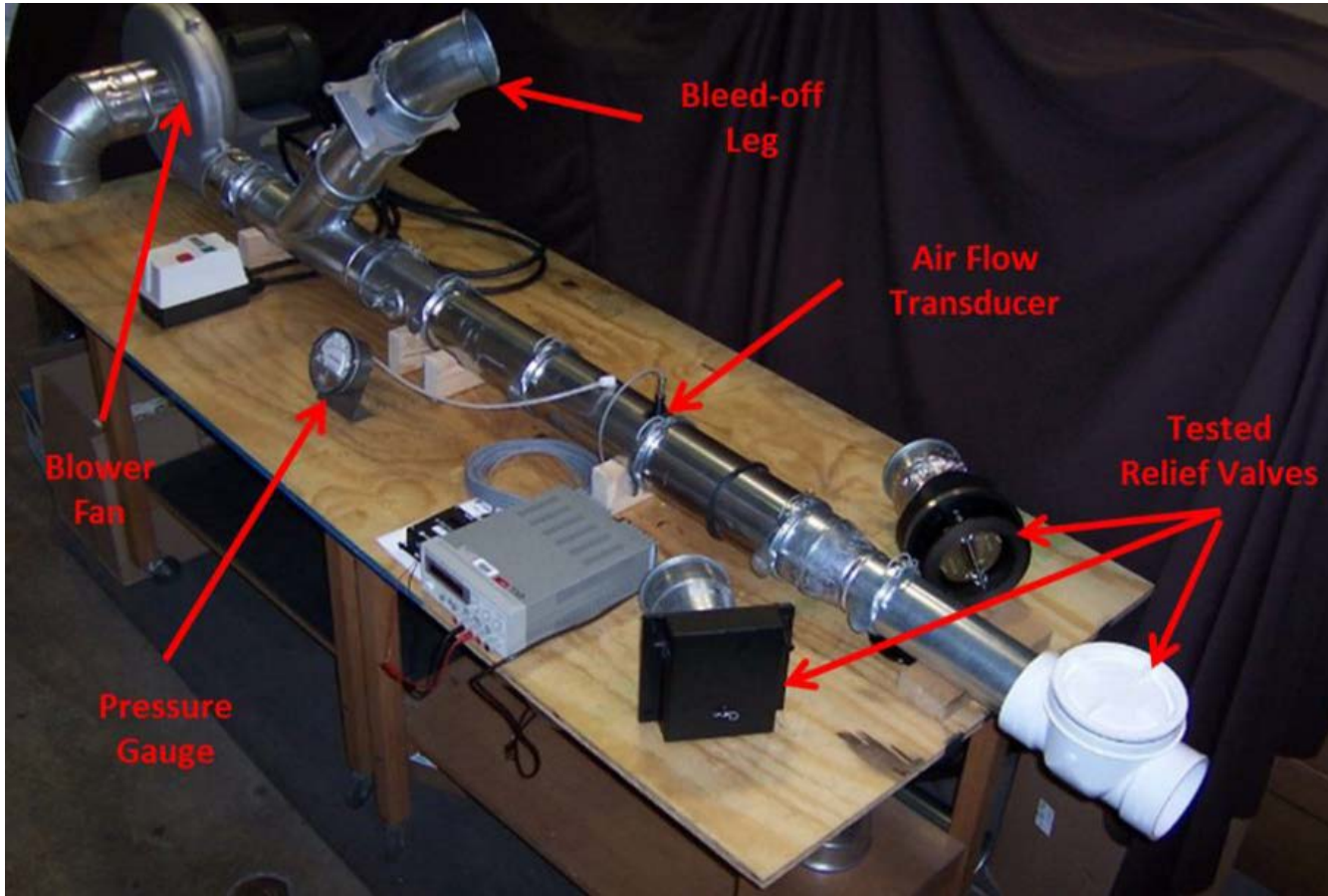


Relief Valve Research for Refuge Alternatives

Relief Valve Pressure / Flow Test Stand



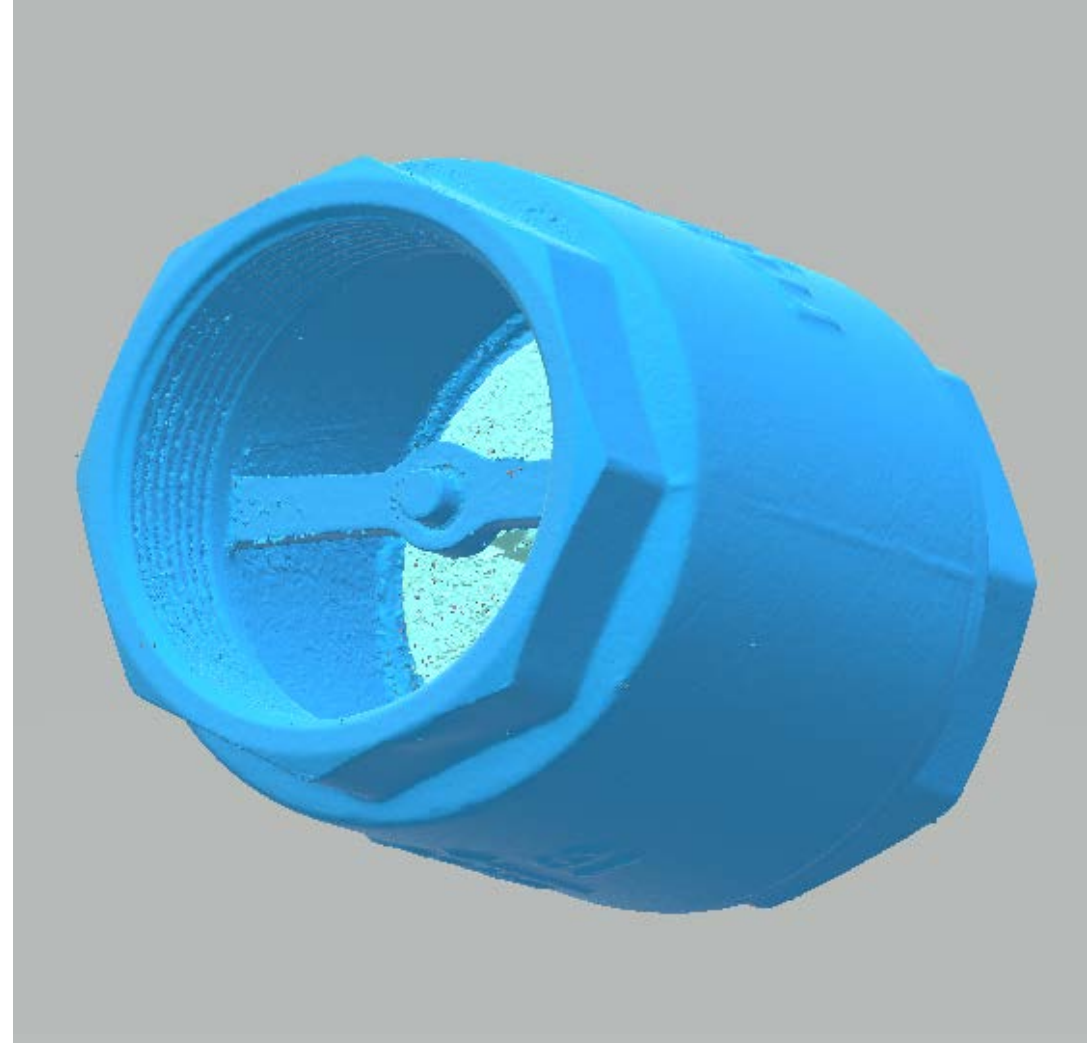
NIOSH research concluded that

- Relief valve concepts can meet regulatory specifications for pressure relief and flow
 - 0.18 psi above mine atmospheric pressure
 - 12.5 CFM per person
- Additional testing is needed to assess the survivability of relief valves subjected to blast conditions (15 psi overpressure for 0.2 seconds)
- Blast valves may be needed to supplement and protect relief valves

Relief Valve Research

- Objectives
 - Assess the ability of relief valves to survive an explosion
 - Determine design factors critical to their reliability
 - Investigate blast valves as a supplemental protection
- Assessment Plan
 - Subject relief valves to a simulated blast
 - Evaluate pre- and post-test performance metrics (flow, pressure, and leakage)
 - Compare pre- and post-test 3D surface scans

Pre-test 3D Relief Valve Scan



Valve Types

Check Valves

- RA applications
- Normally closed
- Single-direction flow
- Open at pressure threshold



Blast Valves

- Bomb shelters
- Normally open
- Bi-directional flow
- Close at pressure threshold



Test Valves



4-inch manufactured
RA relief valve



2-inch manufactured
RA relief valve



4-inch steel butterfly
check valve



Test Valves



6-inch PVC swing
check valve

4-inch PVC swing
check valve

4-inch cast iron swing
check valve

4-inch cast iron butterfly
check valve

Test Valves



4-inch blast valve



9-inch blast valve

Test Facility

- The MSHA Approval and Certification Center (A&CC) has a facility used to test explosion-proof components for approval
- This facility is equipped with a test gallery capable of generating and igniting methane-air mixtures within an enclosure

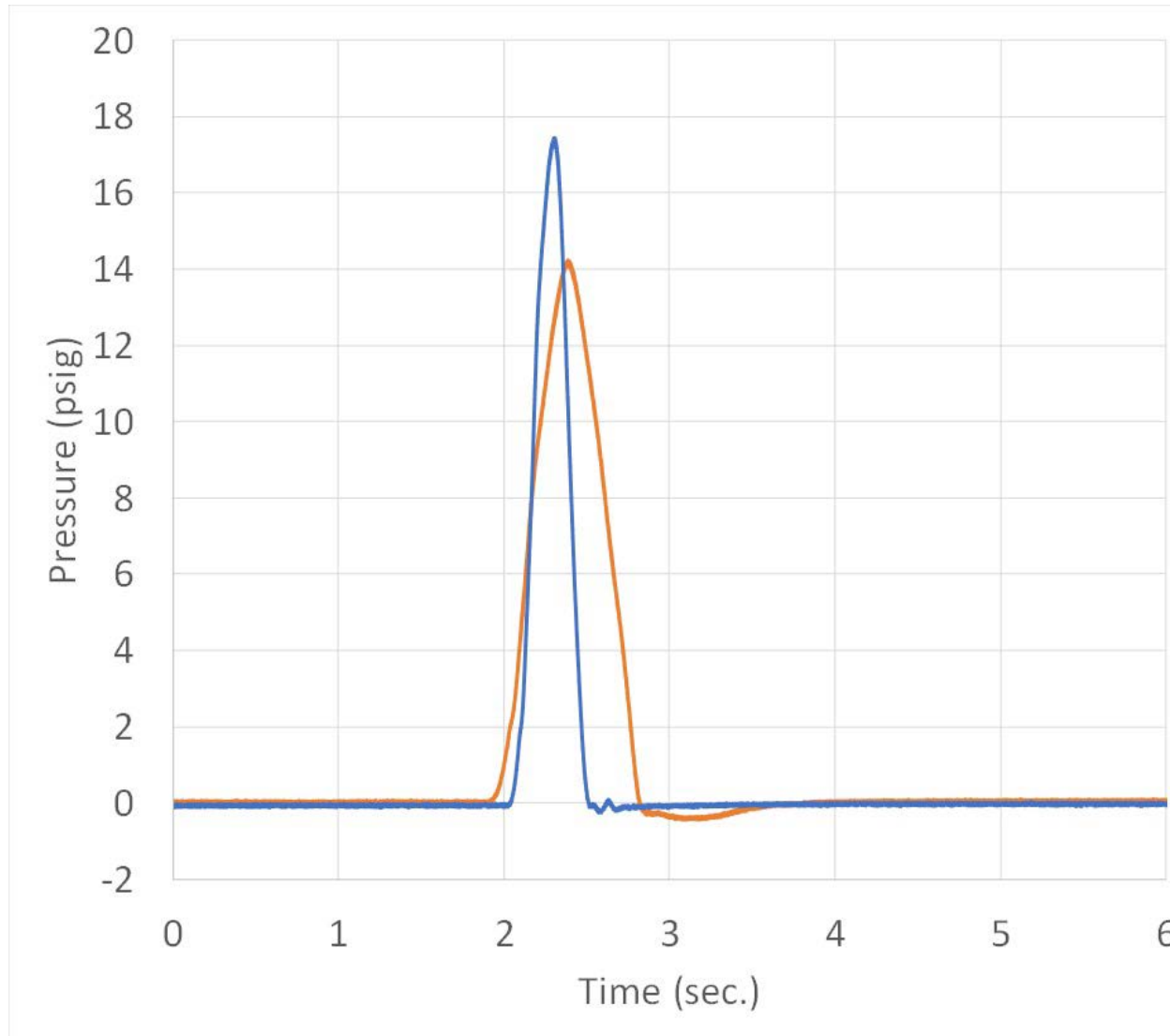


Overpressure Control

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



Overpressure Waveforms



- 7.3% methane by volume
 - 14.5 psig (+/- 2 psig)
 - ~0.9-second duration
- 9.6% methane by volume
 - 17.5 psig (+/- 3 psig)
 - ~0.5-second duration

Relief Valve Testing

- Relief valves were attached to the explosion-proof box using a custom adaptor plate and standard pipe fittings
- Various transducers were employed to record strain, temperature, pressure, and acceleration
- Video monitoring was conducted to capture and observe points of leakage, surface deformation, and failure



4-inch Cast Iron Swing Check Valve - 7.3% Methane Test

NIOSH Valve 4 shot 2
10-31-2018
Real Time

4-inch Steel Butterfly Check Valve - 7.3% Methane Test

NIOSH Valve 2
10-30-2018
Real Time

Results and Conclusions

- Seven relief valves were subjected to the 7.3% methane test
- Overpressures ranged from 12.7-21.4 psig and ~0.9 seconds in duration
- No catastrophic failures occurred in the first round of testing
- All seven relief valves appeared to be intact upon visual inspection
- Video revealed leakage from the 4-inch steel butterfly check valve



Future Work

- Pre- and post-test metrics will be compared to
 - Quantify changes in valve performance (flow, pressure, and leakage)
 - Measure any permanent changes in physical shape (3D scans)
- Pressure, temperature, strain, and acceleration data will be used for engineering analysis
- Finite element (FE) modeling will be performed and validated using test data
- Blast valves will be assessed as a supplemental protection to relief valves
- Enclosure volume will be investigated for achieving faster durations, 0.1 seconds and less
- In-test valve leakage should be further investigated in order to quantify the potential for contamination ingress
- Valves should be tested in the open position, as when flowing

Questions?

Thank you!

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