Pressure Relief Device Investigation Testing – Lessons Learned

2018 General Meeting Presentation

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The National Board of Boiler and Pressure Vessel Inspectors

Overview

- National Board Investigation Testing Process
- Summary of Results from Investigation Testing
- Pressure Equipment Lessons Learned

Investigation Testing Process

Purpose of Testing

- Assist National Board members, Inspection Agencies and others in determining performance of pressure relief devices.
  - Accidents
  - Potential deficiency with a pressure relief device

Side “benefit”: Issues found during testing can provide guidance to address or avoid the same problems elsewhere.

Investigation Testing Process

Cont.

We are not acting as a forensic engineering laboratory.

- Test results are presented based upon applicable standards and anticipated performance.
- Detailed physical inspection to outline potential issues of concern

NB information is just part of a complete investigation.

Investigation Testing Process

Cont.

Based upon ASTM Standard E860

Standard Practice for Examining and Preparing Items That Are or May Become Involved in Criminal or Civil Litigation

Basic Principles:

1. Document the condition of the item prior to any testing or work on the item.
   A. Has the item changed since the incident?

2. If the tests may change the condition of the item being tested, notify all affected parties and have those parties participate and record the tests.

Investigation Testing Process

Cont.

3. Perform nondestructive tests prior to destructive tests.
4. Use exemplars instead of the subject item where applicable (used for rupture disk testing).
5. Document the methods used and the results obtained.
6. Preserve and label each item to protect and maintain its identity.

Investigation Testing Process

Cont.

Practical concerns for pressure relief devices

1. Do not use the lifting lever to try and actuate a pressure relief valve.
2. Identify, document and preserve inlet and discharge piping.
3. Prevent unnecessary handling of the device, and package it well after the initial examination at the site.

Investigation Testing Process

Obtain NB senior management approval.

Notify affected parties.

- Owner or their representative
- Device manufacturer
- Valve Assembler or Repair Company where applicable
- Jurisdiction
- Inspection Agency

Establish test date.

Investigation Testing Process

Develop Special Test Procedure (STP)

- STP is based upon standard National Board certification procedures adapted for the specific item to be tested, and how it may have been used.
- Adds additional detailed inspection, pictures, etc.
- Emphasizes recording of the first opening
  - Certification testing uses stabilized average set
- Capacity tests done at overpressure permitted for the application and the pressure vessel MAWP
- STP is reviewed with observers prior to test.

Investigation Testing Process

Receive test object.

- Maintain chain of custody if required.
- Perform detailed physical inspection.
- Document using checklist and pictures.

Conduct test – *Personnel safety comes first.*

- Inspect after test for any changes to the item.
- Prepare and distribute test report.

It may be surprising what can actually be tested

Figure C1

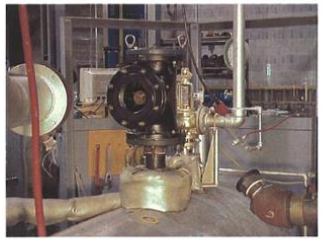


Figure C2

Figure C3

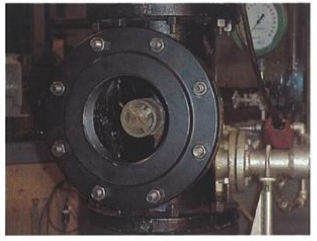
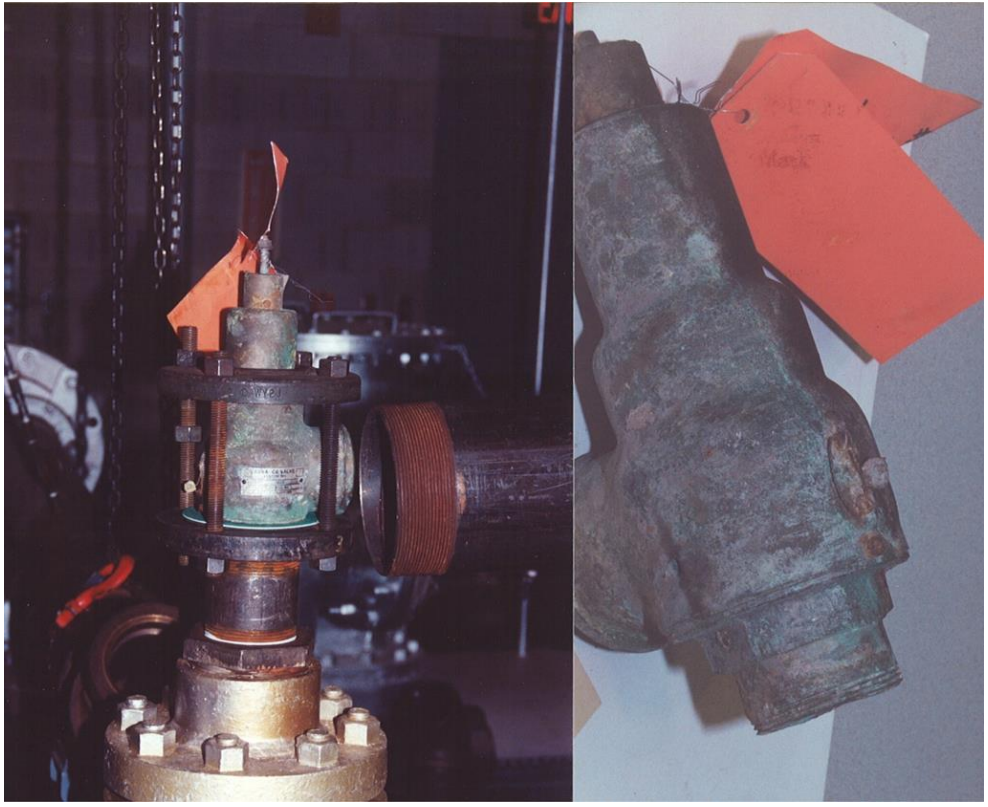


Figure C4

Figure C5

Figure C6

Test rig: Valve with broken inlet



Valve tested with supplied elbows

Tests besides Pressure Relief Devices

- Excess flow valve
- Warning whistle
- Pressure gages
- Pressure switch
- Steam injectors
- Sound level of safety valve discharge

Test Attributes

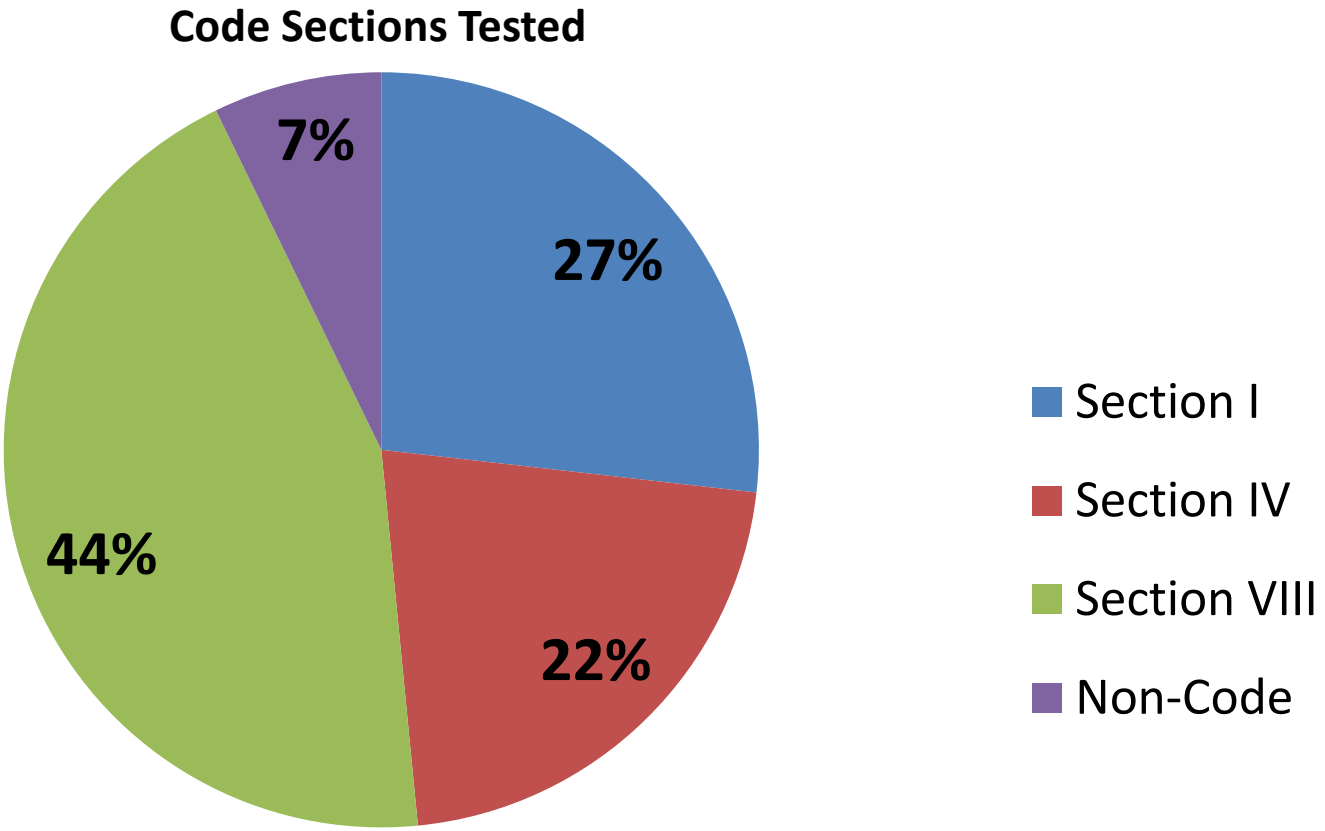
1. Initial leak pressure
2. Initial set pressure measurement (and reclose pressure)
    - Complete set pressure sequence may be done.
3. Perform capacity test (set pressure before and reclose after capacity measurement recorded).
    - Lift sometimes used in place of capacity test for safety concerns
4. Additional tests as applicable
    - Examples: Test with additional supplied piping or on different fluid

Summary of Results

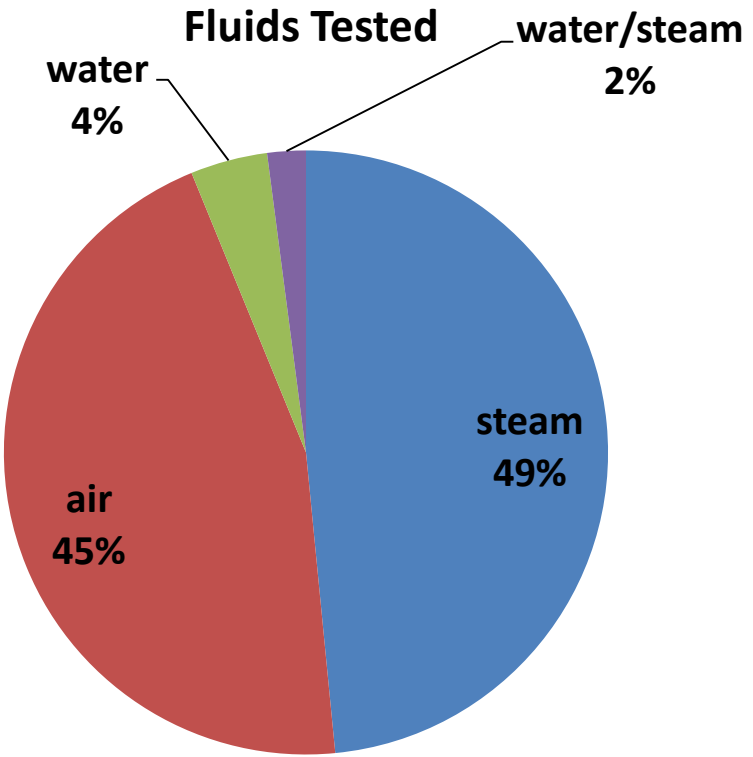
Total number of tests reviewed: 97

Tests records from 1991 to this year

Summary of Results

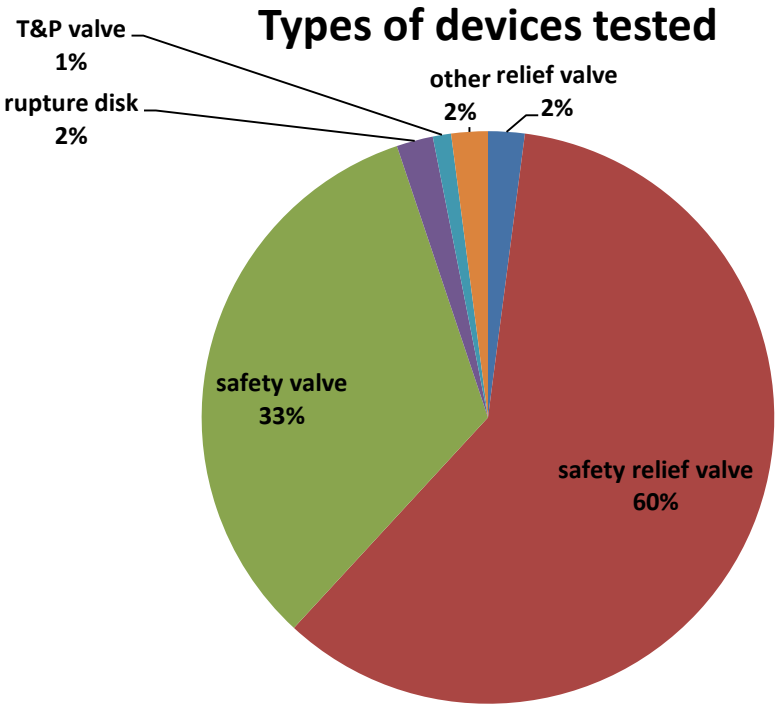


Summary of Results



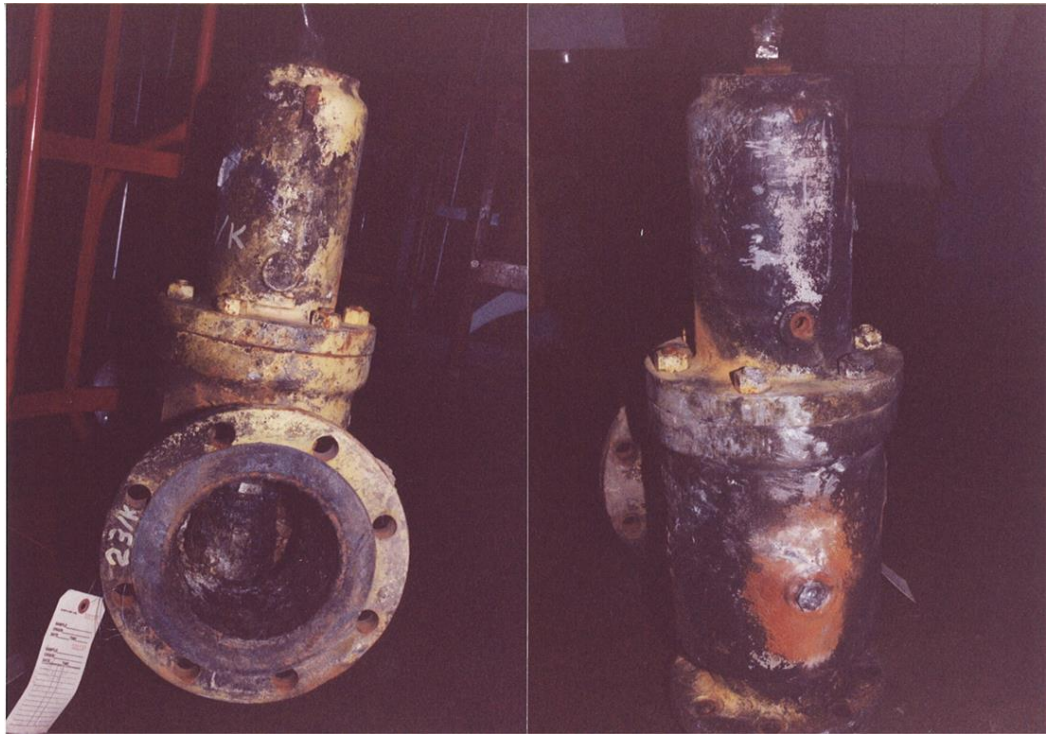
Summary of Results

Cont.



Lesson Learned 1

Everything is important (not just test data)



Lesson Learned 2

Proper application of pressure relief devices is important.

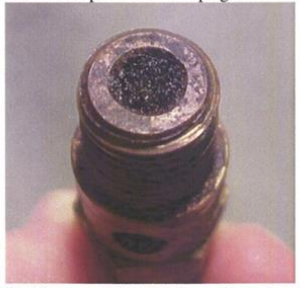
- Ammonia release, gas valve installed on liquid line
- Asphyxiation accident, valve with no outlet connection used on nitrogen system in enclosed area

Lesson Learned 3

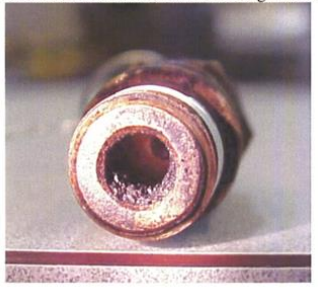
Periodic inspection and maintenance is important.

- In place testing is a simple inspection method (If you do it…)

B. On receipt inlet of 125 psig valve is clogged with debris



C. After test debris is blown through valve, rubber seat of valve is missing.



Lesson Learned 3

Set at 200, 1st pop at 234 psi

Would inspection have flagged this pressure relief valve?

Lesson Learned 3

Random Inspection Notes

- Duplicate plate by non VR company
- Valve built in 1967 (tested in 2011 after expansion tank explosion – still worked!)
- Set pressure seal missing
- Manufacturer’s seal broken
- Seal did not match manufacturer’s name.
- Valve was 30 years old.
- Masking tape on bonnet vent caused chatter/ removed and tested acceptably.

Lesson Learned 3

Random Inspection Notes

- 1.5 inch valve on 1.25 connection, flowed 96% of required capacity, met rated capacity on correct inlet pipe.
- 150 psi set valve did not open by 201 psi, valve was 19 years old, corroded, and lift lever did not open valve.
- Section I valve was installed on a 5.5 foot long inlet pipe.

Lesson Learned 4

Correct in-place testing procedures are important

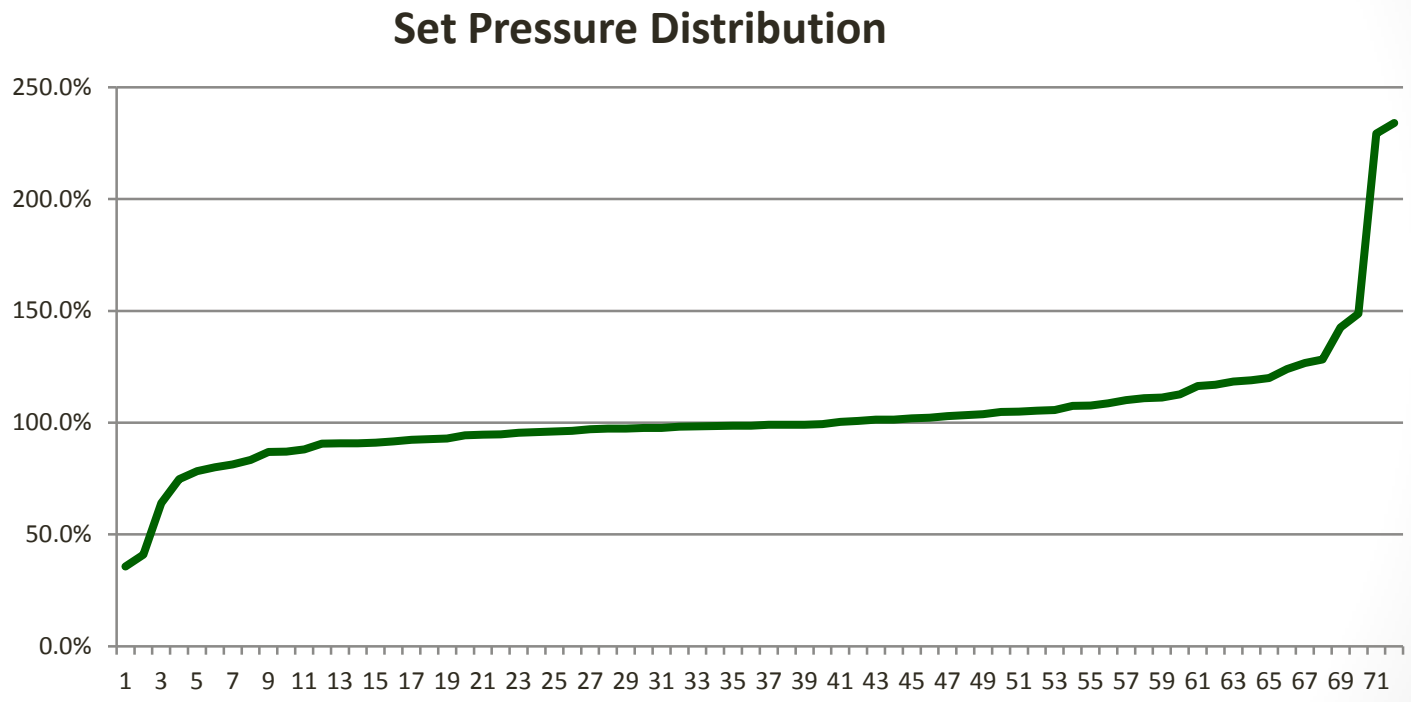
- Lift lever performance checked at 75% of set on 6 valves, all were functional.
- Conclusion: Valves were being tested without pressure under them.

Lesson Learned 5

A majority of accidents did not happen because "The safety valve did not work"!

(The safety valve "caused" the vessel to explode)

For 72 Devices that Opened:



Some Did Not Open

Leak only: 4

Stuck: 7

Plugged up: 1

Leaked low: 4

N/A: 4

No test: 5

Lesson Learned 5

- 59% of the objects tested opened at 110% of set pressure or less
- 73% opened at 1.5 times the set pressure or less
  - (13% opened between 1.1 and 1.5 times the set)
- 2 opened above 1.5 x set pressure and 12 were stuck, plugged up or leaking only (14%)

Lesson Learned 5

- 2 autoclave door accidents, valves tested and confirmed that overpressure did not occur.
- Boiler tube failure, valves tested and confirmed that overpressure did not occur.

Lesson Learned 6

Most accidents have multiple causes

- Did an overpressure condition occur? If so, what what *caused* the overpressure condition?
- Did a faulty pressure relief device fail to alleviate that condition?
- Were there other defects or issues that adversely affected the pressure containing integrity?

Conclusion

Pressure relief device investigation testing can be an important part of understanding why an accident occurred.

Investigation test data and the lessons learned can hopefully alleviate similar problems in the future.

Thank You

The National Board remains available to perform investigation tests when necessary.