

Rocket Safety Hazards

Friends of Amateur Rocketry, Inc.

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Rocket Safety Hazards List

- “ **Pressure Release Injury**
- “ **Hearing Injury**
 - . High-Noise Levels
- “ **Explosion Injury or Death**
 - . Shrapnel, Blast, Impact
- “ **Burn Injury or Death**
 - . Low-Explosives: Igniters, Black Powder, Pyrotechnic Chemicals, Electric Matches & Solid Propellants
 - . Fire
 - . Extreme Hot or Cold Temperatures
 - . Chemicals Exposure
 - . Electric Shock
- “ **Toxic Injury or Death**
 - . Chemical Exposure, Inhalation
 - . Asphyxiants
- “ **Fall Injury**
- “ **Impact Injury**
- “ **Desert Exposure Injury**

Hazard: Pressure Release Injury

Causes	Mitigations	Personal Protective Equipment
Rupture, Boiling Liquid Expanding Vapor Explosion (BLEVE)	" Tank Damage Protection " ASTM Welds " Proof Test with Water and Hand Pump " <u>Factors of Safety</u> " 1.0—1.25 – Do Not Move, Touch, or Approach – Pressurize Remotely " 1.5—2.0 – Do not move or touch " 3.0 – Do not move " 4.0 – Transport on road (DOT Rating) " Relief Valves " Remote Activated Vent Valves	" Safety Glasses " Face Shield " Safe Distance
Gas Jet	" Direct Vents Away from People " Non-Propulsive Vents	" Safety Glasses " Face Shield
Hose Whipping	Well Attached Hose Ends	

Hazard: Hearing Injury (High-Noise Levels)

Causes	Mitigations	Personal Protective Equipment
" Venting " Pressure Relief " Gas Jet	Vent Mufflers	" Ear Plugs " Ear Muffs " Blockhouse Windows
" Rocket Engine Firing " Rocket Motor Firing		

Hazard: Explosion Injury or Death (Shrapnel, Blast, Impact)

Causes	Mitigations	Personal Protective Equipment
<p><u>Mixing Fuel & Oxidizer</u></p> <p><u>Fuel</u></p> <ul style="list-style-type: none"> " Leakage " Venting " Rupture " Contamination <p><u>Oxidizer</u></p> <ul style="list-style-type: none"> " Leakage " Venting " Air <p><u>Initiation</u></p> <p><u>Sparks</u></p> <ul style="list-style-type: none"> " Electrical Short " Static Discharge " RF <p><u>Impact</u></p> <p><u>Friction</u></p>	<ul style="list-style-type: none"> " Factors of Safety " Seal Compatibility " Cleanliness " Relief Valves " Remote Activate Relief Valves " Safe Distance " No Smoking " No Sparks " Fuses/Circuit Breakers " Grounding 	<ul style="list-style-type: none"> " Blockhouse " Viewing Bunkers " Earth Berms/Barriers

Hazard: Burn Injury (Low-Explosives: Igniters, Black Powder, Pyrotechnic Chemicals, Electric Matches & Solid Propellants)

Causes	Mitigations	Personal Protective Equipment
<p><u>Inadvertent Ignition</u></p> <ul style="list-style-type: none"> - Smoking - Sparks - Chemical Reaction - Friction - Electrical 	<ul style="list-style-type: none"> “ No Smoking/Sparks “ Use Grounded/Conductive Work Surface “ Keep Work Surface Clean and Clutter Free “ Keep Working Quantities Small “ Keep Chemical/Explosive Containers Closed and Stored Away from the Work Surface “ Make Sure Chemicals/Explosives are Compatible/Non-Reactive “ Avoid Grinding Explosive Mixtures “ Keep Igniter/Electric Match Lead Ends Shorted Until Installation “ If Not to be Use Immediately, Place in Explosive Magazine “ <u>Arm Ignition/Recovery System</u> <ul style="list-style-type: none"> - Only after rocket is place in launch rack or test stand - Personnel Safe Distance “ Safely Clean Up and Burn Excess/Waste Chemicals/Explosives 	<ul style="list-style-type: none"> “ <u>Use two-step ignition system</u> <ul style="list-style-type: none"> - Arming key at ignition point - Arming key at control point - Use only one arming key - Momentary ignition switch - Safe state shorts igniter/electric match leads together “ Safety Glasses “ Hearing Protection “ ESD Wrist Band

Hazard: Burn Injury (Fire)

Causes	Mitigations	Personal Protective Equipment
<p><u>Fire Triangle</u></p> <p><u>Fuel</u></p> <ul style="list-style-type: none"> “ Leakage “ Venting “ Rupture “ Spill <p><u>Oxidizer</u></p> <ul style="list-style-type: none"> “ Leakage “ Venting “ Rupture “ Spill “ Air <p><u>Ignition</u></p> <ul style="list-style-type: none"> “ Smoking “ Sparks “ Electrical Short “ Impact 	<ul style="list-style-type: none"> “ Factors of Safety “ Relief Valves “ Remote Activate Relief Valves “ Safe Distance “ Seal Compatibility “ Cleanliness “ No Smoking “ No Sparks 	<p>Fire Extinguisher</p>

Hazard: Burn Injury (Extreme Hot or Cold Temperatures)

Causes	Mitigations	Personal Protective Equipment
<u>Thermal</u> " Rocket Engine " Rocket Motor " Solar	" Thermal Insulation " Paint White	Hot-Gloves
<u>Freeze</u> <u>Venting Refrigerants</u> " Nitrous Oxide " Ethane " Propane <u>Venting Cryogenics</u> " Liquid Oxygen <u>Cold Lines</u>	" Thermal Insulate Lines and Tanks " Point Vents Away from Personnel	" Cold-Gloves " Face Shields " Nomex Suit

Hazard: Burn Injury (Chemicals Exposure)

Causes	Mitigations	Personal Protective Equipment
<u>Acid</u> " Nitric Acid <u>Bleach</u> " Hydrogen Peroxide	Open Air Operations	" Gloves " Safety Glasses " Face Shields " Aprons " Boots " Chemical Suits " Chemical Gas Mask " Compatible with chemicals in use

Hazard: Burn Injury or Death (Electric Shock)

Causes	Mitigations	Personal Protective Equipment
High-Voltage (110-Volt)	<ul style="list-style-type: none">" Use Low-Voltage (6, 12, 24, 28 Volts)" Guarded Terminals" Insulation" Equipment Grounding" Keep Work Area and Equipment Dry" Turn Off Equipment While Working On It" Use NEMA rate electrical boxes	ABC Fire Extinguisher

Hazard: Toxic Injury (Chemical Exposure, Inhalation)

Causes	Mitigations	Personal Protective Equipment
<u>Vapors</u> " Fuels " Oxidizers " Resins " Hardeners	" Open Air Operations " Well Ventilated Work Areas	" Gloves " Safety Glasses " Face Shields " Aprons " Boots " Chemical Suits " Chemical Gas Mask
<u>Dust</u> " Composite Cloth " Composite Resins	Vacuum Up Dust as Created	" Dust Mask " Protective Gloves

Hazard: Toxic Injury or Death (Asphyxiants)

Causes	Mitigations	Personal Protective Equipment
<u>Inert Gases</u> " Helium " Nitrogen " Nitrous Oxide <u>Flammable Gases</u> " Methane " Hydrocarbon	" Open Air Operations " Well Ventilated Work Area	" Self Contained Breathing Equipment

Hazard: Fall Injury

Causes	Mitigations	Personal Protective Equipment
<u>Climbing</u> " Launch Rails " Test Stands	" Guard Rails " Hand Rails	Fall Harness
Holes	Take Care While Walking	Flashlight

Hazard: Impact Injury

Causes	Mitigations	Personal Protective Equipment
Recovery System Failure	Redundant Recovery Systems	" Blockhouse " Viewing Bunkers
Inadvertent Recovery System Initiation	" Clear Area In Front of Recovery System While Working on it " Arm Recovery System While Rocket is on Launch Rail	
Engine Burn Through/ Hard Start	Safe Distance	" Blockhouse " Viewing Bunkers
Launch Rail Topples	" Guywires " Stakes/Anchors " Leveling Legs " Wind Limits	
Vehicle/Trailer Backing Up	" Backup Camera " Guide Person	
Guywires	" Mark Guywires with Flags " Mark Stakes with Cones	
Hanging Equipment	" Pad Edges and Corners " Round Edges and Corners	Hard Hat

Hazard: Desert Exposure Injury

Causes	Mitigations	Personal Protective Equipment
Cold Temperature	" Dress Appropriately " Have Appropriate Camping Equipment	Thick Soled Shoes
Hot Temperature	<u>Clothing</u> Light Weight Light Color Layers	Thick Soled Shoes
Sun Burn	<u>Shade</u> " Quonset Hut " Bunkers	" Wear a Hat " Use Sunscreen
Dehydration	Drink Plenty of Water	
Bites	<u>Avoid</u> " Ants " Black Widows " Scorpions " Rattle Snakes <u>Sleep Off the Ground</u> " Tents " Cots	