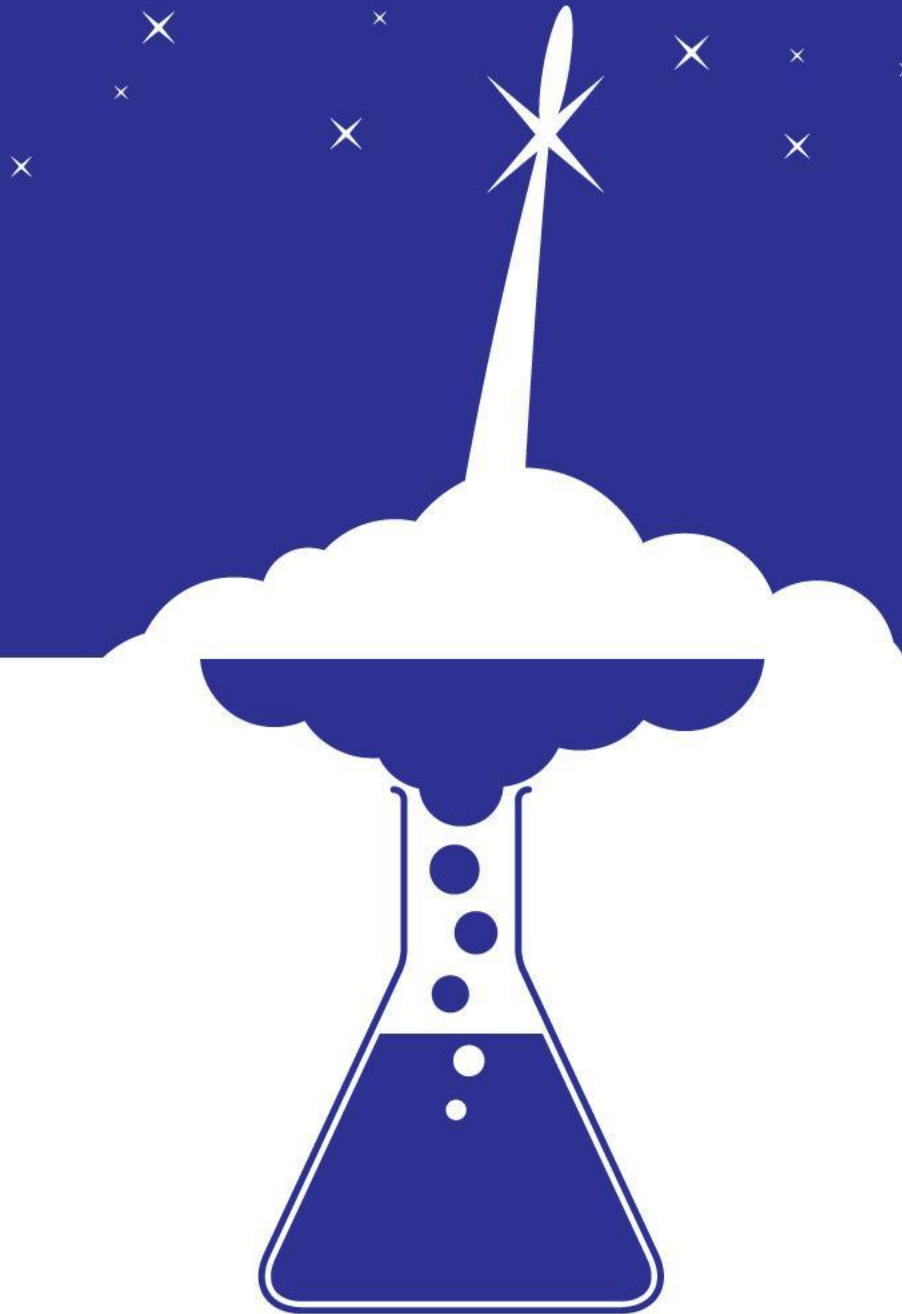


Oxygen Safety

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ACADEMIC-INDUSTRY
LIQUID ROCKET SYMPOSIUM **2023**



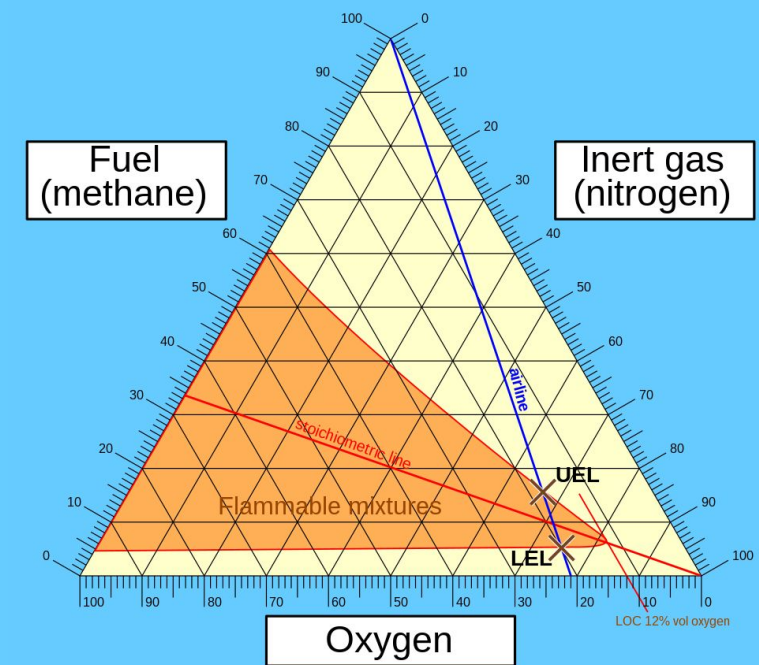
Introduction

- Important References
- Oxygen and Combustion
- Material Compatibility
- Oxygen Rich Environments
- Ventilation
- Oxygen Cleanliness

Important References

- ASTM G88
- ASTM MNL 36
- NASA 1740.15

Oxygen and Combustion



wikiwayman/Power.corrupts 2018/2009 GNU FL

- Once a quantity of flammable fuel-oxygen mixture reaches autoignition temperature, it will ignite
 - Volatile fuels can be lit by a small initial heat source in a runaway reaction
- Oxygen fuels combustion, and pure O₂ is more capable of supporting combustion



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Material Compatibility



- Aluminum and Steel can sometimes ignite
 - Small particles or freshly eroded surfaces
 - Titanium is highly combustible with GOX and LOX
- Stainless steels, copper and nickel alloys, and PTFE are generally acceptable, **but not always.**
- Wood and plastics are also fuels
- Lubricants, Oils, and Grease are combustible, and may be found inside valves and components
 - Use oxygen compatible lubricants
- Kerosene fuels contaminate surfaces
- Natural fibers, though combustible, will not melt to your skin like synthetics

Oxygen and Combustion



- Ignition sources are not limited to a spark, consider:
 - Temperature: Hot gas or materials can transfer thermal energy to a combustible mixture
 - Impact and friction: Both generate heat
 - Static Electricity: Generates sparks that produce heat
 - Compression Heating: Compressing gasses generates heat

$$\cdot \text{Heat} = c_p m \Delta \text{temp}$$

$$\cdot \frac{P_1 V}{T_1} = \frac{P_2 V}{T_2} \text{ (ideal gas)}$$

Oxygen Rich Environments



- LOX creates an oxygen rich environment where it ends up
 - Not just in the motor, but also in fabrics, on surfaces, in the air
 - LOX leaking through valve stems and seals generates GOX
 - Humans and other organic materials
- Concentrated oxygen supports combustion easier
 - Case Study: Apollo 1
- Oxygen and fuel rich volumes can detonate
 - Case Study: Boomie Zoomie B

Ventilation



- Know where to place your ullage vents. Get the gasses away from the rocket and from each other
 - Vent oxygen and fuel and different heights. The wind may carry them horizontally
 - Use standoff tubes to vent gasses outside of the airframe
- Don't trap fuel and oxygen vapors inside partially enclosed volumes
- LOX may leak from valve stems or fittings and generate oxygen gas
 - Will also occur with fuels such as LNG

Oxygen Cleanliness



- Systems can be kept fairly safe for oxygen use if you keep your systems clean:
 - Keep equipment and hardware off dirt
 - Clean all valves, fittings, and tubing
 - Clean fuel or lubricant spills promptly before you forget or track it elsewhere
 - Deburr parts and maintain passivation

- Purge with inert gas to help remove contaminants from oxygen systems and oxygen from fuel systems
- Cleaning procedures will be covered in a later demonstration
- **ALWAYS CAP AND PLUG OR TAPE**