Geothermal Steamfield Asset Management

Pressure Protection Plan Case Study
Overview

• Steamfield Pressure Protection System Design impacts steamfield asset lifecycle costs:
  – Vessel & piping process design: HMB, sizing & selection
  – Design code and hazard assessment for vessel & piping
  – Vessel design & piping design & specifications,
  – Pressure protection design & specifications,
  – Regulatory compliance DV, ITPs, NDT & annual inspections & maintenance
Steamfield – Pressure Protection

• Pressure Zones:
  – Wellheads
  – Steam
  – Brine

• Pressure Protection Methods:
  – Design Pressure
  – Pressure Control
  – Pressure relief devices:
    • N+1, PSEs & PSVs, primary & secondary etc.
Steamfield – Pressure Protection

• Health & Safety & Environmental Issues:
  – Noise > 120 dBA
  – Steam & condensate discharges to environment
  – H$_2$S exposure
  – Heat
  – Debris
Lumut Balai Case Study

• ‘Complex’ 55 MW Steamfield (FCRS):
  – 3 cluster single flash system,
  – Gravity brine reinjection,
  – 663 m elevation difference between wellhead clusters & reinjection
  – Multiple pressure zones with intermediate isolation
  – Station steam vent system
Design Pressure Zones
Brine System
Design Pressure

- Pipe schedule selection:
  - Operating Pressure
    » Maximum operating pressures
  - Corrosion allowance
  - Dynamic Losses
  - Cost
# Design Spec Example

<table>
<thead>
<tr>
<th>Pipe Spec</th>
<th>Use</th>
<th>Pressure Rating bar(g)</th>
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<tr>
<td>CB15A</td>
<td>Large Bore Steam Mains</td>
<td>9</td>
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<td>CB15C</td>
<td>Two Phase and Steam Lines</td>
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<td>CB30B</td>
<td>Brine</td>
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<td>CB60A</td>
<td>Reinjection Wells and Brine Lines</td>
<td>72</td>
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Lumut Balai Example
Pressure Protection Zones

- Wellheads:
  - Full shut in pressure
  - No pressure protection devices required
Pressure Protection Plan

- Two-Phase lines:
  - Downstream of wellhead piping isolation. Increased risk of over pressure – Not rated to wellhead pressure
  - Larger bore to reduce losses
  - Pressure protection required
Pressure Protection Plan

- Steam line:
  - Large bore lines:
    - Reduced Losses
    - Increased hoop stress
  - Pressure protection required:
    - Typical protection options:
      - Pressure control system with rock mufflers
      - Pressure relief valves
      - Rupture discs
      - Vacuum relief devices
Vacuum Relief

• Large lines not rated to full Vacuum
• Isolated lines and condensing steam will cause a Vacuum
• Vacuum rupture disc sized for rate of condensation in cooling pipe
• ITPs & maintenance of vacuum relief system OPEX costs ongoing
Brine System

- Brine lines:
  - Static water pressure and steam pressure of steam relief devices
  - Lines are typically small bore and can withstand higher pressures
  - Pressure protection on steam lines:
    - Upstream relief from wellhead pressures
Vessel Pressure Protection

- Separator vessels
  - rated for 12.0 & 9.5 bar & FV (not 40 bar wellhead pressure)
  - protected by pressure relief on steam system
Steamfield Pressure Control

• Separator vessels:
  – ‘Trim’ flow control valve on one ‘index’ well to separator for each cluster

• Station vent system / steam header pressure control to 6 bar +/-:
  – 2 x 100% duty 0-55 t/h trim PCVs
  – 4 x 33% duty 40-167 t/h steam vent valves to rock mufflers
Lumut Balai Pressure Protection Zones Initial
Initial Design - PSEs & PSVs

• One set of rupture discs:
  – LMB 1, 6 & 9 Steam - 3 x 8.0 bar(g) N+1 each

• One set of pressure relief valves:
  – LMB 1, 6 & 9 Steam - 1 x 7.2 bar(g) each
Lumut Balai Pressure Protection Zones Required Changes

- Separator isolation valves requested:
  - Additional set of pressure safety relief equipment to protect cluster piping
  - Higher rupture disc pressure required
  - Additional vacuum protection devices required
- Vessel rupture discs or relief valves requested for regulatory compliance
Lumut Balai Pressure Protection Zones Final
Final Design - PSEs & PSVs

• Four sets of rupture discs:
  – LMB 6 Separator – 1 x 12.0 bar(g)
  – LMB 1 & 9 Separator – 1 x 9.5 bar(g) each
  – LMB 1, 6 & 9 Steam - 3 x 9.0 bar(g) N+1 each
  – Steam manifold & mist eliminator – 1 x 8 bar(g) each

• One set of pressure relief valves:
  – LMB 1, 6 & 9 Steam - 1 x 7.2 bar(g) each
Separator Pressure Protection
Station Vent Pressure Control
Implications on Asset Management

- Increased number of burst discs.
- Increased number of isolation valves.
- Operating constraint due to tighter tolerance (0%) burst pressure
- Higher cost for tighter tolerance rupture discs
How a Designer can help?

• Keep it simple
• Limit number of pressure zones
• Common rupture discs
  – Physical size difference for each pressure zone
• Burst pressure tolerance (0 - +5%)
  – Cheaper rupture discs
• Increased operating pressure flexibility.
World-class skills. World-class team.