Crude Unit Upgrade Study

API RBI User Group Meeting
February 23-24, 2005

Background

- RBI implementation project for FHR Fairbanks, Alaska in V3.3.3
- Upgrade and inspection planning comparison completed as a part of the project
- Crude Unit Study
  - In service 1998
  - Arid/Dry external environment
  - No cooling water system
  - 100,000 bpd/$100,000 $/day
  - Crude topping unit, 1 wt.% Sulfur; TAN 0.1
  - No pressure vessel inspections conducted to date

Modules Tested

- Internal Thinning
- CUI/External – Arid/Dry
- SCC – HIC/SOHIC, SSC
- Likelihood
- Consequence
- Risk
- Inspection Planning
  - Area Target
  - Financial Target

File Upgrade Activities

- Data Conditioning
  - Removed all symbols for equipment/component names
  - Set Asset ID to correctly associate components to equipment
- Upgraded materials of construction ASTM spec, grade, year (Cladding and Base materials)
- Added Design pressures and temperatures
  - Option to enter specified T_{min}
- UT of piping in 2000, updated thickness measurements at inspection dates
- Upgraded multiple times/versions i.e. V5.00, V5.01, V6.00 and V6.01

Findings V6.01 - Consequence

- Good consistency between V3 and V6.01 for flammable areas
- Toxic areas much lower in V6.01
  - Inventory calculations using ideal gas law
- Maximum Consequence Setting:
  - Consequences driven by conservative Toxic areas in V3
  - Consequences driven by flammable injury areas in V6.01

Findings V6.01 - Consequence

- Original Consequence module calculations
  - Uses equations in BRD for release type and fluids/phase
  - Considers Release Rate and Mass
  - Considers Continuous and Instantaneous releases
  - Limits pool fire spread for releases ≥10,000 lbs.
  - Considers proximity to AIT
  - Blends results when continuous

Findings V6.01 - Probability

- CUI/External – not tested due to Arid/Dry environment
- SCC
  - Calculated DF's matched closely
  - Inspection plan Area Risk Target 100 sq. ft./yr. recommended no inspection for cracking, few thinning
  - Area Risk Target best matching V3 recommendations was 50 sq. ft./yr
- Internal Thinning
  - ½ inspection recommendations matched
  - Remainder on V3 ***OR*** V6.01
    - Tmin + CA comparison
    - Differences in consequence areas

Findings V6.01 - Risk

- Area Risk
  - No maximum DF/POF for low consequence/risk items
  - No minimum inspection requirements for high consequence/risk items
- Risk Target (this example):
  - 30-50 sq. ft./yr.
  - $200,000-500,000 $/yr.

Module Calculations Verified

- Tested translator mapping and logic
- Reproduced hand calculations for:
  - Consequence Areas in V3, V5.0X and V6.01
  - Thinning DF's
  - SCC DF's
  - POF
  - Risk results using original and revised G_{ff}
  - Tested sensitivity of inspection planning module recommendations to Area and Financial Risk Targets

Example - Thinning

Result	V6.01	V3.3.3
Total G_{ff}	3.060E-05	1.56E-05
Thinning DF	0	10
POF	3.06E-05	1.56E-04
COF	29,145.93	23,435.28
Risk, ft^2/yr.	0.89	3.66
Future Thinning DF w/out Inspection	636.58	375
Future Risk w/out inspection	567.74	137.10
Inspection Recommended	1A	1A
Future Risk w/ inspection	25.84	10.60
Financial Risk	$3,000.03	$233,388

Example - Cracking

Result	V6.01	V3.3.3
Total G_{ff}	3.060E-05	1.56E-05
SCC DF	86.73	85
POF	2.65E-03	1.326E-03
COF	10,037.47	14,945.64
Risk, ft^2/yr.	26.63901	19.82
Future SCC DF w/out Inspection	227.43	226
Future Risk w/out inspection	69.85	53.39
Inspection Recommended	1C	1C
Future Risk w/ inspection	4.80	4.89
Financial Risk	$110,270	$31,785

Conclusions/Recommendations

- Comfortable with POF, COF and risk calculations
- Inspection planning module returns reasonable inspection recommendations except for:
  - High POF and Low consequence/risk
  - Low POF and High consequence/risk
- A file upgrade include actual Furnished thicknesses and design C.A. or use actual at date of thickness measurement used
- New consequence modeler can more conservative areas than original approach
  - Testing sensitivity of ignition probabilities and other assumptions

Recommendations – ar/t, DF's

- Replaced old ar/t factor with:

$$\frac{ar}{t} = \max\left[1 - \left(\frac{sthk - crate \cdot time}{t_{\min} + C.A.}\right), 0.0\right]$$

where
sthk – *most recent thickness reading*
crate – *corrosion rate of the base or cladding material, as applicable, estimate at the time of the most recent thickness reading*
time – *time difference between the RBI date and the date of the most recent thickness reading*
C.A. – *corrosion allowance*

- Implement adjustment for when equipment C.A. is not 25% of furnished thickness
  - 25% furnished thickness/actual C.A. ratio
  - Apply to the calculated ar/t
- ar/t factor calculation:
  - Current inspection when T_{min} + C.A. reached
  - Determine smoothing logic
- Iso-risk target vs. Consequence weighted risk target

Conclusions/Recommendations

- Need to continue to test
  - Translator mapping and logic
  - Risk target sensitivity
  - Other damage type modules
  - Other damage mechanisms
- Continue Validation testing with 3-4 additional studies
  - Hydrocracker
  - HF Alkylation
  - Chemical plant application
  - Refining unit
- May 1st completion of studies