

# API RBI User Group Meeting

## September 1, 2005

# Background

- Project approved at last UG meeting or a 4 unit study validation test of the production software
- Purpose was:
  - To production test as many modules as possible in V7.0
  - Assure that V7.0 is providing the capabilities specified and yielding results that can be applied during inspection plan development
- Only a limited amount of effort was to be spent comparing results to V3

# Project Scope

- V3 files were recent, current with validated data
- No on-site data gathering or validation was performed
- ASTM specifications were updated with data provided electronically
- Equipment thicknesses were updated into inspection histories, as appropriate, from electronic data (linking equip\_ID with inspection data Circuit\_ID)
- No evergreening was performed
- Units for Study
  - Flint Hills Resources, Pine Bend (639) - GOHT
  - ConocoPhillips, Ponca City (1,127) – HF Alkylation
  - Lyondell, Matagorda (1,203) – HDPE
  - Motiva, Convent (106) – FCCU (pressure vessels only)
- No formal inspection planning performed
- Significant comparison of results to V3 was performed

# Modules Tested

- V3 to V7 translator
- Internal Thinning
- CUI/External
- SCC
- Likelihood
- Consequence
- Risk
- Inspection Planning
  - Area Target
  - Financial Target

# Project Process

- Files upgraded through translator and calculated
  - With inspection updates
  - Without inspection updates
- Global Settings applied, data upgrades performed, as applicable
- SWG conference call - #1
  - Decision to use file without updates to compare V3 with V7 results
  - Identification of translator changes and software changes
- Release of updated software version
- Re-upgrade and calculation of files
- SWG conference call - #2
- Identification of remaining Punch List items
  - Testing of previous findings by SWG
  - Finalize Punch List for V7 Release
- Final Release of V7.0

# 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)
- UT of equipment and measured thicknesses at inspection date, as appropriate
- V3 Data assumed correct for:
  - Global Settings
  - Design Temperature/Pressure
  - Brittle Fracture Upset Temperature
  - Furnished Thickness/Component Start Date
  - Corrosion Allowance
  - Inspection History/Effectiveness

# File Upgrade Activities

## ■ Data Upgrade

- Thickness associated with inspection (last inspection only)
- Base material of construction spec/grade/year
- Clad/Overlay materials of construction
- Clad/Overlay thickness
- Clad/Overlay corrosion rate/type

## ■ Inspection Database

- Check Materials, start date, furnished thickness, design temperature/pressure, CA
- Measured thickness (shell/STR measurements, filter out nozzles, heads, etc)
- Calculated Corrosion Rate

# File Upgrade Activities

## ■ Data Upgrade Cautions

- Create credible link between inspection and RBI database naming convention
- Thickness from inspection database should be filtered minimums and consider only the applicable components
- Corrosion rate type should be consistent with V3 assignments
- Corrosion Rate from V3 program should be compared to inspection database before accepting
- All Materials of construction from V3 should be compared to the spec/grade/year in inspection database programs
- Match inspection date, thickness and corrosion rates

# Findings/Recommendations

- Translator – minor modifications and updates
- Probability Calculator
  - Thinning/External thickness coupling
  - ar/t modifications for C.A.
  - External SCC susceptibility modifications
- Consequence Calculator
  - Efficiency factor correction
  - Acid/Caustic and other new chemicals testing corrections
- Ability to cut & paste into component settings table
- Tank Module testing, fixes and modifications
- Report additions/testing

# Findings V7.0 - Consequence

- Improved consistency between V3 and V7.0 for flammable areas
- Toxic areas much lower in V7.0
  - Inventory calculations using ideal gas law
- Maximum Consequence Setting:
  - Consequences driven by conservative Toxic areas in V3
  - Consequences driven by flammable injury areas in V7.0
  - Added fluids to V3 inconsistencies with BRD
- Risk Results and Targets

# Findings V7.0 - 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
  - Blends results when continuous
  - Considers proximity to AIT
  - Limits pool fire spread for releases  $\geq 10,000$  lbs
- Modification to original consequence model
- New fluid additions for Chemical applications do not use blending and AIT adjustment factors (embedded in equations)

# Findings V7.0 - Probability

- Thinning
  - T<sub>min</sub> + CA comparison
  - ar/t calculation changes
  - Coupling of Damage Types/Mechanisms
- External (CUI/Atmospheric)
  - Inconsistencies with BRD for Cracking
- SCC
  - Calculated DF's matched closely
- Other Mechanisms
  - No significant changes
  - Good correlation with V3

# T<sub>min</sub> Calculator

- Calculated T<sub>min</sub> is based on code (API 579) calculations specific to geometry type
- For a Cylinder:

$$t_{\min}^C = \frac{PR_c}{SE - 0.6P}$$

*Where:*

*P - Pressure*

*S - allowable stress*

*R - Radius*

*E - Joint efficiency*

- Uses the larger of a structural T<sub>min</sub> (user defined) and Calculated T<sub>min</sub>
- User override by entering Specified T<sub>min</sub> and corrosion allowance, if desired

# MAWP Calculator

- For a Cylinder:

$$MAWP^C = \frac{SEt_c}{R_c + 0.6t_c}$$

*Where:*

*P - Pressure*

*S - allowable stress*

*R - Radius*

*E - Joint efficiency*

*t - thickness*

- Calculated MAWP for RBI Date based on estimated thickness at date
- Comparable to re-rate pressure
- Note that V7 Diameter is Inside Diameter (V3 was Outside Diameter)

# ar/t Calculator

- Thickness and Corrosion Allowance used for  $T_{\min}$  calculation
- Modified ar/t

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

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

- Uses Furnished Thickness and CA
- Clad/Overlay thickness defaulted to 0.1 inch

# Thinning & Linings Coupling

- Both modules are populated and calculated separately
- The final internal Thinning DF is assigned as the **LOWER** of the two module DF's

# Thinning & External Coupling

- Corrosion rates are assigned separately
- Date and thickness is the last for Thinning or External/CUI (whichever is most recent)
- Or component start date and furnished thickness if no measured data is available for either module
- $T_{\min}$  adjustment is calculated
- Final External DF:  
= External DF –  $T_{\min}$  adjusted DF
- Final DF:  
= Thinning DF + External DF –  $T_{\min}$  adjusted DF

# Findings V7.0 - Risk

- Inspection plan Area Risk Target 50 sq. ft./yr. recommended similar inspection as V3
- Average Area Future Risk Target w/inspection in V3 is 20-30 sq. ft./yr.
- Average Financial Future Risk Target w/inspection is V3 wide range
- Risk for V7 ~5-10x of V3
- Added Damage Factor Target to address low consequence and high probability items

# Findings V7.0 - Risk

## ■ Area Risk

	<u>Safety Risk</u>	<u>Financial Risk</u>
– FHR	28.1 ft <sup>2</sup> /yr	\$650,673
– CoP	31.3 ft <sup>2</sup> /yr	\$279,386
– Lyon	22.2 ft <sup>2</sup> /yr	\$ 73,916
– Motiva	31.4 ft <sup>2</sup> /yr	\$597,104

# Validation Testing

- Validation of 5 unit files in refining and chemical application
- Tested most modules in V7
- Correlation good with V3, except where differences are known and expected
- 4 plant files reviewed by inspection/engineering personnel
- Identified bugs and logic/technology issues that were reviewed by SWG and recommendations for changes made
- Impact of modifications tested for correlation
- Final version reviewed by SWG for input to generate final punch list for release
- New equipment modules and new consequence modeler not included in validation tests

# Conclusions/Recommendations

- Good correlation with DF, COF and risk calculations
- Modification of new fluids added in V3 generates good correlation with V7
- Change in ar/t and DF determination for thinning mechanisms generate larger DF than V3
- Inspection planning module returns comparable inspection recommendations

# Conclusions/Recommendations

- Release V7.0 production version at UG meeting September 1<sup>st</sup>
- TWG accelerate RSF approach for development, testing and release in 2006
- Short term IT team to address and streamline network installation process
- Add Network support contract to API User Group activity