LP-ICDA

Update, Issues, Next Steps

Trevor Place
Enbridge Pipeline

February 7-8, 2007

LP-ICDA Developments

PRCI

- Feasibility of ICDA for liquid pipelines **(PR-186-04305/DTR56-05-T-005)**
- Behavior and consequence of solid contamination in liquid pipelines: Understanding sediment transport and deposition **(IC-7-2)**
- Define operating conditions in which internal corrosion is extremely unlikely to exist **(IC-1-1)**

Non-PRCI

- Liquid petroleum internal corrosion direct assessment methodology for pipelines **(NACE TG-315)**

Related Works:

- Internal corrosion direct assessment methodology for pipelines carrying normally dry natural gas **(NACE SP0206-2006)**
- Internal corrosion direct assessment for wet gas pipelines **(NACE TG-305)**

ICDA – Four Steps

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Pre-Assessment

- Collect essential information regarding the historic and present operation of a pipeline used to establish feasibility of ICDA process and to define regions of interest

Indirect Inspection

- Use of flow models to determine areas where accumulation of corrodents, and corrosion, is most likely

Detailed Examination

- Performance of excavations and direct examination of pipe to determine if significant internal corrosion has occurred

Post Assessment

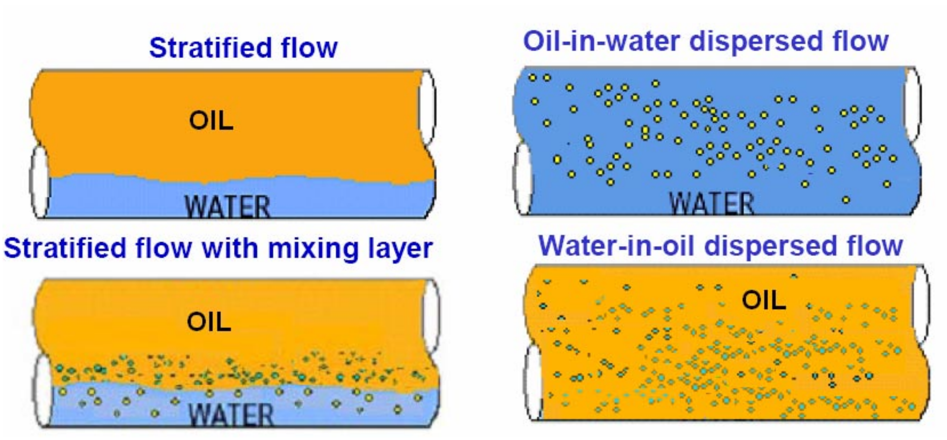
- Validation of ICDA process, review data from previous three steps to evaluate pipeline integrity and determine reassessment intervals

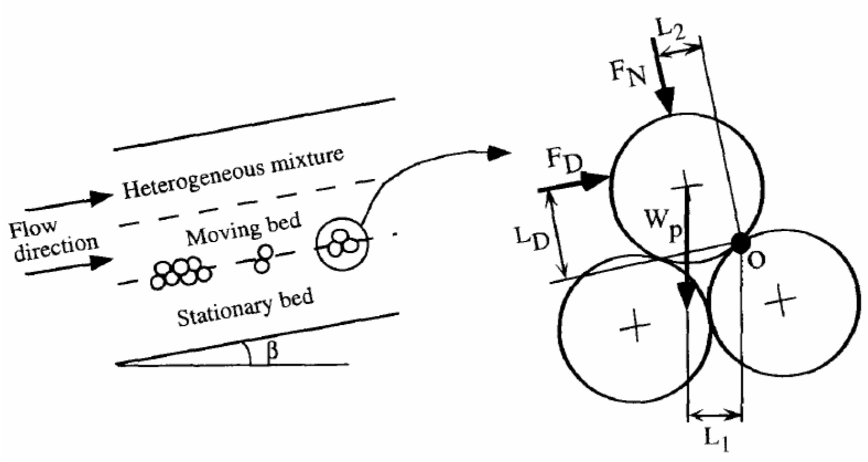
1. Pre-Assessment

- Pipeline diameter
- Operating history
- Composition of products
- Elevation profile
- Temperature
- Chemical Treatment
- Pigging operations
- Presence of flow coatings
- Injection and receipt points
- Upset conditions
- Water and solid content of petroleum liquid
- Maximum, nominal and minimum flowrates
- Previous ILI or direct inspection results
- Documented corrosion events
- Corrosion monitoring data (coupons etc)
- Specific contaminants and chemical properties:
  - H_2O, CO_2, H_2S, O_2, bacteria, pH, TAN, total chlorides, S, others?

2. Indirect Examination

Requires detailed flow modeling for each region





- There are several commercial and proprietary flow models available
- TG315 provides the model developed for PRCI
- Option is left for any validated flow model to be used

- Models are used to create a ranked listing of sites most likely to have corrosion
- Commonality among models:
  - Inclines and low spots are expected to collect corrodents*

3. Direct Examination

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Keynotes

- Most susceptible locations in each region are excavated for examination
  - Progressively non-susceptible locations are examined
  - Root cause analysis is performed for all corrosion damage
  - Integrity repairs are conducted as required
  - Excavations continue until negligible corrosion is observed at ‘n’ successive next worst cases
- Susceptible fixtures (drips, dead legs, etc.) are inspected
- ‘Other’ corrosion mechanisms are identified for inclusion in DA process

4. Post Assessment

Keynotes

- Check if models were effective and reassess feasibility if required

- Define reassessment interval (work needed – not defined)
  - CGR is corrodent related – more modeling required
  - Some factors may preclude reliable assessment
  - Many assumptions are expected

- Review overall process performance

LP-ICDA – Outstanding Issues

- Many flow models – metrics to select and validate?
- More work is required to validate re-entrainment of settled corrodents – may be irreversible for some corrodents
- How many digs with negligible corrosion are required to complete direct examination step? (How many is 'n')?
- A clear definition or established metric for 'process effectiveness' (step 4) is required
- More work is required to determine corrosion growth rates for reassessment intervals
- An improved model is required for settling and accumulation of corrodents in large diameter pipelines and/or pipes carrying dense oil products

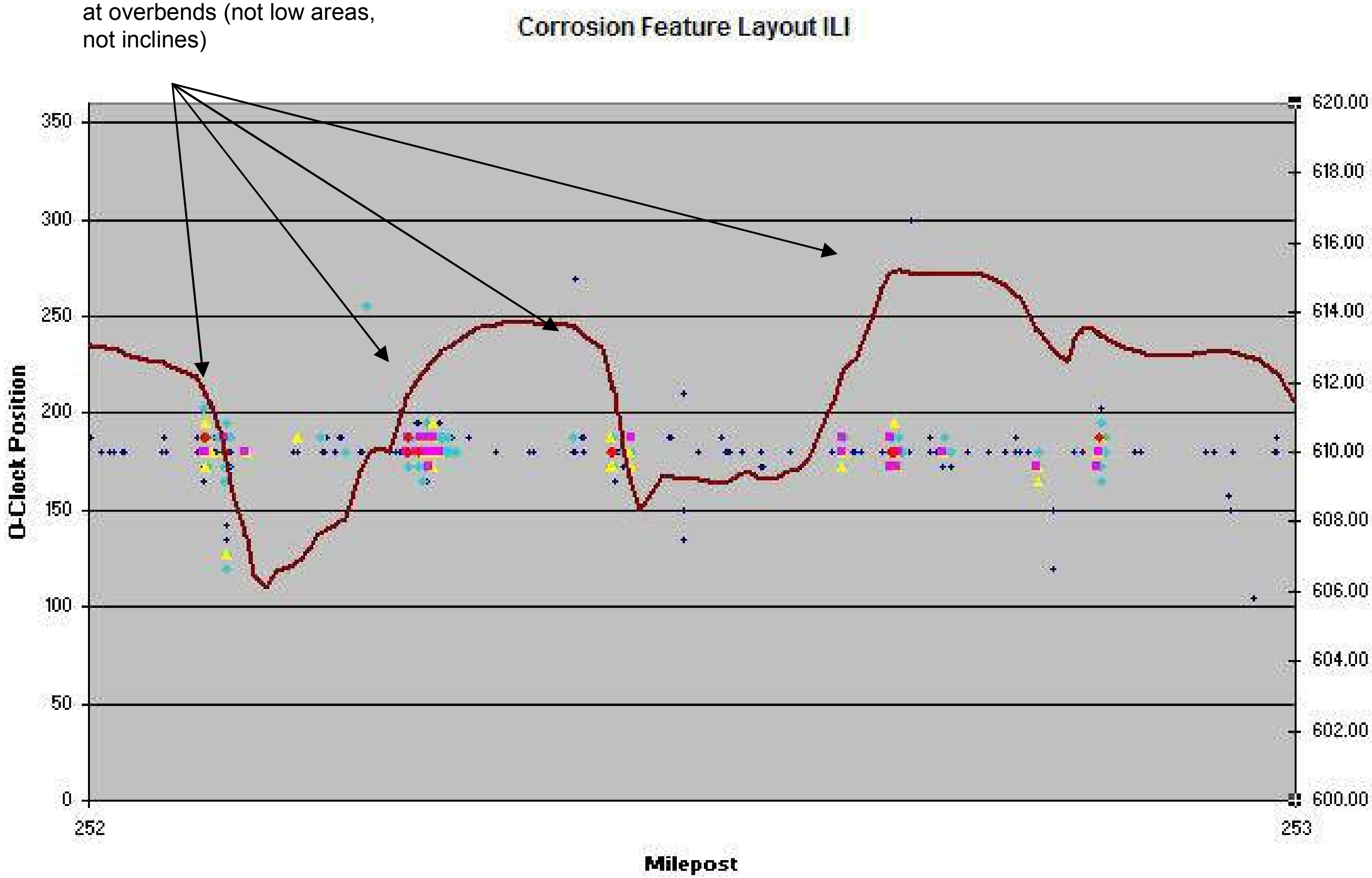
LP-ICDA ISSUES

- Certain pipeline operating conditions may lead to corrosive conditions at locations not predicted by present water and solid accumulation models

- Heavy oils (>920 kg/m3, API)
- Large diameter pipelines where significant stratification of corrodents may occur under normal operations

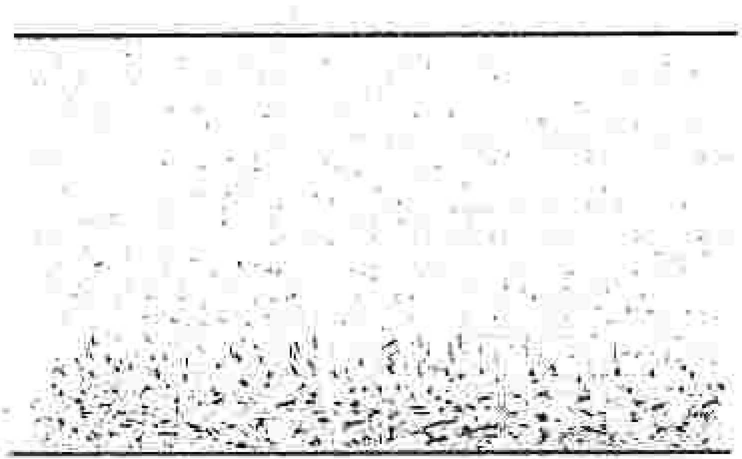
Heavy Oil Pipeline Example 1

Corrosion occurs preferentially at overbends (not low areas, not inclines)

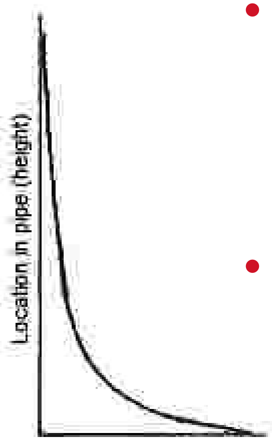


Brown line is elevation in metres (RH axis) Colored dots are corrosion indications plotted milepost (X axis) against circumferential location (LH axis) Color scale is dark blue (shallow) – light blue – yellow – purple – red (deep)

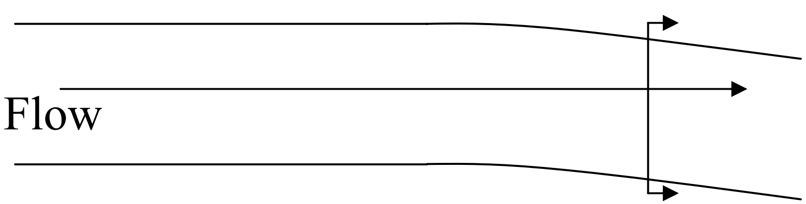
Sedimentation Mechanism in Heavy Oil Pipeline

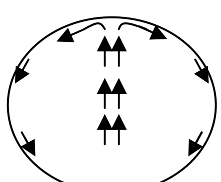


Gravity causes stratification of solids to pipe floor (most significant in large pipes)



Concentration of solids





Cross section of pipe
Showing secondary flow pattern

- Significant stratification of entrained solids may result in large, long pipes (see note)
- An equilibrium condition may result whereby the oil flow moves a local maxima of solid matter
- At this flow condition, slight changes in local turbulence have a significant effect
- Overbends create decrease in turbulence at pipe floor and corrodents may accumulate

Note: Concentration of water and solids may be sufficient to require new flow models

LP-ICDA Summary

- Preliminary indications suggest LP ICDA process is feasible for liquid pipelines (see recent PRCI project PR-301-03-151)
- TG 315 will continue efforts to develop a proposed standard methodology
- Draft will be available at Nashville
- May initially have a defined application limits – but within those limits will be a sound integrity verification technique

LP-ICDA Next Steps

- **Further refinement of flow models are required, especially around solids (PRCI IC-7-2)**
- **Validation of flow models from ILI inspected pipe is recommended (PRCI 2008)**
- **Limited scope application is very achievable – even with present uncertainties**
- **Can be used to validate the integrity of pipelines with minimal internal corrosion**

Factors Affecting Water Accumulation - examples