Oxygen Safety

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ACADEMIC-INDUSTRY LIQUID ROCKET SYMPOSIUM **2023**

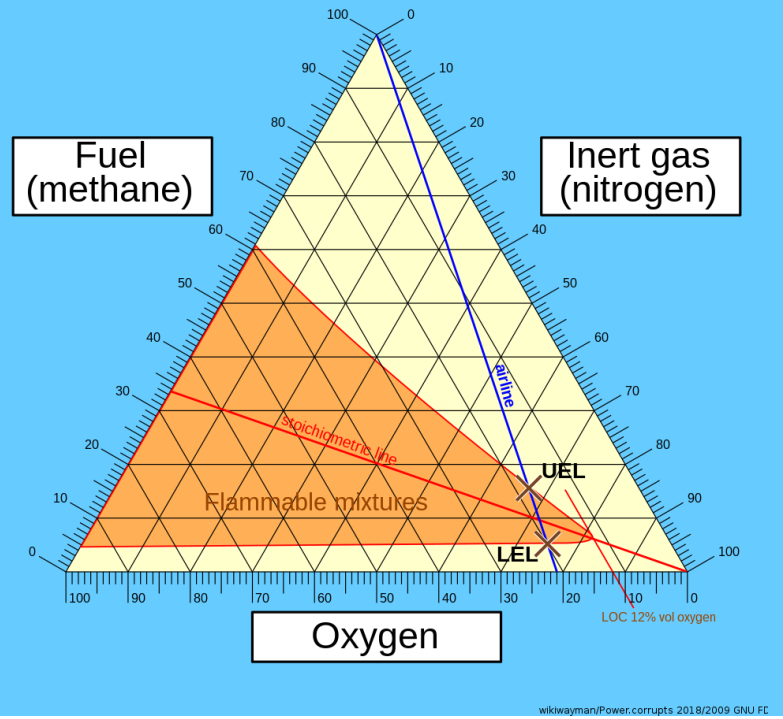
Introduction

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

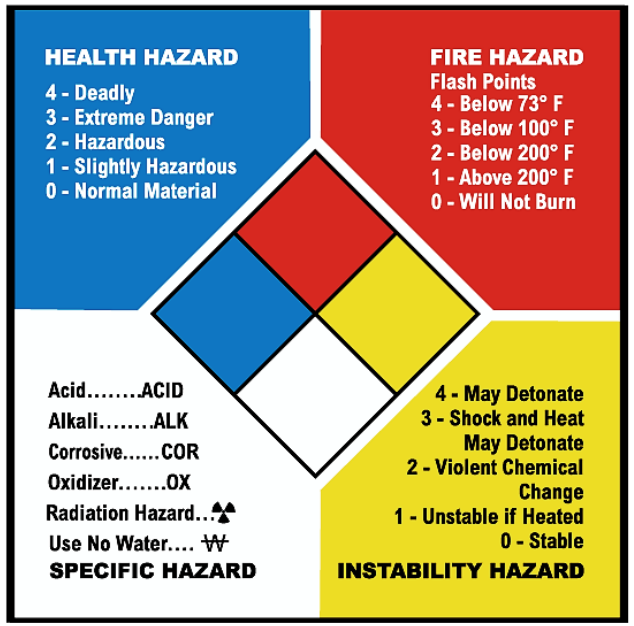
Important References

- ASTM G88
- ASTM MNL 36
- NASA 1740.15

Oxygen and Combustion



- 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

- $Heat = c_p m\, \Delta temp$
- $\frac{P_1 V}{T_1} = \frac{\uparrow P_2 V}{\uparrow T_2}$ (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