Pressure Test Objectives and Acceptance Criteria

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RCP Inc.
Hello!

• RCP
  • Engineering Consulting Firm in Houston, TX

• Director of Integrity Services
  • ILI & Pressure Testing Services
  • Previously: Managed ILI for 3,000 miles of Natural Gas Transmission
What’s a good pressure test?
Pressure Testing

Background

• 1940’s-50’s
• Result:
  • Tools: Low-technology
  • Engineering Standards/Procedures: Outdated
  • Analysis: Inadequate to prove compliance
Case Study 1

“ILI will find any anomaly that would fail a hydrotest.”

- an ILI vendor who shall remain anonymous
Case Study 1

- Pipe specs:
  - 8-inch, Grade B, 0.188 wt.
  - Seam type: LF-ERW
  - 1950s vintage

- Goal: Re-establish MAOP at 400 psig; incomplete material records

- Test Details:
  - 8 hour test
  - Target test pressure: 765 psig (26% SMYS)
  - ~1.55 miles
### Case Study 1

<table>
<thead>
<tr>
<th></th>
<th>Pressure</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Test</td>
<td>766 psig</td>
<td>66°F</td>
</tr>
<tr>
<td>End Test</td>
<td>754 psig</td>
<td>68°F</td>
</tr>
</tbody>
</table>

2 injects = 3.6 gallons

Calculated Loss 9.3 gallons

Lost ~45 psi
Case Study 1
Retest

<table>
<thead>
<tr>
<th></th>
<th>Pressure</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Test</td>
<td>765 psig</td>
<td>65˚F</td>
</tr>
<tr>
<td>End Test</td>
<td>762 psig</td>
<td>64˚F</td>
</tr>
</tbody>
</table>

5 injects = 8.9 gallons
Calculated Loss  7.6 gallons

Lost ~75 psi
1°F = 15 psi
Leaking Defect ID’d by Hydro

Strength Test ✅

Leak Test ❌

Leaking manufacturing defect in long seam = A potentially hazardous leak
1. Don’t let the testing contractor call your hydro-tests!

2. A pressure test can find defects not found by ILI.

3. Verifying the absence of leaks is required to meet the test objectives.
• 192.503: No person may operate a new segment of pipeline, or return to service a segment of pipeline that has been relocated or replaced, until... *Each potentially hazardous leak has been located and eliminated.*

• 192.507: *The pipeline operator must use a test procedure that will ensure discovery of all potentially hazardous leaks in the segment being tested.*
Problem Statement

1. How do you prove the absence of potentially hazardous leaks?
2. What test procedure ensures the discovery of all potentially hazardous leaks?
Proving the absence of leaks

• If all pipe is visible: Visual Inspection
  • Buried pipe: Mass-Balance Calculations
    • Hydrotests
    • Pneumatic tests
Physics of a Pressure Test

Temperature \uparrow

Pressure \uparrow

n \uparrow

Pressure \uparrow

PV = nRT
Pressure – Volume – Temperature

• If 1°F = 5 psi
• If water temp 55°F → 56°F
• Does pressure 1,000 psi → 1,005 psi
Mass-Balance Calculations

1. How much mass did I start with?
2. How much mass did I end with?
3. Compare the two numbers.
4. If there’s a loss, is it acceptable?
   • Example:
     • On Test = 100 gallons
     • End of Test = 99 gallons
     • Is that Acceptable?
Acceptable Loss

API 1110: “The ability to identify leaks with confidence against the uncertainty of measurement accuracy is the fundamental basis of the leak acceptance criteria.”

• Temperature resolution (accuracy) = allowable loss
  • Analog: 1°F = allowable loss in mass
  • At 70°F, 1°F = 20 psi
### Basic Scenarios - Hydrotest

**Time** | **Pressure** | **Temperature** | **Balance**
--- | --- | --- | ---
0 Hours | 1000 psig | 70°F | 
8 Hours | 1005 psig | 70°F | Gain +

**PASS**

69.8°F to 70.2°F

---

**Time** | **Pressure** | **Temperature** | **Balance**
--- | --- | --- | ---
0 Hours | 1000 psig | 70°F | 
8 Hours | 995 psig | 71°F | Loss -

**FAIL**
## Basic Scenarios - Hydrotest

<table>
<thead>
<tr>
<th>Time</th>
<th>Pressure</th>
<th>Temperature</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Hours</td>
<td>1000 psig</td>
<td>70°F</td>
<td></td>
</tr>
<tr>
<td>8 Hours</td>
<td>1005 psig</td>
<td>72°F</td>
<td>Loss -</td>
</tr>
</tbody>
</table>

**1°F = 20 psi**

<table>
<thead>
<tr>
<th>Time</th>
<th>Pressure</th>
<th>Temperature</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Hours</td>
<td>1000 psig</td>
<td>70°F</td>
<td><strong>FAIL</strong></td>
</tr>
<tr>
<td>Bleed 50 oz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Hours</td>
<td>995 psig</td>
<td>71°F</td>
<td>Depends on total volume</td>
</tr>
</tbody>
</table>

**Need more info**
What about Pneumatic Tests?

Temperature change has a much smaller effect on the pressure.

<table>
<thead>
<tr>
<th>Test Medium</th>
<th>Fluid Density at 70°F (lb/ft³)</th>
<th>Allowable Pressure Loss at 70°F (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>62</td>
<td>25</td>
</tr>
<tr>
<td>Nitrogen/Air</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>
## Basic Scenarios - Pneumatic

<table>
<thead>
<tr>
<th>Time</th>
<th>Pressure</th>
<th>Temperature</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Hours</td>
<td>1000 psig</td>
<td>70°F</td>
<td></td>
</tr>
<tr>
<td>8 Hours</td>
<td>1005 psig</td>
<td>70°F</td>
<td>Gain +</td>
</tr>
</tbody>
</table>

PASS

<table>
<thead>
<tr>
<th>Time</th>
<th>Pressure</th>
<th>Temperature</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Hours</td>
<td>1000 psig</td>
<td>70°F</td>
<td></td>
</tr>
<tr>
<td>8 Hours</td>
<td>995 psig</td>
<td>71°F</td>
<td>Loss -</td>
</tr>
</tbody>
</table>

FAIL
## Basic Scenarios - Pneumatic

### Time | Pressure  | Temperature | Balance
---|------------|-------------|------
0 Hours | 1000 psig | 70°F        |      
8 Hours | 1005 psig | 72°F        | Gain +

1°F = 2 psi

---

### Time | Pressure  | Temperature | Result
---|------------|-------------|------
0 Hours | 1000 psig | 70°F        |      
Bleed 50 oz
8 Hours | 995 psig  | 71°F        | Depends on total volume

PASS
Leak Acceptance Criteria

- Hydrotests
  - All visible: Visual Inspection
  - Non-visible: Mass-Balance Calculations

<table>
<thead>
<tr>
<th>Test Objective</th>
<th>Test Subject</th>
<th>Test Type</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Re)Establish MAOP</td>
<td>MAOP ≥ 30% SMYS</td>
<td>Strength &amp; Leak</td>
<td>8 hours</td>
</tr>
<tr>
<td>(Re)Establish MAOP</td>
<td>Fabrication, MAOP ≥ 30% SMYS</td>
<td>Strength &amp; Leak</td>
<td>4 hours</td>
</tr>
</tbody>
</table>
### Steel Gas Pipelines

#### Test Parameters

<table>
<thead>
<tr>
<th>Test Objective</th>
<th>Test Subject</th>
<th>Test Type</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Re)Establish MAOP</td>
<td>100 psig ≤ MAOP ≤ 30% SMYS</td>
<td>Strength &amp; Leak</td>
<td>≥ 1 hour</td>
</tr>
<tr>
<td>(Re)Establish MAOP</td>
<td>1 psi ≤ MAOP ≤ 100 psig</td>
<td>Leak</td>
<td>≥ 1 hour (not defined)</td>
</tr>
<tr>
<td>(Re)Establish MAOP</td>
<td>MAOP ≤ 1 psig</td>
<td>Leak</td>
<td>≥ 1 hour (not defined)</td>
</tr>
</tbody>
</table>

Utilize a test procedure that ensures the discovery of all potentially hazardous leaks?
### Plastic Gas Pipelines

#### Test Parameters

<table>
<thead>
<tr>
<th>Test Objective</th>
<th>Test Subject</th>
<th>Test Type</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Re)Establish MAOP</td>
<td>Plastic Gas Pipeline</td>
<td>Leak</td>
<td>≥ 1 hour (not defined)</td>
</tr>
</tbody>
</table>

---

**Image:** A plastic gas pipeline running through a rocky area, with a yellow section indicating a possible test point. The background features a blue and white RCP logo.
Pneumatic Tests

• 4 or 8-hour Duration
  • Mass-Balance Calcs or
  • Criteria determined by mass-balance calcs:
    • Pressure: +/- 2 psi
    • Temperature +/- 5°F window

• Duration undefined?
  • Put it “On Test”
  • Wait until 1 hour of constant pressure (no change)
“The test is deemed acceptable if there is no evidence of leaks.”

• What about when the pipe is not visible?

• What about for gas tests?
“If the pressure drops below minimum specified, the test segment shall be re-pressurized and the test duration requirement be restarted.”

- So if you have a leak, as long as you keep re-injecting to keep the pressure above minimum, the test is acceptable??
### Case Study 2

Increasing pressure doesn’t mean there aren’t any leaks!

<table>
<thead>
<tr>
<th>#</th>
<th>Test Period</th>
<th>Test Pressure</th>
<th>Temperature °F</th>
<th>Comment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ambient</td>
<td>Pipe</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unrestrained</td>
<td>Restrained</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>10/06/2016 12:45</td>
<td>2025 psig</td>
<td>83.0 °F</td>
<td>81.0 °F</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>10/06/2016 13:00</td>
<td>2025 psig</td>
<td>84.0 °F</td>
<td>82.0 °F</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>10/06/2016 13:15</td>
<td>2025 psig</td>
<td>86.0 °F</td>
<td>83.0 °F</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10/06/2016 13:30</td>
<td>2025 psig</td>
<td>87.0 °F</td>
<td>83.0 °F</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>10/06/2016 13:45</td>
<td>2025 psig</td>
<td>88.0 °F</td>
<td>84.0 °F</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>10/06/2016 14:00</td>
<td>2026 psig</td>
<td>89.0 °F</td>
<td>84.0 °F</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>10/06/2016 14:15</td>
<td>2026 psig</td>
<td>90.0 °F</td>
<td>85.0 °F</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>10/06/2016 14:30</td>
<td>2026 psig</td>
<td>90.0 °F</td>
<td>85.0 °F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10/06/2016 14:45</td>
<td>2026 psig</td>
<td>90.0 °F</td>
<td>85.0 °F</td>
<td></td>
</tr>
</tbody>
</table>

**Pressure**

- **On Test**: 2023 psig
- **End Test**: 2026 psig

**Temperature**

- **On Test**: 69°F
- **End Test**: 85°F

**Calculated Loss**: 500+ gallons

\[1°F = 25 \text{ psi (400 psi)}\]
This does not make an effective argument.

• “Pressure chart looked good.”
• “I just know it was a good test.”
• “I’ve been doin’ this for 25 years.”
• “It was late at night so...”
• And so on.....
## Case Study 3

<table>
<thead>
<tr>
<th></th>
<th>Time 0 hours</th>
<th>Time 8 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>409 psig</td>
<td>327 psig</td>
</tr>
<tr>
<td>Pipe Temp</td>
<td>64°F</td>
<td>63.5°F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CSFM* ALLOWABLE LOSS</th>
<th>RCP MODEL ALLOWABLE LOSS</th>
<th>PREDICTED LOSS</th>
<th>PREDICTED LEAK SIZE</th>
<th>PREDICTED LEAK RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.47 GALLONS</td>
<td>0.30 GALLONS</td>
<td>0.54 GALLONS</td>
<td>0.0025 IN DIAMETER</td>
<td>0.23 GAL/HR</td>
</tr>
</tbody>
</table>

* CSFM = CALIFORNIA STATE FIRE MARSHAL
## Case Study 4

<table>
<thead>
<tr>
<th>Test Period</th>
<th>Test Pressure</th>
<th>Ambient</th>
<th>Unrestrained</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/11/2016 14:30</td>
<td>1820 psig</td>
<td>91.0°F</td>
<td>82.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 14:45</td>
<td>1820 psig</td>
<td>92.0°F</td>
<td>82.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 15:00</td>
<td>1819 psig</td>
<td>91.0°F</td>
<td>82.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 15:15</td>
<td>1819 psig</td>
<td>93.0°F</td>
<td>83.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 15:30</td>
<td>1819 psig</td>
<td>95.0°F</td>
<td>83.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 15:45</td>
<td>1819 psig</td>
<td>93.0°F</td>
<td>84.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 16:00</td>
<td>1819 psig</td>
<td>94.0°F</td>
<td>84.0°F</td>
<td></td>
</tr>
<tr>
<td>09/11/2016 16:15</td>
<td>1819 psig</td>
<td>94.0°F</td>
<td>84.0°F</td>
<td></td>
</tr>
</tbody>
</table>

**Pressure**

- **On Test**: 1820 psig
- **End Test**: 1814 psig

**Temperature**

- **79°F**
- **82°F**

Stamped by a PE... Found multiple leaks!
Summary

1. Understand your Test Objective(s)
2. Understand Code requirements for leaks
3. Revisit your pressure test acceptance criteria
Questions for you!

• What are your Test Objectives?
  • Meet Code requirements
  • Keep the product in the pipeline

• What’s your Company’s leak acceptance criteria?
Thank You!

Sheri Baucom

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