposal. Comply with Federal, State, and local regulations on reporting releases. Refer to Regulatory Information for reportable quantity and other regulatory data.

The following Electron Microscopy Sciences clean up kit is recommended for this product:

SX0863  Solvent Spill Treatment Kit

HANDLING AND STORAGE

Keep container closed. Store in a cool, dry area away from ignition sources and oxidizers. Do not breath vapor or mist. Do not get in eyes, on skin, or on clothing. Electrically ground all equipment when handling this product. Retained residue may make empty containers hazardous; use caution!

EXPOSURE CONTROLS/PERSONAL PROTECTION
ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT:

Ventilation, Respiratory Protection, Protective Clothing, Eye Protection

Material should be handled or transferred in an approved fume hood or with adequate ventilation.

Protective gloves should be worn to prevent skin contact (Viton or equivalent).

Safety glasses with side shields should be worn at all times.

Respiratory Protection: If workplace exposure limit(s) of product or any component is exceeded (see TLV/PEL), a NIOSH/MSHA approved air supplied respirator is advised in absence of proper environmental control. OSHA regulations also permit other NIOSH/MSHA respirators (negative pressure type) under specified conditions (see your safety equipment supplier). Engineering and/or administrative controls should be implemented to reduce exposure.

WORK/HYGIENIC PRACTICES:

Wash thoroughly after handling. Do not take internally. Eye wash and safety equipment should be readily available.

EXPOSURE GUIDELINES:

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>TWA</th>
<th>STEL</th>
<th>CL</th>
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<tbody>
<tr>
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<td>150</td>
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ACGIH - TLV:

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<th>STEL</th>
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</thead>
<tbody>
<tr>
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PHYSICAL AND CHEMICAL PROPERTIES

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<tr>
<th>PROPERTY</th>
<th>VALUE</th>
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<tr>
<td>BOILING POINT (C 760 mmHg):</td>
<td>N/A</td>
</tr>
<tr>
<td>MELTING POINT (C):</td>
<td>N/A</td>
</tr>
<tr>
<td>SPECIFIC GRAVITY (H2O = 1):</td>
<td>.91</td>
</tr>
</tbody>
</table>
VAPOR PRESSURE (mm Hg): N/A
PERCENT VOLATILE BY VOL (%): N/A
VAPOR DENSITY (AIR =1): N/A
EVAPORATION RATE (BuAc = 1): N/a
SOLUBILITY IN WATER (%): Soluble
APPEARANCE: Colorless, viscous liquid.

STABILITY AND REACTIVITY

STABILITY: Stable.
HAZARDOUS POLYMERIZATION: Does not occur.
HAZARDOUS DECOMPOSITION: CO2, hydrocarbons.
CONDITIONS TO AVOID: Heat; contact with ignition sources.
MATERIALS TO AVOID: Oxidizers.

TOXICOLOGICAL INFORMATION

TOXICITY DATA: None established.
TOXICOLOGICAL FINDINGS: None-Cited in Registry of Toxic Effects of Substances (RTECS).

DISPOSAL CONSIDERATIONS

EPA WASTE NUMBERS: D001 U220
TREATMENT:
Incineration, fuels blending or recycle. Contact your local permitted waste disposal site (TSD) for permissible treatment sites. Always contact a permitted waste disposer (TSD) to assure compliance with all current local, State and Federal regulations.
TRANSPORT INFORMATION

DOT SHIPPING NAME: Flammable liquid, n.o.s. (contains Toluene)

DOT NUMBER: UN1993

REGULATORY/OTHER INFORMATION

TSCA STATEMENT: This product is a "Mixture". CAS number(s) of component(s) NOT listed on TSCA Inventory.

For Research and Development Use only; Not for Manufacturing or Commercial purposes.

COMPONENT: SARA EHS (302) SARA EHS TPQ (lbs) CERCLA RQ (lbs)

<table>
<thead>
<tr>
<th>Component</th>
<th>SARA EH (302)</th>
<th>SARA EHS TPQ (lbs)</th>
<th>CERCLA RQ (lbs)</th>
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</thead>
<tbody>
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<tr>
<td></td>
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<td>1000</td>
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</table>

OSHA Floor List SARA 313 DeMinimis for SARA 313 %

<table>
<thead>
<tr>
<th>Component</th>
<th>Y</th>
<th>Y</th>
<th>1.0</th>
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</thead>
<tbody>
<tr>
<td>Toluene</td>
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</tr>
</tbody>
</table>

NFPA Hazard Ratings: Health - 1
Flammability - 3
Reactivity - 0
UNION OIL CO OF CALIFORNIA, CORP. DIV-EASTERN -- MINERAL SPIRITS 75 -- 8010-01-127-6897

============================== Product Identification ===============================

Product ID: MINERAL SPIRITS 75
MSDS Date: 01/01/1985
FSC: 8010
NIIN: 01-127-6897
MSDS Number: BGNCM

=== Responsible Party ===
Company Name: UNION OIL CO OF CALIFORNIA, CORP. DIV-EASTERN
Address: 1650 EAST GOLF ROAD
City: SCHAUMBURG
State: IL
ZIP: 60195
Country: US
Info Phone Num: 708-619-2644
Emergency Phone Num: 708-619-2644
CAGE: 77416

=== Contractor Identification ===
Company Name: UNION OIL CO OF CALIFORNIA, CORP. DIV-EASTERN
Address: 1650 EAST GOLF ROAD
Box: City: SCHAUMBURG
State: IL
ZIP: 60195
Country: US
Phone: 708-619-2644
CAGE: 77416

================================= Composition/Information on Ingredients ==========================

Ingred Name: NAPHTHA (PETROLEUM SPIRITS OR BENZIN)
CAS: 8030-30-6
RTECS #: SE7555000
Fraction by Wt: 100%
OSHA PEL: 100 PPM

================================== Hazards Identification ================================

Effects of Overexposure: EYES: SEVERE IRRIT. SKIN: DRYNESS.
INH: HDCH, DIZZ, NAUSEA.
First Aid Measures

First Aid: EYES: FLUSH W/WATER 15 MINS, CALL MD. SKIN: WASH W/MILD SOAP & WATER, APPLY SKIN CREAM. INH: MOVE TO FRESH AIR & CALL MD. APPLY ARTIFICIAL RESP IF NEC.

Fire Fighting Measures

Flash Point: 108F. 42C PCC
Lower Limits: 1.0
Upper Limits: 6.0
Extinguishing Media: WATER SPRAY, CO2, FOAM, DRY CHEMICAL
Fire Fighting Procedures: WEAR SCBA. USE WATER SPRAY TO COOL FIRE-EXPOSED CONTAINERS.
Unusual Fire/Explosion Hazard: A DANGEROUS FIRE HAZARD IF HEATED OR SPRAYED IN AIR.

Accidental Release Measures

Spill Release Procedures: FLUSH WITH WATER INTO RETAINING AREA OR CONTAINER. AVOID EXPOSURE TO SPARKS, FIRE, OR HOT METAL-surfaces.
   VENTILATE AREA.

Handling and Storage

Handling and Storage Precautions: KEEP AWAY FROM HEAT, SPARKS & OPEN FLAME. USE WITH ADEQUATE VENTILATION. AVOID PROLONGED OR REPEATED CONTACT W/SKIN. KEEP CNTNRS CLSD WHEN NOT IN USE.

Exposure Controls/Personal Protection

Respiratory Protection: SCBA FOR CONCENTRATIONS ABOVE TLV LIMITS.
Ventilation: LOCAL EXHAUST
Protective Gloves: YES
Eye Protection: YES
Other Protective Equipment: EYE BATH AND SAFETY SHOWER.
Supplemental Safety and Health CONFORMS TO TT-T-291E, TYPE II, GRADE A. BP: 156-198C. EVAP
RATE:<0.1,N-BUAC PER GE MSDS #1257.CONTAINER SIZE:1 QT. CAN.

================== Physical/Chemical Properties ===================

HCC:F4
Boiling Pt:B.P. Text:313F-388F
Vapor Pres:2.0
Vapor Density:4.9
Spec Gravity:0.781
Evaporation Rate & Reference:SEE SUPP DATA
Solubility in Water:NEGLIGIBLE
Appearance and Odor:CLEAR LIQUID, CHARACTERISTIC ODOR.
Percent Volatiles by Volume:100

================= Stability and Reactivity Data ==================

Stability Indicator/Materials to Avoid:YES
STRONG OXIDIZING AGENTS
Stability Condition to Avoid:HEAT, SPARKS, OPEN FLAMES & FIRE.
Hazardous Decomposition Products:THERMAL DECOMP MAY YIELD CO.

================ Disposal Considerations =================

Waste Disposal Methods: INCINERATE UNDER SAFE CONDITIONS OR DISPOSE OF IN ACCORDANCE WITH LOCAL, STATE, OR FEDERAL REGULATIONS.

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HENRY SCHEIN INC -- ALCOHOL-DENATURED -- 6810-00F012186

================================== Product Identification =============================

Product ID: ALCOHOL-DENATURED
MSDS Date: 01/01/1987
FSC: 6810
NIIN: 00F012186
MSDS Number: BJBWG

=== Responsible Party ===
Company Name: HENRY SCHEIN INC
Address: 5 HARBOR PARK DR
City: PORT WASHINGTON
State: NY
ZIP: 11050
Info Phone Num: (516) 621-4300
Emergency Phone Num: (516) 621-4300
CAGE: 64682

=== Contractor Identification ===
Company Name: HENRY SCHEIN INC
Address: 5 HARBOR PARK DR
Box: City: PORT WASHINGTON
State: NY
ZIP: 11050
Phone: (516) 621-4300
CAGE: 64682

================================== Composition/Information on Ingredients ==================

Ingred Name: METHYL ALCOHOL (METHANOL) (SARA III)
CAS: 67-56-1
RTECS #: PC1400000
Other REC Limits: 200 PPM
OSHA PEL: S, 200 PPM/250 STEL
ACGIH TLV: S, 200 PPM/250 STEL; 93
EPA Rpt Qty: 5000 LBS
DOT Rpt Qty: 5000 LBS

================================== Hazards Identification ==============================

Routes of Entry: Inhalation: YES Skin: NO Ingestion: NO
Reports of Carcinogenicity: NTP: NO IARC: NO OSHA: NO
Health Hazards Acute and Chronic: INHALATION: MAY CAUSE SYSTEMIC
POISONING.
Explanation of Carcinogenicity: NONE
Effects of Overexposure: INHALATION: MAY CAUSE SYSTEMIC POISONING.

================================ First Aid Measures
================================

First Aid: EYES: FLUSH W/PLENTRY OF WATER. CONTACT PHYSICIAN. SKIN: WASH
   CONTAMINATED AREA W/SOAP & WATER. INGESTION: INDUCE VOMITING. GIVE  
   2 GLASSES WATER & STICK FINGER DOWN THROAT OR DILUTE POINT W/WATER.  
   INHALATION: REMOVE FROM CONTAMINATED AREA IMMEDIATELY.

================================= Fire Fighting Measures  =====================

Flash Point Method: TOC
Flash Point: 60F
Lower Limits: 5.5%
Upper Limits: 36.5
Extinguishing Media: ALCOHOL OR POLYMER FOAM, CO2 OR DRY CHEMICAL
Fire Fighting Procedures: ADDITION OF WATER TO BURNING FUEL WILL REDUCE  
   THE INTENSITY OF FLAME.  
Unusual Fire/Explosion Hazard: NONE

================================ Accidental Release Measures  ===============

Spill Release Procedures: ELIMINATE IGNITION SOURCE. CONTAIN SPILL FOR  
   SALVAGE OR DISPOSAL. USE OF ANY DILUTION WATER SHOULD BE CLOSELY  
   CONTROLLED TO MINIMIZE SPILL VOLUME. AVOID RUN-OFF INTO STORM  
   SEwers & DITCHES WHICH LEAD TO NATURAL WATERWAYS. ADVISE  
   AUTHORITIES OF SPILL.

================================ Handling and Storage
================================

Handling and Storage Precautions: DON'T LEAVE CONTAINER OPEN. USE W/ADEQUATE VENTILATION. AVOID PROLONGED/REPEATED CONTACT W/SKIN.
Exposure Controls/Personal Protection

Respiratory Protection: SELF-CONTAINED BREATHING APPARATUS.
Ventilation: MECHANICAL: ACCEPTABLE. LOCAL EXHAUST: PREFERABLE
Protective Gloves: NEOPRENE, RUBBER
Eye Protection: CHEMICAL SAFETY GOGGLES
Other Protective Equipment: IMPERVIOUS APRON, BOOTS, EYE BATH & SAFETY
SHOWER.

Supplemental Safety and Health

Physical/Chemical Properties

Boiling Pt: B.P. Text: 64.6F
Vapor Pres: 96.0
Vapor Density: 1.11
Spec Gravity: 0.7925
Evaporation Rate & Reference: (BU AC = 1): 1
Solubility in Water: COMPLETE
Appearance and Odor: WATER-WHITE LIQUID; CHARACTERISTIC ODOR.
Percent Volatiles by Volume: 100%

Stability and Reactivity Data

Stability Indicator/Materials to Avoid: YES
Stability Condition to Avoid: HEAT, SPARKS & FIRE

Disposal Considerations

Waste Disposal Methods: CHEMICAL INCINERATOR; BIOLOGICAL TREATMENT;
LANDFILL.

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GOEX INC -- BLACK POWDER -- 1376-00N037788
================================ Product Identification =================

Product ID: BLACK POWDER
MSDS Date: 09/01/1988
FSC: 1376
NIIN: 00N037788
MSDS Number: BQWTX
=== Responsible Party ===
Company Name: GOEX INC
Address: 1002 SPRINGBROOK AVE
City: MOOSIC
State: PA
ZIP: 18507
Country: US
Info Phone Num: 717-457-6724
Emergency Phone Num: 717-457-6724; 800-424-9300 (CHEMTREC)
CAGE: 51580
=== Contractor Identification ===
Company Name: GOEX INC
Address: 1002 SPRINGBROOK AVE
Box: City: MOOSIC
State: PA
ZIP: 18507
Country: US
Phone: 717-457-6724
CAGE: 51580

================= Composition/Information on Ingredients ==================

Ingred Name: POTASSIUM NITRATE
CAS: 7757-79-1
RTECS #: TT3700000
Fraction by Wt: 70-76%

Ingred Name: CHARCOAL
CAS: 16291-96-6
RTECS #: FL7243500
Fraction by Wt: 8-18%

Ingred Name: SULFUR; (SULPHUR)
CAS: 7704-34-9
RTECS #: WS4250000
Fraction by Wt: 9-20%

==================================== Hazards Identification =====================================

LD50 LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation: YES  Skin: NO  Ingestion: NO
Reports of Carcinogenicity: NTP: NO  IARC: NO  OSHA: NO
Explanation of Carcinogenicity: NOT RELEVANT

==================================== First Aid Measures =====================================

First Aid: INGEST: CALL MD IMMEDIATELY. INHAL: REMOVE TO FRESH AIR.
SUPPORT BREATHING (GIVE O2/ARTF RESP). EYES: IMMEDIATELY FLUSH
W/POTABLE WATER FOR A MINIMUM OF 15 MINUTES, SEEK ASSISTANCE FROM MD.
SKIN: FLUSH W/ COPIOUS AMOUNTS OF WATER. CALL MD.

==================================== Fire Fighting Measures =====================================

Extinguishing Media: WATER.
Fire Fighting Procedures: DO NOT FIGHT FIRES. EVACUATE AREA.
Unusual Fire/Explosion Hazard: DO NOT FIGHT FIRES. BLACK POWDER MAY DEFLAGRATE OR EXPLODE IN A FIRE WHILE CONFINED. EVACUATE AREA.

==================================== Accidental Release Measures =====================================

Spill Release Procedures: CAREFULLY PICK UP SPILLS W/NONSPARKING & NONSTATIC PRODUCING TOOLS. SUPERVISION ONLY BY A PERSON KNOWLEDGEABLE IN EXPLOSIVES.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.

==================================== Handling and Storage =====================================

Handling and Storage Precautions: NO SMOKING. STORE IN A COOL, DRY PLACE.
Other Precautions: AFFECTED EQUIPMENT MUST BE THOROUGHLY WATER CLEANED BEFORE ATTEMPTING REPAIRS. USE ONLY NONSPARKING TOOLS.

==================================== Exposure Controls/Personal Protection =====================================
Respiratory Protection: USE NIOSH/MSHA APPROVED RESPIRATOR APPROPRIATE FOR EXPOSURE OF CONCERN.
Ventilation: NOT REQUIRED IN OPEN, UNCONFINED AREAS.
Protective Gloves: IMPERVIOUS GLOVES.
Eye Protection: CHEMICAL WORKERS GOGGLES.
Other Protective Equipment: METAL FREE & NONSTATIC PRODUCING CLOTHES.
Work Hygienic Practices: WASH HANDS/SHOWER.
Supplemental Safety and Health SPEC GRAV: 1.7-1.82 (H2O = 1).

=============== Physical/Chemical Properties ================
Spec Gravity: SUPP DATA
pH: 6-8
Solubility in Water: HIGH
Appearance and Odor: BLACK; NO ODOR.

=============== Stability and Reactivity Data ================
Stability Indicator/Materials to Avoid: YES
Stability Condition to Avoid: KEEP AWAY FROM HEAT, SPARKS & OPEN FLAME.
    AVOID IMPACT, FRICTION & STATIC ELECTRICITY.
Hazardous Decomposition Products: NONE SPECIFIED BY MANUFACTURER.

=============== Disposal Considerations ================
Waste Disposal Methods: DE-SENSITIZE BY DILUTING IN WATER. OPEN TRAIN
    BURNING OF SMALL UNCONFINED QUANTITIES. ALL PROCEDURES MUST BE IN
    COMPLIANCE W/ALL LOCAL, STATE & FEDERAL REGULATIONS.

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BUCKEYE FIRE EQUIPMENT CO -- CARBON DIOXIDE (CO2) -- 4210-00-203-0217

Product Identification

Product ID: CARBON DIOXIDE (CO2)
MSDS Date: 12/01/1990
FSC: 4210
NIIN: 00-203-0217
MSDS Number: BXWLF

Company Name: BUCKEYE FIRE EQUIPMENT CO
Address: 102 INDUSTRIAL DR
City: KINGS MOUNTAIN
State: NC
ZIP: 28086
Country: US

Info Phone Num: 704-739-7415
Emergency Phone Num: 704-739-7415
CAGE: 57658

Contractor Identification

Company Name: BUCKEYE FIRE EQUIPMENT CO
Address: 110 KINGS RD
Box: 428
City: KINGS MOUNTAIN
State: NC
ZIP: 28086
Country: US
Phone: 704-739-7415
CAGE: 57658

Composition/Information on Ingredients

Ingred Name: CARBON DIOXIDE
CAS: 124-38-9
RTECS #: FF6400000
Other REC Limits: NONE RECOMMENDED
OSHA PEL: 5000 PPM
ACGIH TLV: 5000 PPM/30000 STEL: 95

Hazards Identification

Routes of Entry: Inhalation: YES  Skin: NO  Ingestion: NO
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:ACUTE: DIRECT CONTACT WITH LIQUID OR
SOLID WILL CAUSE BURNS, FROSTBITE OR BLINDNES. CARBON DIOXIDE IS AN
ASPHYXIANT (DISPLACES OXYGEN). CHRONIC: NONE SPECIFIED BY MANUFACTURER.
Explanation of Carcinogenicity:NO INGREDIENT OF A CONCENTRATION OF 0.1%
OR GREATER IS LISTED AS A CARCINOGEN OR SUSPECTED CARCINOGEN.
Effects of Overexposure:INHALED-SHORTNESS OF BREATH, INCREASED INHALATION RATE, UNCONSCIOUSNESS, POSSIBLE DEATH. CONTACT (SKIN, EYES): BURNS, FROSTBITE, PAIN.
Medical Cond Aggravated by Exposure:NONE KNOWN.

======================== First Aid Measures
 ========================
First Aid:SKIN/EYES-TREAT AREA EXPOSED TO SOLID OR LIQUID AS FROSTBITE.
GET IMMEDIATE MEDICAL ATTENTION. INHALED-REMOVE TO FRESH AIR.
RESTORE BREATHING IF REQUIRED. GET MEDICAL ATTENTION.

======================== Fire Fighting Measures  =======================
Extinguishing Media:NONE, THIS MATERIAL IS AN EXTINGUISHING AGENT. DLA-HMIS: USE MEDIA APPROPRIATE FOR SURROUNDING FIRE. Fire Fighting Procedures:NONE. DLA-HMIS: WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE GEAR. COOL FIRE EXPOSED CONTAINERS WITH WATER. Unusual Fire/Explosion Hazard:NONE.

====================== Accidental Release Measures  ======================
Spill Release Procedures:RELEASED GAS WILL DISSIPATE RAPIDLY AND HARMLESSLY TO ATMOSPHERE, IN OPEN AREAS. IN CONFINED OR ENCLOSED AREAS, MOVE PERSONNEL AND VENTILATE AREA. VENT TO ATMOSPHERE. Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.
Handling and Storage

Handling and Storage Precautions: STORE AWAY FROM DIRECT HEAT OR FLAME.
Other Precautions: NONE.

Exposure Controls/Personal Protection

Respiratory Protection: IF ENGINEERING CONTROLS FAIL OR NON-Routine USE
   OR AN EMERGENCY OCCURS; WEAR AN MSHA/NIOSH APPROVED AIR-SUPPLIED
   RESPIRATOR OR SCBA, AS REQUIRED. USE IN ACCORDANCE WITH 29 CFR
   1910.134 AND MANUFACTURE R'S RECOMMENDATIONS.
Ventilation: USE ADEQUATE MECHANICAL VENTILATION OR LOCAL
   EXHAUST TO
   MAINTAIN EXPOSURE BELOW TLV(S).
Protective Gloves: USE INSULATED GLOVES IF LIQUID OR SOLID.
Eye Protection: SAFETY GLASSES.
Other Protective Equipment: NONE REQUIRED.
Work Hygienic Practices: USE GOOD HYGIENE AND GOOD HOUSEKEEPING
   PRACTICES.
Supplemental Safety and Health
   CONTAINS 15 POUNDS, NOMINAL.

Physical/Chemical Properties

HCC: G3
Boiling Pt: B.P. Text: -109F, -78C
Vapor Pres: GAS @ 70F
Vapor Density: 1.52
Evaporation Rate & Reference: HIGH (N-BUTYL ACETATE=1)
Solubility in Water: SLIGHT
Appearance and Odor: COLORLESS LIQUID OR GAS; NO ODOR.

Stability and Reactivity Data

Stability Indicator/Materials to Avoid: YES
   NONE SPECIFIED BY MANUFACTURER.
Stability Condition to Avoid: NONE SPECIFIED BY MANUFACTURER.
Hazardous Decomposition Products: NONE SPECIFIED BY MANUFACTURER.
Conditions to Avoid Polymerization: WILL NOT OCCUR.
Waste Disposal Methods: DLA-HMIS: DISPOSE OF IN ACCORDANCE WITH LOCAL, STATE AND FEDERAL ENVIRONMENTAL REGULATIONS.

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AERVOE-PACIFIC CO INC -- 936 SILICONE LUBE, 50A -- 6850-00N078808

============== Product Identification ===============

Product ID: 936 SILICONE LUBE, 50A
MSDS Date: 01/14/1993
FSC: 6850
NIIN: 00N078808
MSDS Number: CGGPN

=== Responsible Party ===
Company Name: AERVOE-PACIFIC CO INC
Address: 1198 SAWMILL RD
City: GARDNERVILLE
State: NV
ZIP: 89410
Country: US
Info Phone Num: 702-782-0100
Emergency Phone Num: 800-424-9300 (CHEMTREC)
Preparer's Name: MIKE A. TRAQUINA
CAGE: 0UPL1

=== Contractor Identification ===
Company Name: AERVOE-PACIFIC CO INC
Address: 1198 SAWMILL RD
Box: City: GARDNERVILLE
State: NV
ZIP: 89410
Country: US
Phone: 702-782-0100
CAGE: 0UPL1

============== Composition/Information on Ingredients =============

Ingred Name: HEXANE; (N-HEXANE) (CERCLA). LD50:(ORAL, RAT) 28710 MG/KG.
CAS: 110-54-3
RTECS #: MN9275000
Fraction by Wt: 30%
OSHA PEL: 500 PPM
ACGIH TLV: 50 PPM
EPA Rpt Qty: 1 LB
DOT Rpt Qty: 1 LB
Ingred Name: VM & P NAPHTHA; (PETROLEUM NAPHTHA). LD50:(ORAL,RAT) >25 MG/KG.
CAS:64742-89-8
Fraction by Wt: 35%
OSHA PEL:400 PPM (MFR)
ACGIH TLV:400 PPM (MFR)

Ingred Name: PROPANE
CAS:74-98-6
RTECS #:TX2275000
Fraction by Wt: 15%
OSHA PEL:1000 PPM
ACGIH TLV:ASPHYXIANT

Ingred Name: PROPANE, 2-METHYL-; (ISOBUTANE)
CAS:75-28-5
RTECS #:TZ4300000
Fraction by Wt: <5%
OSHA PEL:800 PPM (MFR)
ACGIH TLV:800 PPM (MFR)

Ingred Name: BUTANE; (NORMAL BUTANE)
CAS:106-97-8
RTECS #:EJ4200000
Fraction by Wt: 10%
OSHA PEL:800 PPM
ACGIH TLV:800 PPM

Ingred Name: VOLATILE ORGANIC COMPOUNDS (COATING): 5.09 LBS/GAL (610 G/L).
RTECS #:9999999VO

================================================================= Hazards Identification ===========================

LD50 LC50 Mixture:SEE INGREDIENTS.
Routes of Entry: Inhalation:YES Skin:YES Ingestion:YES
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:INHALATION:ANESTHETIC, IRRITATION OF THE RESPIRATORY TRACT OR NERVOUS SYSTEM DEPRESSION-CHARACTERIZED BY HEADACHE, DIZZINESS, NAUSEA OR POSSIBLE UNCONSCIOUSNESS. EYE CONTACT:PRIMARY IRRITATION. SKIN:CONTACT OR ABSORPTION
MAY CAUSE
   IRRITATION OR BURNING SENSATION. PROLONGED OR REPEATED CONTACT MAY
   CAUSE(EFFECTS OF OVEREXPOSURE
Explanation of Carcinogenicity: NOT RELEVANT
Effects of Overexposure: HLTH HAZ: DERMATITIS - EXERCISE DUE CARE.
   INGESTION: NOT APPLICABLE.
Medical Cond Aggravated by Exposure: NONE KNOWN.

======================= First Aid Measures ========================

First Aid: INGEST: CALL MD IMMEDIATELY. INHAL: REMOVE FROM EXPOSURE &
   RESTORE BREATHING, SEEK MEDICAL ATTENTION. SKIN: WASH AFFECTED AREA.
   REMOVE CONTAMINATED CLOTHING. SEE MD IF ANY IRRITATION PERSISTS.
   EYE S: FLUSH IMMEDIATELY W/ WATER FOR AT LEAST 15 MINUTES & TAKE TO
   MD.

===================== Fire Fighting Measures =====================

Flash Point: -0F, -18C
Lower Limits: 1%
Upper Limits: 9.5%
Extinguishing Media: FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL, WATER FOAM.
Fire Fighting Procedures: USE NIOSH APPROVED SCBA & FULL PROTECTIVE
   EQUIPMENT. WATER SPRAY MAY BE USED TO COOL CONTAINERS EXPOSED TO
   HEAT OR FIRE.
Unusual Fire/Explosion Hazard: CLSD CNTNRS MAY EXPLODE DUE TO BUILD UP
   OF PRESS FROM EXTREME HEAT/FIRE. AEROSOL SPRAY IS EXTREMELY FLAMM.
   SENSITIVITY TO IMPACT: DO NOT PUNCTURE. (SUPP DATA)

================== Accidental Release Measures ==================

Spill Release Procedures: REMOVE ALL SOURCES OF IGNITION, FLAMES,
   SPARKS, STATIC ELECTRICITY & ELECTRICAL. VENTILATE AREA & SOAK UP
   W/INERT ABSORBENT USING NON-SPARKING TYPE TOOLS.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Handling and Storage

Handling and Storage Precautions: DO NOT STORE ABOVE 120F. DO NOT STORE OR USE NEAR HEAT, SPARKS OR FLAME. DO NOT GET IN EYES. DO NOT BREATHE VAPORS. AVOID SKIN CONTACT.

Other Precautions: DO NOT TAKE INTERNALLY. SMOKING WHILE USING THIS PRODUCT MUST BE STRICTLY PROHIBITED. AVOID PROLONGED OR REPEATED CONTACT.

Exposure Controls/Personal Protection

Respiratory Protection: IN RESTRICTED AREAS W/POOR VENTILATION USE A NIOSH APPROVED RESPIRATOR W/ORGANIC VAPOR CARTRIDGE.

Ventilation: ALL APPLICATION AREAS SHOULD BE ADEQUATELY VENTILATED IN ORDER TO KEEP INGREDIENTS BELOW THEIR EXPOSURE LIMITS.

Protective Gloves: IMPERVIOUS GLOVES.

Eye Protection: ANSI APPROVED CHEM WORKERS GOGGS.

Other Protective Equipment: EYE WASH FOUNTAIN & DELUGE SHOWER WHICH MEET ANSI DESIGN CRITERIA. IMPERVIOUS APRON IS REC TO PREVENT SKIN CONT.

Work Hygienic Practices: NONE SPECIFIED BY MANUFACTURER.

Supplemental Safety and Health EXPLO HAZ: SENSITIVITY TO STATIC DISCHARGE: PRIMARILY VAPORS.

Physical/Chemical Properties

Boiling Pt: B.P. Text: 10F, -12C
Vapor Density: HVR/AIR
Spec Gravity: 0.7 (H*2O=1)
Evaporation Rate & Reference: FASTER/N-BUTYL ACETATE
Solubility in Water: NEGLIGIBLE
Appearance and Odor: CLEAR LIQUID; SOLVENT BASED ODOR.

Stability and Reactivity Data

Stability Indicator/Materials to Avoid: YES
STRONG OXIDIZING AGENTS.
Stability Condition to Avoid: HIGH TEMPERATURES.
Hazardous Decomposition Products: CARBON MONOXIDE & CARBON DIOXIDE.

==================== Disposal Considerations ====================

Waste Disposal Methods: DISPOSE OF I/A/W LOCAL, STATE & FEDERAL REGULATIONS. DO NOT INCINERATE CLOSED CONTAINERS.

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Product ID: 21911 WHITE LUBE LITHIUM GREASE
MSDS Date: 10/18/1988
FSC: 9150
NIIN: 00F014116
MSDS Number: BJTPZ

=== Responsible Party ===
Company Name: BOWMAN DISTRIBUTION, BANRES GROUP INC
Address: 850 EAST 72ND STREET
City: CLEVELAND
State: OH
ZIP: 44103
Info Phone Num: (216) 391-7200
Emergency Phone Num: (216) 391-7200
CAGE: 05575

=== Contractor Identification ===
Company Name: BOWMAN DISTRIBUTION, BARNES GROUP INC
Address: 1301 EAST 9TH ST, SUITE 700
Box: City: CLEVELAND
State: OH
ZIP: 44114-1824
Country: US
Phone: 216-416-7200
CAGE: 05573

Company Name: BOWMAN DISTRIBUTION, BARNES GROUP INC.
Address: 850 EAST 72ND STREET
City: CLEVELAND
State: OH
ZIP: 44103
Phone: (216) 391-7200
CAGE: 05575

============ Composition/Information on Ingredients ============

Ingred Name: METHYL CHLOROFORM (1,1,1-TRICHLOROEHANE) (SARA III)
CAS: 71-55-6
RTECS #: KJ2975000
Fraction by Wt: 15.0%
Other REC Limits: 350 PPM (CL)
OSHA PEL: 350 PPM/450 STEL
ACGIH TLV: 350 PPM/450 STEL; 9192
EPA Rpt Qty: 1000 LBS
DOT Rpt Qty: 1000 LBS
Ozone Depleting Chemical: 1

Ingred Name: HEXANE (N-HEXANE)
CAS: 110-54-3
RTECS #: MN9275000
Fraction by Wt: 22.0%
Other REC Limits: 50 PPM
OSHA PEL: 500 PPM
ACGIH TLV: 50 PPM; 9293
EPA Rpt Qty: 1 LB
DOT Rpt Qty: 1 LB

Ingred Name: GREASE
Fraction by Wt: 38.0%

Ingred Name: ISOBUTANE, 2-METHYLPROPANE
CAS: 75-28-5
RTECS #: TZ4300000
Fraction by Wt: <25.0%
Other REC Limits: 1000 PPM
OSHA PEL: 1800 MG/CUM
ACGIH TLV: 1000 PPM

Ingred Name: PROPANE
CAS: 74-98-6
RTECS #: TX2275000
Fraction by Wt: <25.0%
Other REC Limits: 1800 MG/CUM
OSHA PEL: 1000 PPM
ACGIH TLV: ASPHYXIANT; 9192

======================  Hazards Identification  ======================

Routes of Entry: Inhalation: YES  Skin: YES  Ingestion: YES
Reports of Carcinogenicity: NTP: NO  IARC: NO  OSHA: NO
Health Hazards Acute and Chronic: INHALATION: DIZZINESS OR NARCOSIS.
   SKIN: DEFATTING, EFFECTS ARE REVERSIBLE. LONG TERM
EXPOSURE VAPOR
   MAY CAUSE LUNG, LIVER OR KIDNEY DAMAGE. THE SOLVENTS LISTED
HAVE
   BEEN REPORTED TO AFFECT THE CENTRAL NERVOUS SYSTEM.
INGESTION:
    HARMFUL.
Explanation of Carcinogenicity:NONE
Effects of Overexposure: INHALATION: DIZZINESS, NARCOSIS. SKIN:
    DEFFATTING, EFFECTS ARE REVERSIBLE. LONG TERM EXPOSURE
VAPOR MAY
    CAUSE LUNG, LIVER OR KIDNEY DAMAGE. THE SOLVENTS LISTED
HAVE BEEN
    REPORTED TO AFFECT THE CENTRAL NERVOUS SYSTEM. INGESTION:
HARMFUL.
Medical Cond Aggravated by Exposure: HEART DISEASE, RESPIRATORY
    DISORDER.

============== First Aid Measures
==============

First Aid: INHALATION: IF UNCONSCIOUS, REMOVE PERSON TO FRESH
AER. EYES:
    FLUSH W/LARGE QUANTITIES OF WATER. OBTAIN MEDICAL
ATTENTION IN ALL
    CASES.

============== Fire Fighting Measures
c==============

Flash Point Method:TCC
Flash Point:-40F
Lower Limits:1.8%
Upper Limits:12.0%
Extinguishing Media: WATERFOG, FOAM, CO2, OR DRY CHEMICAL
Fire Fighting Procedures: KEEP CONTAINERS COOL. USE EQUIPMENT OR
    SHIELDING REQUIRED TO PROTECT PERSONNEL AGAINST BURSTING
OR VENTING
    CONTAINERS.
Unusual Fire/Explosion Hazard: AT ELEVATED TEMPERATURES >130F
CONTAINERS
    MAY VENT, RUPTURE OR BURST.

============== Accidental Release Measures
==============

Spill Release Procedures: USE ABSORBENT SWEEPING COMPOUND TO
SOAK UP
    MATERIAL. PUT INTO CONTAINER. DISPOSE AS HAZARDOUS WASTE.

============== Handling and Storage
==============
Handling and Storage Precautions: DON'T STORE AT TEMPERATURES >120F. Other Precautions: NONE

================== Exposure Controls/Personal Protection =================

Respiratory Protection: AVOID BREATHING CONCENTRATED VAPORS OR PARTICLES FROM ALL PRODUCTS NOT SPECIFICALLY DESIGNED TO BE INHALED. Ventilation: LOCAL EXHAUST: NORMAL USE-NORMAL VENTILATION. Eye Protection: SAFETY GLASSES REQUIRED. Other Protective Equipment: LONG SLEEVES/PANTS. Supplemental Safety and Health

================== Physical/Chemical Properties =================

Boiling Pt: B.P. Text: -40 - >600F
Vapor Pres: 55 PSI
Vapor Density: 4.0
Spec Gravity: 0.8
pH: NONE
Appearance and Odor: LIQUID GAS, WHITE & SOLVENT ODOR.
Percent Volatiles by Volume: 60.0%

================== Stability and Reactivity Data =================

Stability Indicator/Materials to Avoid: YES
Stability Condition to Avoid: PRESSURIZED CONTAINERS COULD RUPTURE >130F.
Hazardous Decomposition Products: CO, CO2, WATER, PHOSGENE & HALOGEN ACIDS.

================== Disposal Considerations =================


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assume responsibility for the suitability of this information to their particular situation.

CHESTER LABORATORIES -- ISOPROPYL RUBBING ALCOHOL, USP -- 6810-00-311-0192

=============  Product Identification  =============
Ingred Name: ISOPROPYL ALCOHOL (SARA III)
CAS: 67-63-0
RTECS #: NT8050000
Fraction by Wt: 70%
Other REC Limits: NONE SPECIFIED
OSHA PEL: 400 PPM/500 STEL
ACGIH TLV: 400 PPM/500 STEL; 9192

================================= Hazards Identification ======================

LD50 LC50 Mixture: TLV = 400 PPM
Routes of Entry: Inhalation: YES  Skin: NO  Ingestion: YES
Reports of Carcinogenicity: NTP: NO  IARC: NO  OSHA: NO
Health Hazards Acute and Chronic: ACUTE: OVEREXPOSURE MAY LEAD TO
CENTRAL NERVOUS SYSTEM DEPRESSION, LEADING TO HEADACHES AND
DIZZINESS. EYE: MAY LEAD TO IRRITATION AND WILL INJURE EYE
TISSUE
IF NOT REMOVED PROMPTLY. SKIN: MAY LEAD TO DERMATITIS.
INGESTION:
MAY LEAD TO VOMITING. CHRONIC: PROLONGED SKIN CONTACT MAY
CAUSE
DERMATITIS.
Explanation of Carcinogenicity: THIS CHEMICAL IS NOT LISTED AS HAVING
ANY EVIDENCE OF BEING CARCINOGENIC.
Effects of Overexposure: OVEREXPOSURE MAY LEAD TO DIZZINESS,
HEADACHES, DERMATITIS AND EYE IRRITATION. HIGH VAPOR CONCENTRATIONS
ARE
ANESTHETIC AND MAY HAVE OTHER CENTRAL NERVOUS SYSTEM
EFFECTS, SUCH
AS LIGHTHEADEDNESS, HEADACHE AND DIZZINESS.
Medical Cond Aggravated by Exposure: PERSONS WITH SKIN, HEART,
RESPIRATORY, OR ANY OTHER MEDICAL CONDITION SHOULD USE
CAUTION WHEN
HANDLING OR USING THIS PRODUCT.

================================= First Aid Measures ======================

First Aid: SKIN: IMMEDIATELY FLUSH WITH SOAP AND WATER. GET
MEDICAL
ATTENTION IF NECESSARY. INHALATION: IMMEDIATELY REMOVE
VICTIM TO
FRESH AIR. GIVE CPR IF BREATHING HAS STOPPED. GET MEDICAL
ATTENTION. EYE: IMMEDIATELY FLUSH WITH WATER FOR 15 MINUTES. GET
MEDICAL ATTENTION. INGESTION: GET PROMPT MEDICAL ATTENTION.
DO NOT
INDUCE VOMITING. KEEP AT REST.

==================== Fire Fighting Measures =====================

Flash Point Method: SCC
Flash Point: 53.0F, 11.7C
Lower Limits: 2
Upper Limits: 13
Extinguishing Media: USE FOAM, OR DRY CHEMICAL. USE WATER SPRAY TO COOL
   FIRE EXPOSED CONTAINERS AND TO PROTECT PERSONNEL.
Fire Fighting Procedures: WEAR FIRE FIGHTING PROTECTIVE EQUIPMENT AND A
   FULL FACED SELF CONTAINED BREATHING APPARATUS.
Unusual Fire/Explosion Hazard: COMBUSTION OR HEAT OF FIRE MAY PRODUCE
   HAZARDOUS DECOMPOSITION PRODUCTS AND VAPORS. VAPORS HEAVIER THAN
   AIR, CAN TRAVEL ALONG GROUND AND FLASHBACK.

=================== Accidental Release Measures ==================

Spill Release Procedures: VENTILATE. ELIMINATE IGNITION SOURCES.
   ABSORB
   MATERIAL WITH CLAY, VERMICULITE, OR SIMILAR ABSORBENT MATERIAL.
   PLACE IN DISPOSAL CONTAINERS. FLUSH AREA WITH WATER.

==================== Handling and Storage ======================

Handling and Storage Precautions: USE ONLY IN WELL VENTILATED WORK AREA.
   KEEP CONTAINERS CLOSED WHEN NOT IN USE. FLAMMABLE LIQUID.
   DO NOT
   STORE ABOVE 120F.
Other Precautions: DO NOT PRESSURIZE, CUT, WELD, BRAZE, SOLDER, DRILL,
   GRIND, OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC
   ELECTRICITY, OR OTHER SOURCES OF IGNITION. EXPLOSION HAZARD.
Exposure Controls/Personal Protection

Respiratory Protection: NONE NORMALLY REQUIRED. USE NIOSH/MSHA APPROVED RESPIRATOR. AIR-SUPPLIED OR FILTERING TYPE WITH ORGANIC VAPOR CARTRIDGES IF TLV IS EXCEEDED.
Ventilation: LOCAL AND MECHANICAL EXHAUST RECOMMENDED. AVOID OPEN ELECTRICAL SOURCES NEAR PRODUCT VAPOR AREAS.
Protective Gloves: NEOPRENE, NITRILE, OR POLYVINYL ALCOHOL
Eye Protection: USE CHEMICAL SAFETY GOGGLES & FACESHIELD
Other Protective Equipment: SAFETY SHOES, EYE WASH STATION AND SHOWER.
Work Hygienic Practices: DO NOT TAKE INTERNALLY. AVOID SKIN CONTACT.
WASH SKIN AFTER USING PRODUCT. DO NOT EAT, DRINK OR SMOKE IN WORK AREA.

Physical/Chemical Properties

HCC: F2
Boiling Pt: B.P. Text: 194°F, 90°C
Vapor Pres: 38
Vapor Density: 2.0
Spec Gravity: 0.82
Evaporation Rate & Reference: 2.8 (BUTYL ACETATE = 1)
Solubility in Water: 100%
Appearance and Odor: CLEAR, COLORLESS LIQUID WITH AN ALCOHOL ODOR.

Stability and Reactivity Data

Stability Indicator/Materials to Avoid: YES STRONG OXIDIZING AGENTS, REACTIVE ALKALI METALS.
Stability Condition to Avoid: HIGH HEAT, OPEN FLAMES AND OTHER SOURCES OF IGNITION. ALSO AVOID VAPOR ACCUMULATION.
Hazardous Decomposition Products: CARBON MONOXIDE, CARBON DIOXIDE, INCOMPLETELY BURNED CARBON PRODUCTS.
Waste Disposal Methods: DISPOSE OF ALL WASTE IN ACCORDANCE WITH LOCAL, STATE AND FEDERAL REGULATIONS. INCINERATION IS RECOMMENDED.

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