Built-in-place Refuge Alternative Pressure Relief Valve Blast Testing

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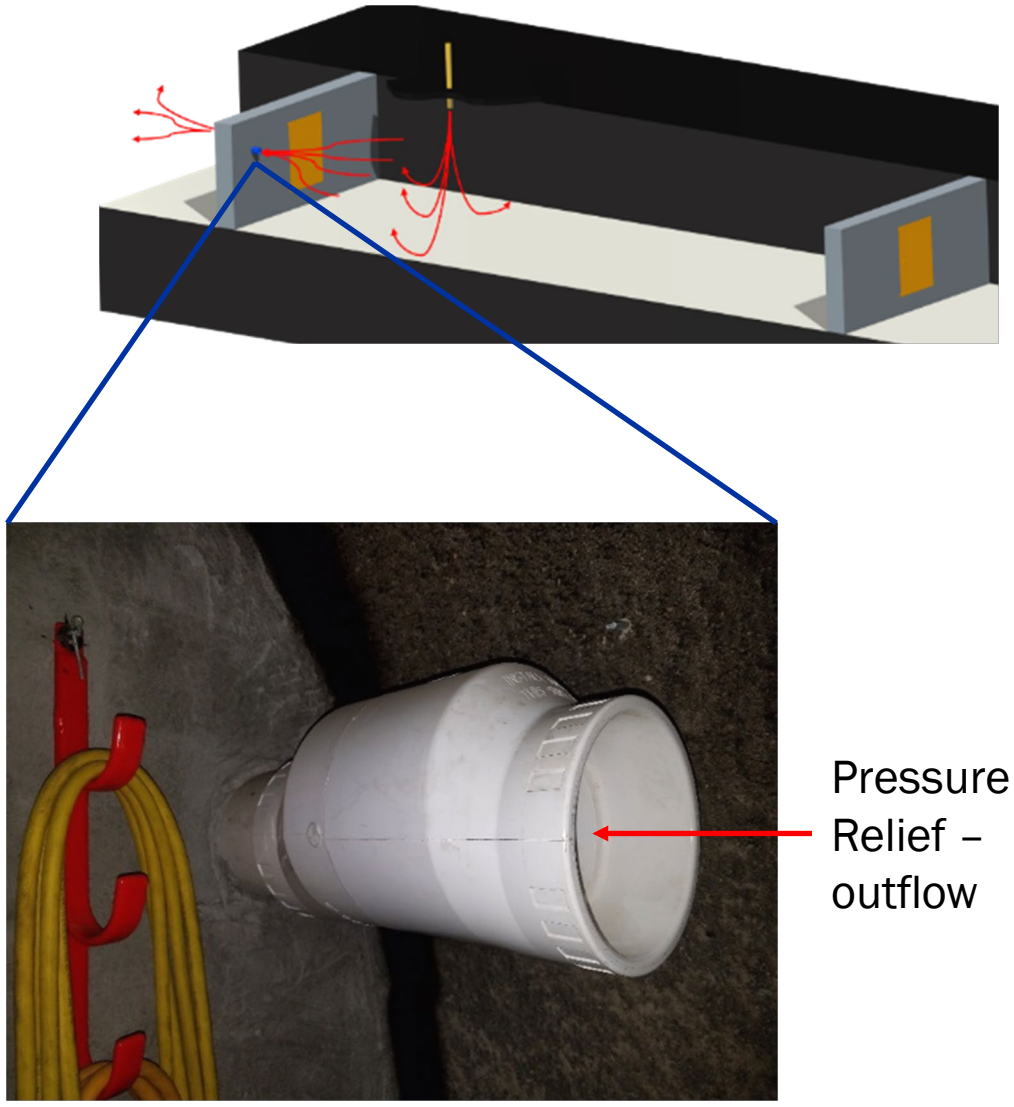
RA Relief Valves

- Relief valves provide essential functions for post-disaster survival
  - Limit positive pressure within the RA
    - Prevent system / component damage
    - Provide occupant safety / comfort
  - Reduce pressure forces that may interfere with door operation during occupant exit / entry
  - Prevent inflow of flash fire, toxic agents, and explosive forces / debris
  - Provide for purging of harmful gases and airborne contaminants



RA Relief Valves

Relief valve design must ensure…

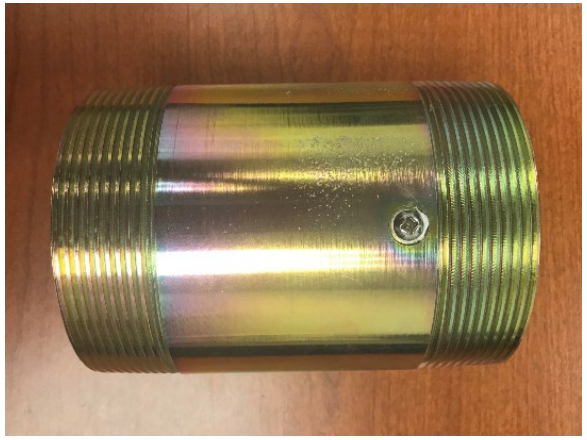
- A minimum flow rate of 12.5 CFM per person in RAs using breathable air supplied by compressed air cylinders, fans, or compressors
- Pressure inside the RA is limited to 0.18 psi, or as specified by the manufacturer, above mine atmospheric pressure
- Functional reliability to withstand flash fire and explosive events

  (15-psi overpressure for 0.2 seconds)
- Fire, harmful gases / contaminants, and explosive forces remain outside the RA

Relief Valves

6-inch PVC swing check valve

4-inch PVC swing check valve



4-inch steel butterfly check valve

4-inch cast iron butterfly check valve

Relief Valves

4-inch RA-specific relief valve

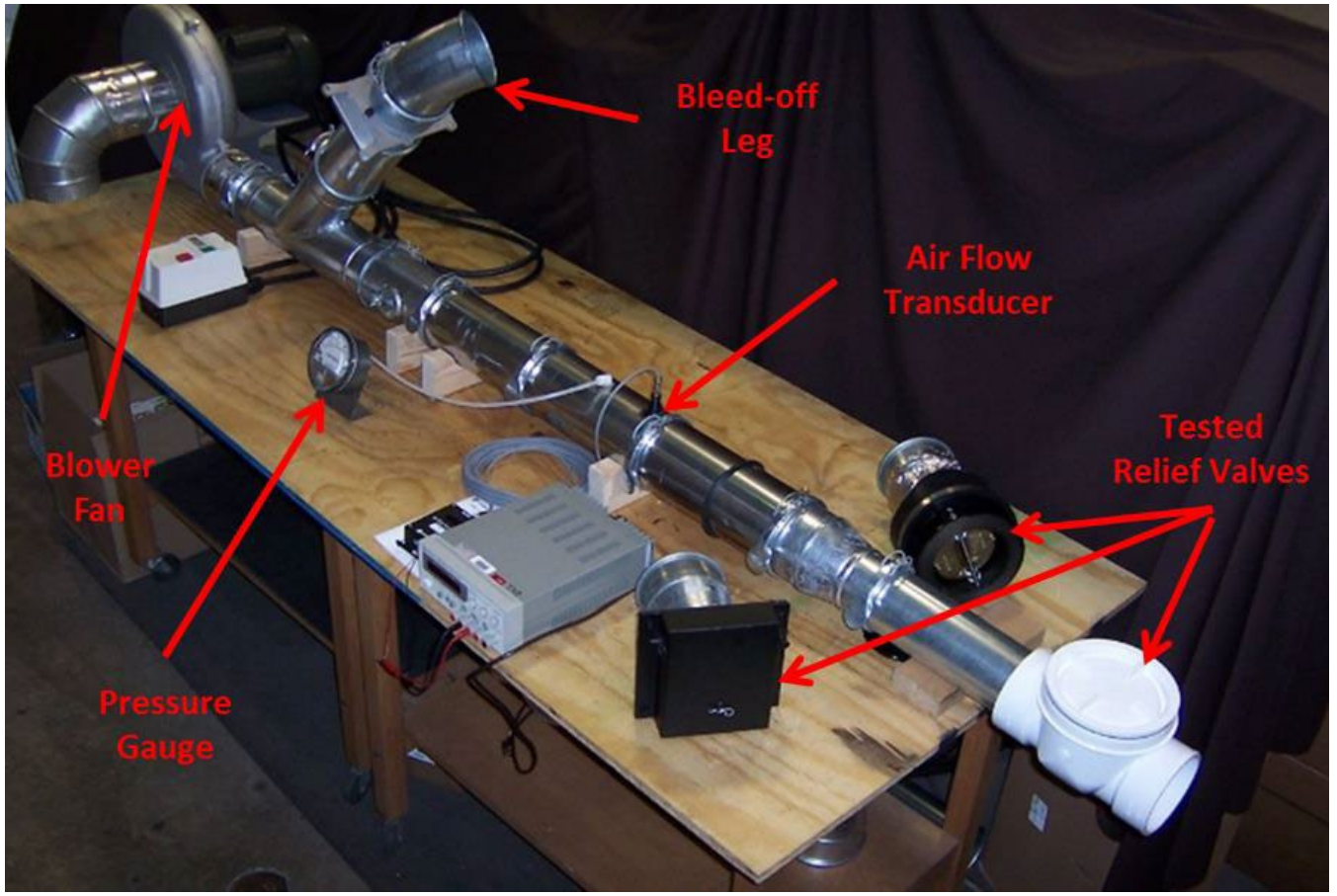
2-inch RA-specific relief valve

4-inch cast iron swing check valve

Pressure Relief / Flow

- NIOSH has researched relief valves for their ability to meet requirements for pressure relief and flow
  - 0.18 psi, above mine atmospheric pressure
  - 12.5 CFM per person
- Various relief valves were tested using different configurations and modifications
- Relief valve concepts can meet requirements for pressure relief and flow in stock configuration or with modification

Relief Valve Pressure / Flow Test Stand

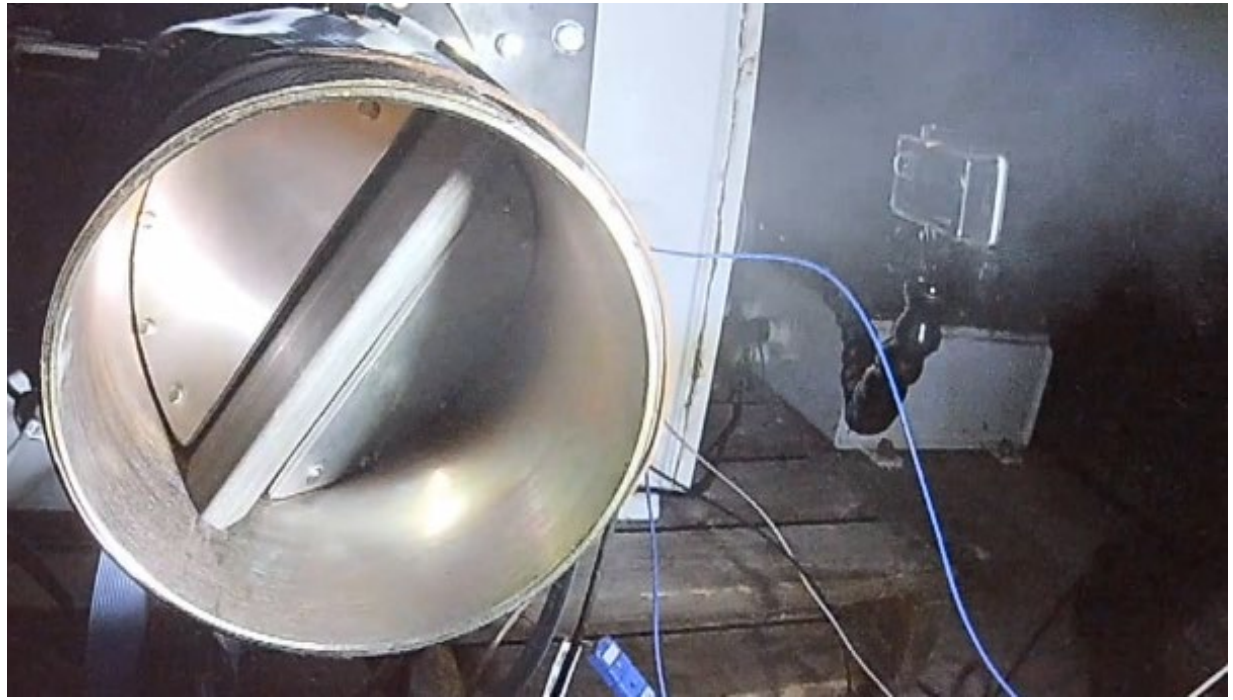


Blast Survivability

- NIOSH has researched relief valves for their ability to survive an explosion
  (15-psi overpressure for 0.8 seconds)

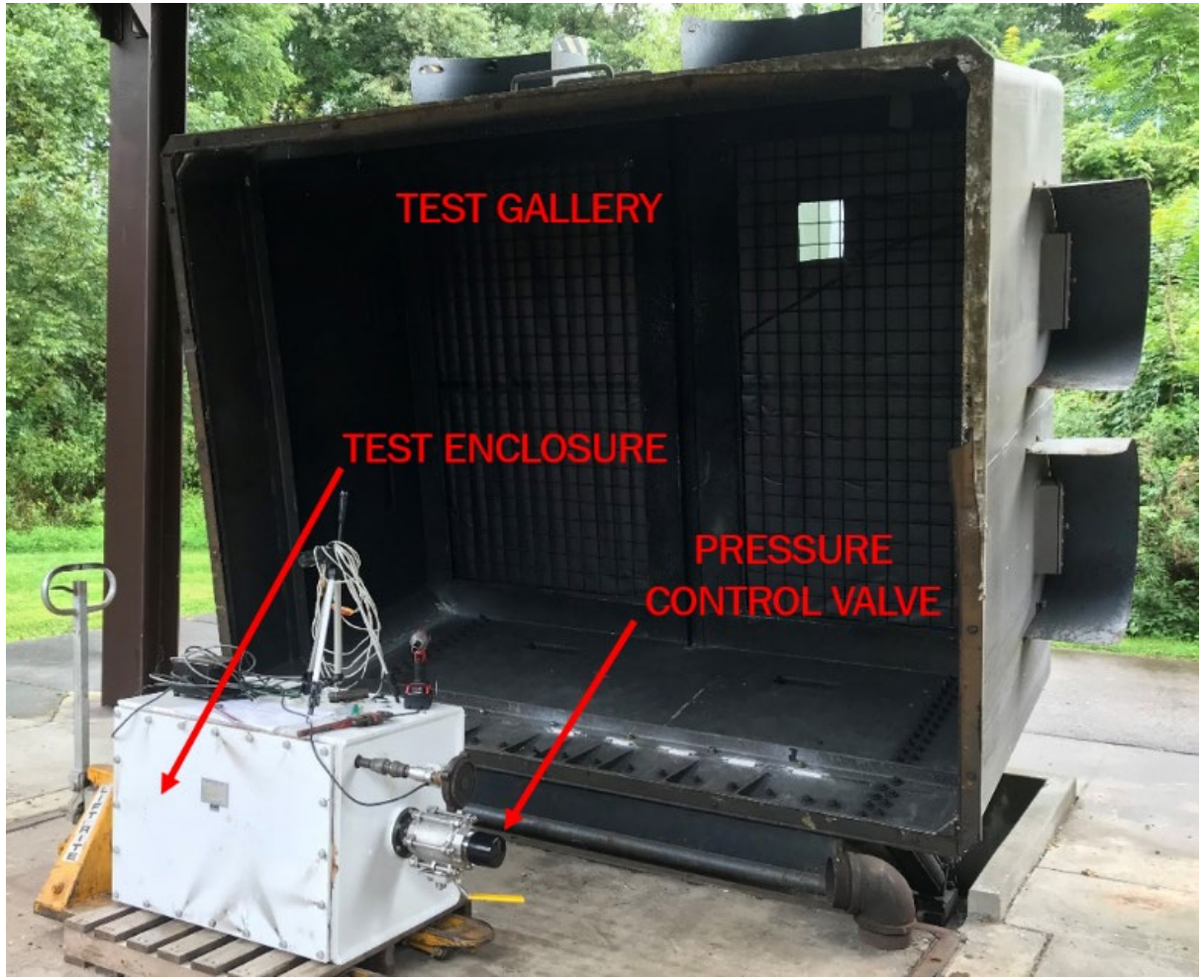
- Relief valves were subjected to a simulated blast

- Pre- and post- performance metrics were compared
  - Flow / Pressure
  - Leakage

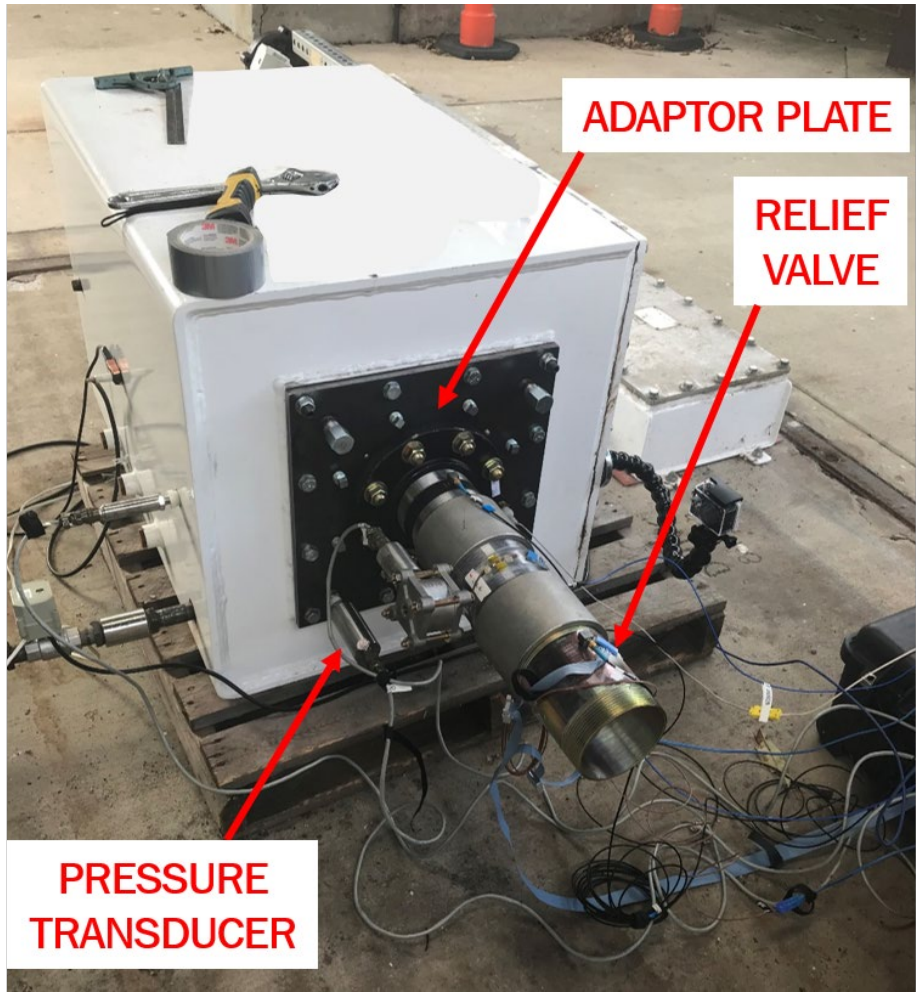


Blast Survivability

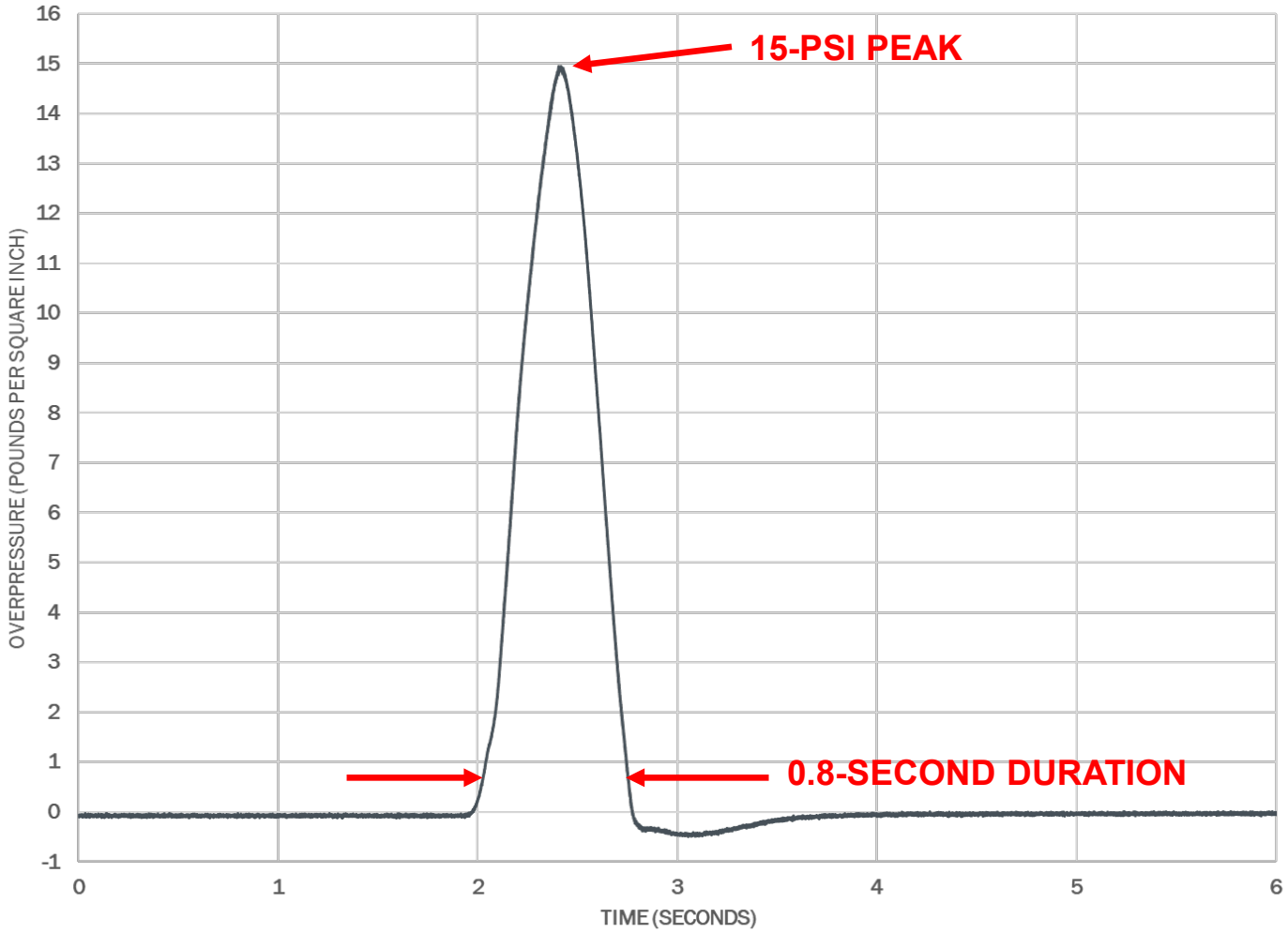
A modified enclosure and pressure control valve were used to simulate a blast



Blast Survivability

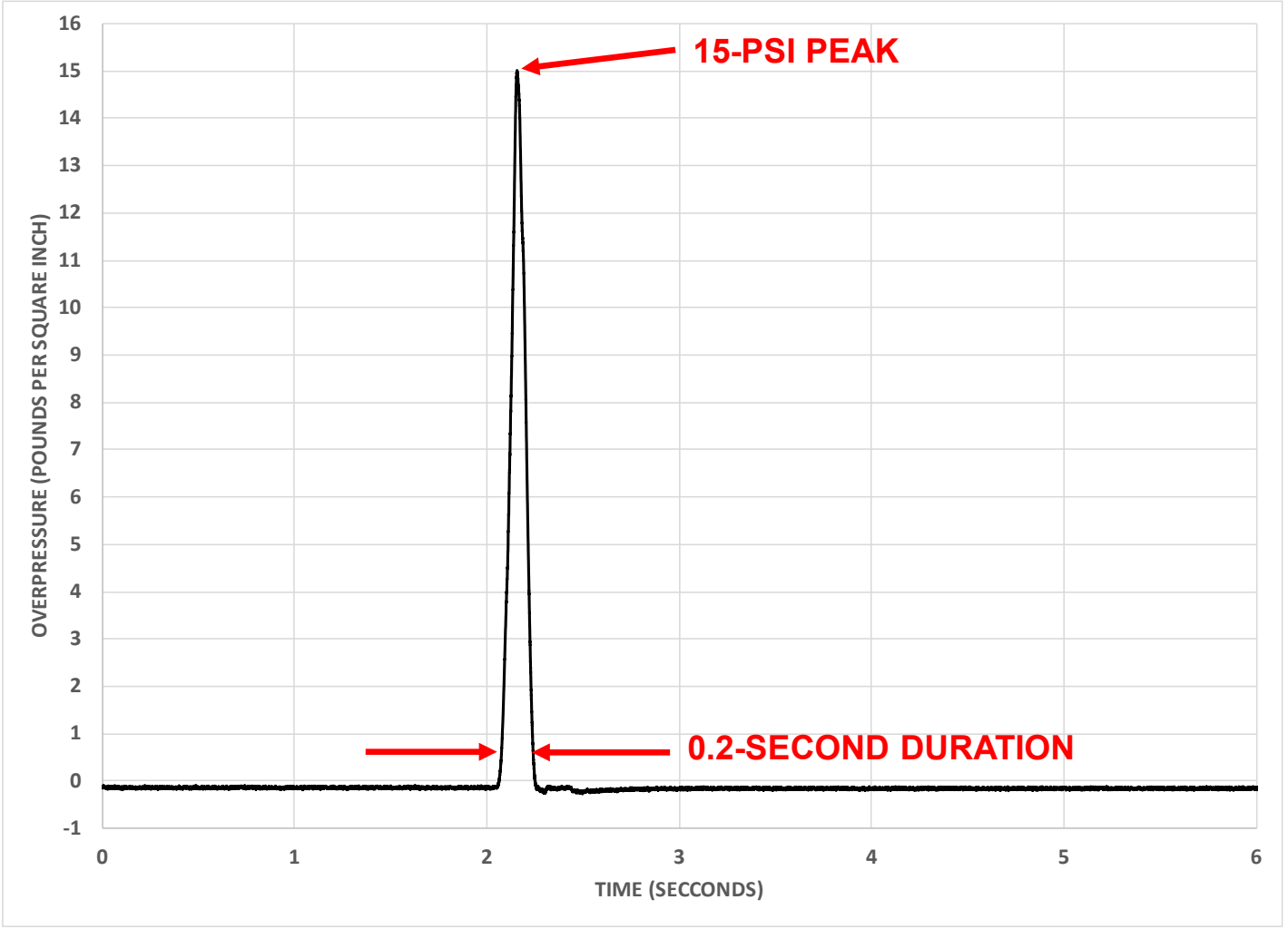


Large Enclosure



7.3% methane

Blast Survivability



Small Enclosure

9.6% methane

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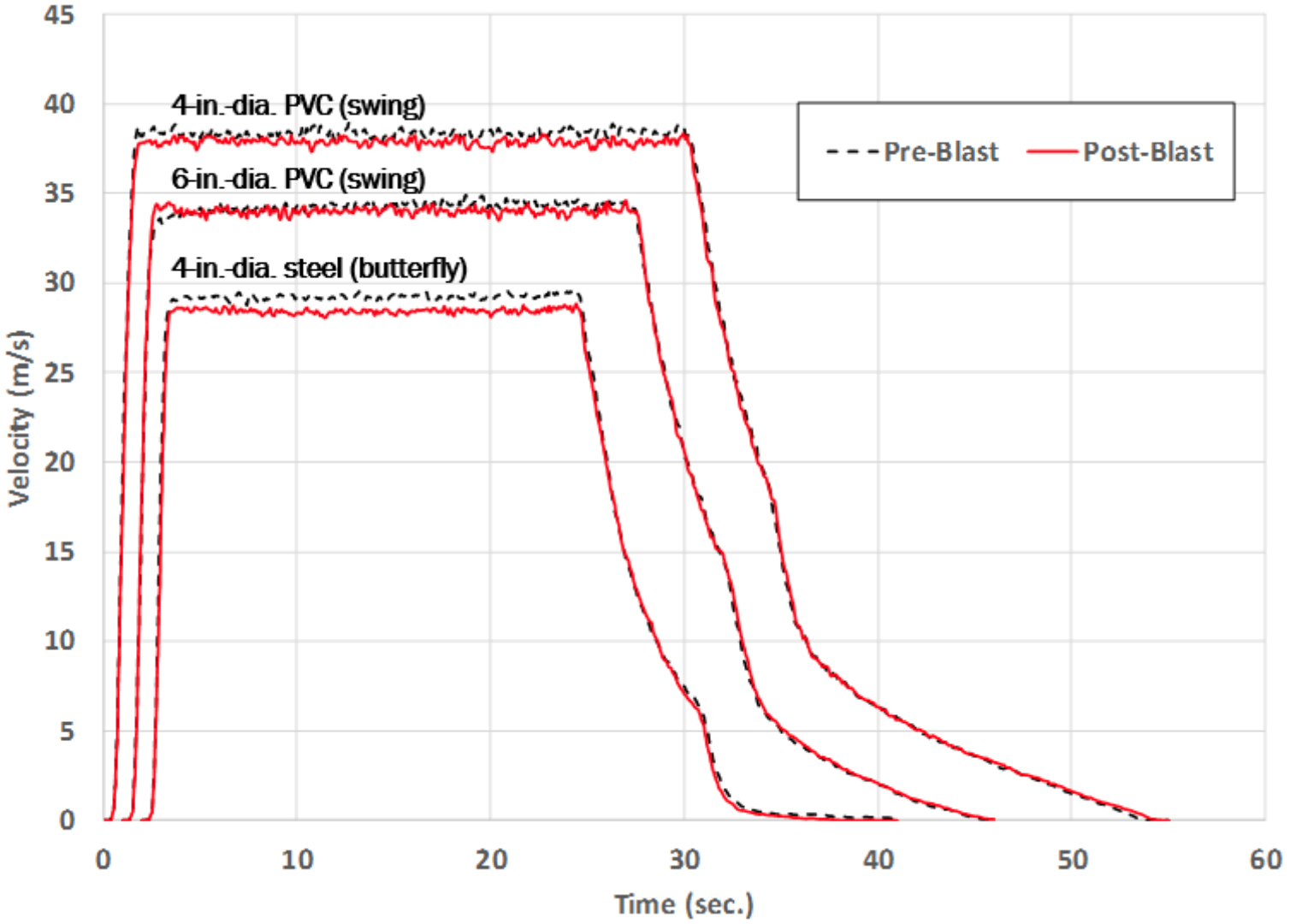
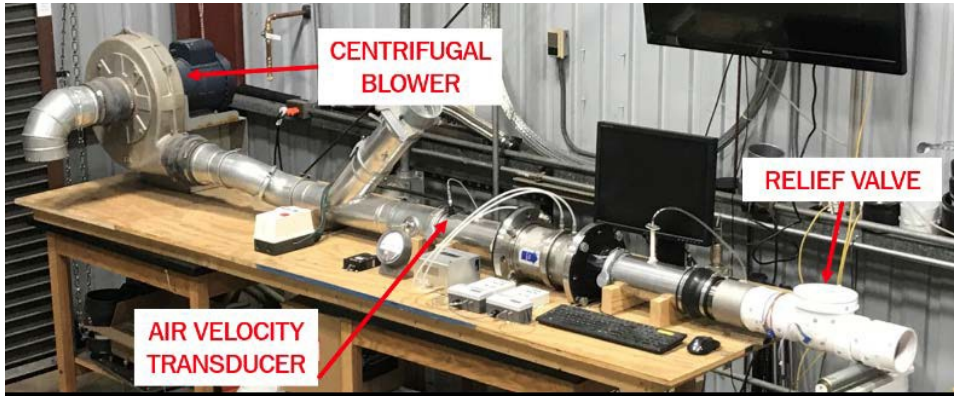
Blast Survivability

- Seven relief valves were subjected to the large enclosure 7.3% methane test
  - Overpressures 12.7-21.4 psi
  - Durations 0.75-0.89 seconds
- No catastrophic failures
- All seven relief valves appeared to be intact upon visual inspection
- Video revealed leakage from the 4-inch steel butterfly check valve

Blast Survivability

Pre- and post-blast velocity profiles were compared to check performance



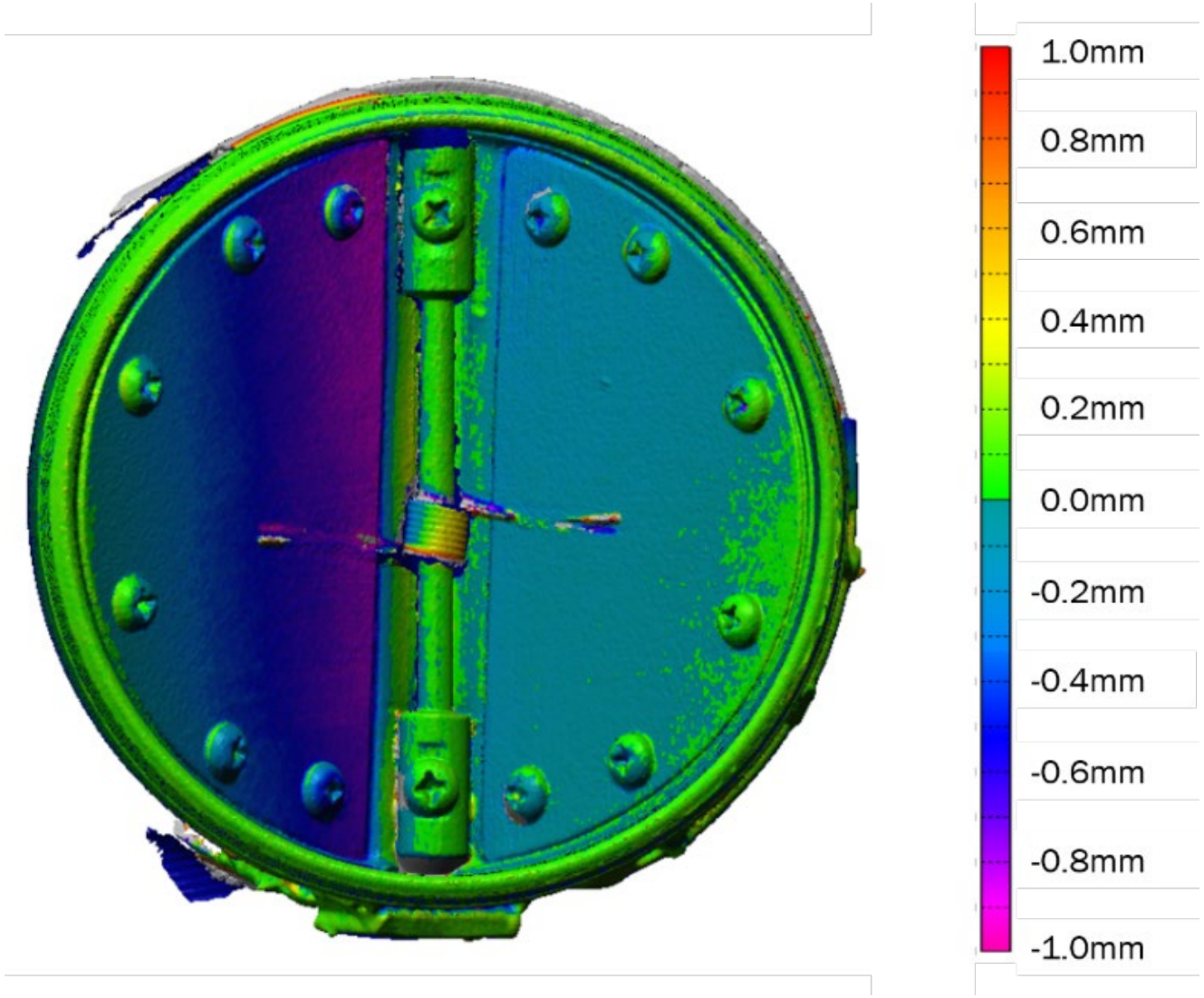


- All seven valves <u>retained normal performance</u>
- <u>Minor changes</u> were observed
  - Possibly due to blast exposure
  - Also include performance test repeatability

    i.e. variation of ambient conditions and valve installation

Pre- and post-blast surface scans were compared to screen for changes in the valve flap

- Limitations
  - Accessibility
    e.g. blocked surfaces
  - Alignment
    e.g. repositioning
- Minor visible changes
- No critical physical damage
  e.g. bending or breakage



Summary / Conclusions

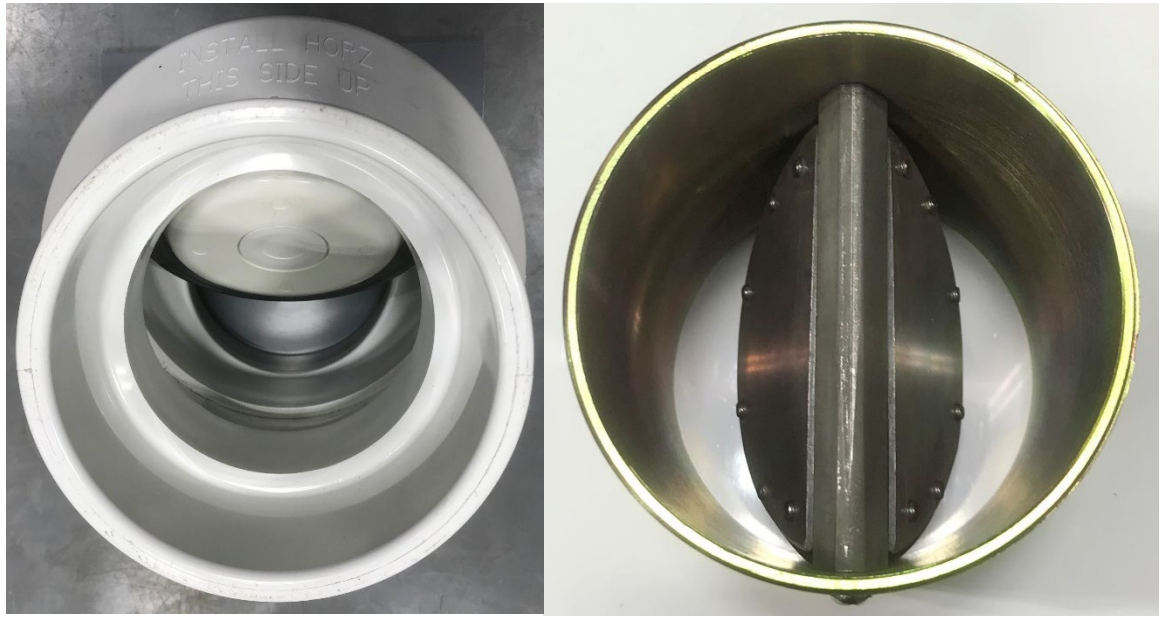
- **Seven relief valves were tested** using 15-psi, 0.8-second overpressure waveforms to assess blast survivability
  - **All survived** maintaining normal performance
  - **No critical deformation** occurred
  - **Some leakage was observed** with one valve during the testing

- Relief valves should be tested using **higher pressures** and **shorter durations** (e.g., the MSHA-specified duration of 0.2 seconds)

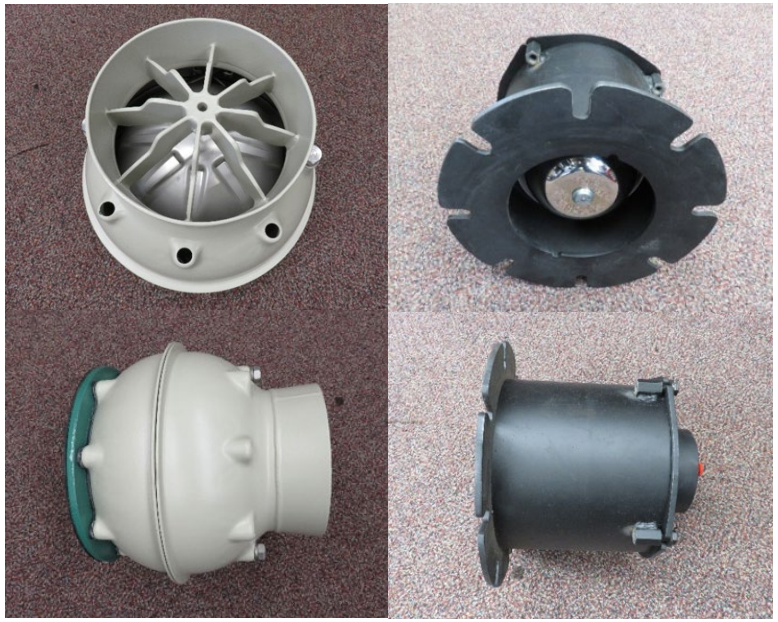
Summary / Conclusions

- Relief valves should also be tested in the **open position**, as when flowing
- **Blast valves** should be considered as a supplemental protection to relief valves

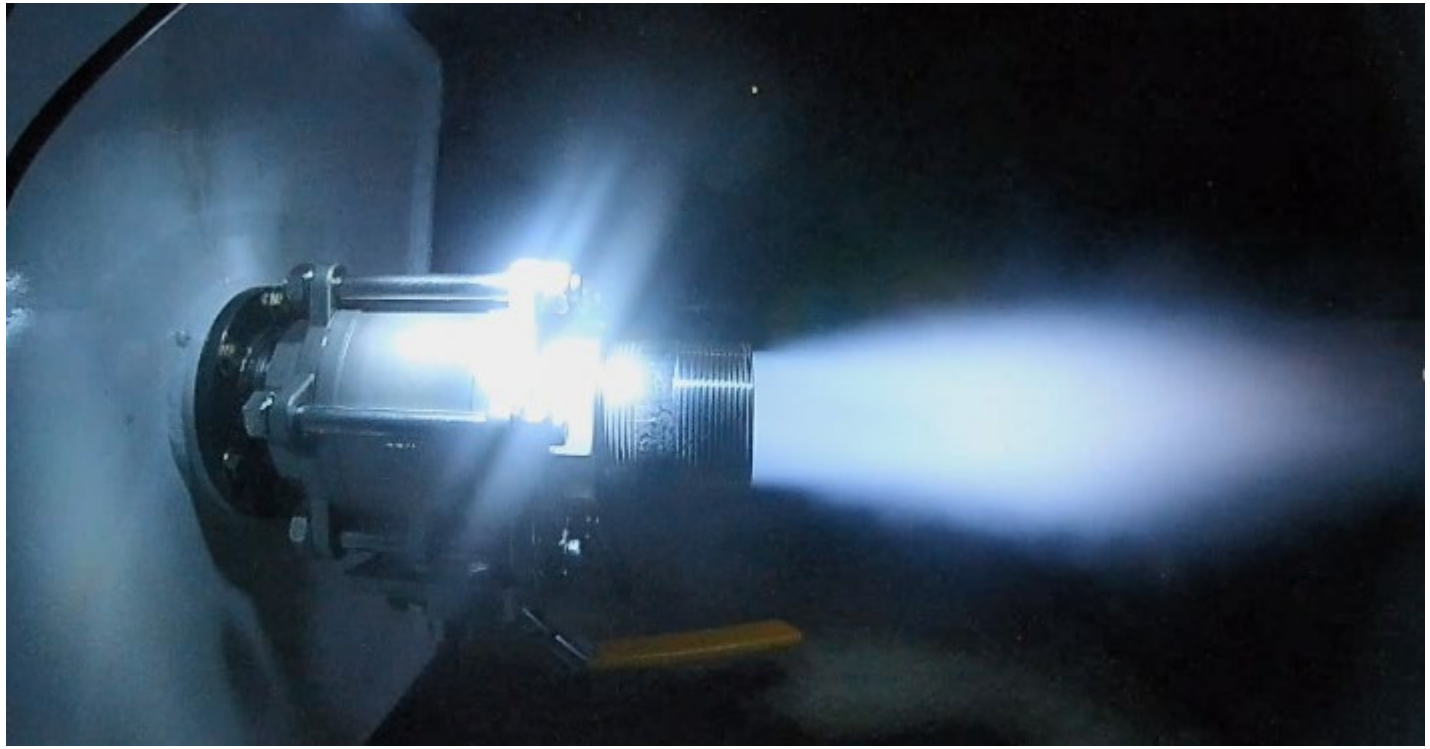
Relief Valves – Open Position



Blast Valves



Thank you!



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