Prevention First - 2012

Solutions for Terminals “New” and “Existing”

Piping Analysis in Elastic Regime
Pipe Stress Analysis Approach

• Existing Terminals:
  – Benefit of actual operating data
    • Design pressure of 275 psig, operates ~100 psig, find maximum incidental pressure
    • Actual operating temperatures (including solar radiation) as opposed to maximum design temperature
    • What is the current condition of the pipe?
Pipe Condition Considerations

• “Not on paper”
• Pipe wall thickness, corrosion rate and remaining service life
• Corrosion allowance
• Actual pipe grade?
  – Pipe material certs or original specifications do not always exist
  – Brinell hardness testing to verify pipe grade
Brinell Hardness Testing vs Pipe Grade

Hardness vs. Stress

- Rockwell vs. Brinell Hardness
- Field Data Correlation
- Rockwell (B) Hardness to Yield Stress
“One Time Faulted Events” vs “Occasional Loads”

- ASME B31.3 and B31.4 limit occasional loads to a percentage of pipe yield strength
  - Limited to CBC accelerations? Or actual structural interaction?
- Allowance by ALA and ASME B31E to inelastic behavior for one time faulted events
  - What is a one time faulted event?
  - How is it different from an occasional load?
  - Applies to cyclic events only...what is cyclic?
Stress vs Strain

- Strain to fracture
- Uniform strain
- Offset yield strength
- Tensile strength
- Fracture stress
- Conventional strain $e$
- Average stress
American Lifelines Alliance 
(ASME B&PV Code)

- When the piping is elastically analyzed the ALA suggests the following ASME B&PV Code Section III, Div. 1 stress limits:
  - $P_m < 70\% S_U$
  - $P_L + P_b < 105\% S_U$
  - $S_U$: minimum ultimate strength of the material, psi
  - $P_m$: primary membrane stress, psi
  - $P_L$: primary general or local membrane stress, psi
  - $P_b$: primary bending stress, psi
Pipe – Structure Interaction

- MOTEMS brings this to light
- Seismic Displacements and Inertial Loads
  - Static analysis for maximum differential displacements, and separate analysis for anticipated seismic accelerations
- Changing the structural analysis conditions
  - With pipe connected to structure, it forms a part of the structural mass, increasing displacements
Response Spectrum Analysis

- New terminals require a time history or response spectrum analysis; can be used to define the actual pipe – structure interaction
  - The structure has a natural period, and goes back at forth at a certain period
  - The pipe has a natural period, and will “excite” or resonate when closer to the structure natural period
  - Pipe restraints and mass participation effects
Responding to the Response Spectra

Typical Response Spectrum

Intersection of period and response spectrum resulting in acceleration of 1.5 g's.
New Terminal Design

• Designing a new terminal allows you to change both the structural response, and the piping response

  – Make structure more rigid or flexible
  – Manipulate mass of piping or location of valves, add / delete restraints, “cut out” mode shapes
  – Minimize accelerations and keep displacements manageable
Summary

• Existing terminals allow the benefit of analyzing towards actual operating conditions, and remaining service life.

• New terminals offer interaction of structural design and easier integration of piping modifications

• All evaluation techniques result in same thing: we’re smarter, with less at risk