Lesson Learned from the Installation of a Flexible Seismic Product Pipeline Mitigation System

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The story you are about to see is true.

The names have been changed to protect the innocent.
Marine Oil Terminal X

- Island wharf
- Mid-1950’s design
- Concrete piles & deck
- 70,000 DWT capacity
Terminal X’s MOTEEMS History

• Medium Risk MOT

• 2010 Initial Audit Completed
  – Complicated kinematic situation
  – Seismically deficient wharf – but vague on reasons/mitigations
  – Pipelines = spill risk in seismic condition

• 2011-2012 Subsequent Seismic Mitigation Development
  – Goal = Develop mitigation plan
  – Wharf Level 2 compliance verified as-is, except …
    • Ramp Damage = Pipeline spill risk
    • Large Seismic Displacements
      – 44 inches (+/- 22 inches) Perpendicular to Shore
      – 40 inches (+/- 20 inches) Parallel to Shore
      – 12 inches (+/- 6 inches) Vertical Moment

• 2012-2014 Implementation of Mitigation
Level 2 Kinematic Seismic Movements

- Wharf Displacement
- ~3-in. Kinematic
- ~16-in. Total Lateral

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Terminal X – Impacted Wharf Pipelines
Terminal X – Very Congested
Terminal X’s Seismic Compliance Challenges

- Large seismic displacements
- Extensive existing infrastructure in project area
- Traditional piping expansion loops would not work!
  - Limited working footprint
  - Convention loops too big
- No clear regulatory path to introduce “new” technologies or non-traditional approaches
- What would State Lands accept?
Terminal X’s Mitigation Attack Plan

1) Brainstorm solutions
   - Include all stakeholders

2) Work out the technical issues
   - Avoid the unproven concepts
   - Apply available technologies
   - Minimize regulatory issues

3) Concept ranking
   - Risk reduction & overall safety
   - Present & future cost
   - Regulatory risk

4) Develop regulatory path forward
   - Concept driven
   - Regulator participation
   - Stepped approach
Concept 1 - Conventional Hose Approach
Think Vessel-to-Vessel
Think Vessel-to-Vessel
Concept 2 - Flex-Hose Loop Approach
Concept 3a - Swivel Joints – Nested Approach
Concept 3b – Swivel Joints – Distributed Approach
Terminal X’s Final Decision

• Flex-hose was selected over swivel joint designs
  – Equal safety & spill risk reduction
  – Greater displacement flexibility / More robust
  – Quicker installation
  – Flex-hoses significantly less costly
    • ~½ (even with periodic replacement)
  – No swivel joint maintenance / exercising

• State Lands Concessions
  – Conduct Hazard & Risk Assessment of Concept
  – Flex-hose treated like convention transfer hoses
    • Follow existing hose regulations
    • Annual hydrotesting
    • Maximum replacement interval
Flex-Hose Loop Design

TYPICAL LONGITUDINAL SECTION - HOSE OPTION
Flex-Hose Loop

- Stainless steel double braided hose
- Hard piped hose saddle
Lessons Learned

• Don’t exclude Operators from design! – They know a lot!
• Regulatory approval process takes time – Plan for it!
  – New systems require extra thought
  – Communicate with State Lands often
    • Educate them on goals / problems / constraints
    • Listen to their concerns (often defines path forward)
    • Update them on progress
• Critical systems assessment and hazard & risk assessment are effective tools …
  • to define mitigation scope
    – Pipelines are the only systems requiring post-event operability
    – Not all systems require flexibility
  • to identify design risks
  • to address regulators concerns
  • to document design process
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Questions?

... and special thanks to Terminal X for allowing SGH to share their story!