Pressure System Safety

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ACADEMIC-INDUSTRY LIQUID ROCKET SYMPOSIUM **2023**

Mark Holthaus' Background

- BS Electrical Engineering, University of Detroit
- MS Electrical Engineering, University of Southern California
- 10-Year RADAR Transmitter Electrical Design, Hughes Aircraft
- 10-Years Space Shuttle Avionics Reliability, Rockwell International

- 23-Years System Safety and Flight Termination, Boeing, Retired
- 25-Years Amateur Liquid Rocketry
- 20-Years Founder, Treasurer, and Pyrotechnic Operator Lead, Friends of Amateur Rocketry

Safety Concerns

- Burst (Shrapnel, Overpressure)
- Jetting
- Venting (Burns, Asphyxiation, Toxicity)
- Rocketing-Kinetic Impact
- Leaking (Fire, Explosion)
- Burns
- Asphyxiation
- Toxicity

Commercial Versus Experimental Tanks

- Commercial tanks
  - ASME rated
    - Designed by a licensed engineer
    - Built by a licensed company
    - Safety factor 4
    - Lot sampled burst testing
  - Used at or below their pressure rating

- Experimental tanks
  - Self-manufactured
    - Not ASME rated
      - Safety factor < 4
      - No lot sampled burst testing
  - Commercial tanks used above their pressure rating

Tank Testing

- Proof Testing
  - Test to a pressure above the maximum expected operating pressure
  - Does not cause deformation
- Burst Testing
  - Test to a pressure where the tank deforms and bursts
- Leak Testing
  - Testing plumbing joints with a soap solution at a pressure ¼ the maximum expected operating pressure (MEOP) to find leaky joints

Tank Pressure Burst Protection

- Overpressure causes a tank to burst
  - Pressure blast
  - Shrapnel
- Causes of overpressure
  - Regulators
    - Fails to lock up at set pressure
  - Locked up cryogenics
    - Warming cryogens builds vapor pressure

- Overpressure protection
  - Use relief device
    - Relief valves
    - Commercial burst disks only
  - Set to below proof pressure
  - Continuous remote pressure monitoring
  - Remote controlled vents to depressurize
  - Maintain safe distance/protective shelter

Other Hazards

- Pressure System Burst due to Damage
  - Fire
  - Scrape
  - Dent
  - Impact
  - Too Many Pressure Cycles
  - Protect from Damage
  - Don’t Use If Damaged

- Inadvertent Activation
  - Tank Pressurization
  - Main Valve Open
  - Ignition
  - Use Single Key Lockout

- Venting Nitrogen, Helium, Methane, Propane are Asphyxiants
  - Use Open Air Operations
- Pressure Venting Injury
  - Hearing
    - Use Ear plugs
  - Eyes
    - Use Safety Glasses

Use Safety Provisions and Be Safe

- Check Pressure System For Damage
- Proof Test Tank
- Don’t Use a Damaged Tank
- Use Relief Devices
- Use Remote Pressure Monitoring
- Use Remote Vent Valves
- Use Single Key Lockout

- Use Open Air Operations
- Use Eye Protection
- Use Hearing Protection
- Keep Personnel Safe Distance