OPERATOR PANEL THREE

October 22, 2008

ANOMALY EVALUATION & REPAIR

On this panel -

Keith Leewis

- Process flow - response & remediation decisions

John Kiefner

- Development of methods and standards

Chia-Pin (CP) Hsiao

- Recent evaluation of methods – still ok?

Dave Johnson

- Perspective Summary

PROCESS FLOW FOR RESPONSE & REMEDIATION DECISIONS

- Keith Leewis P-PIC

API 1163 Fig 2 In-Line Inspection Flow Diagram

(Preassessment, Indirect, & Direct Inspection)

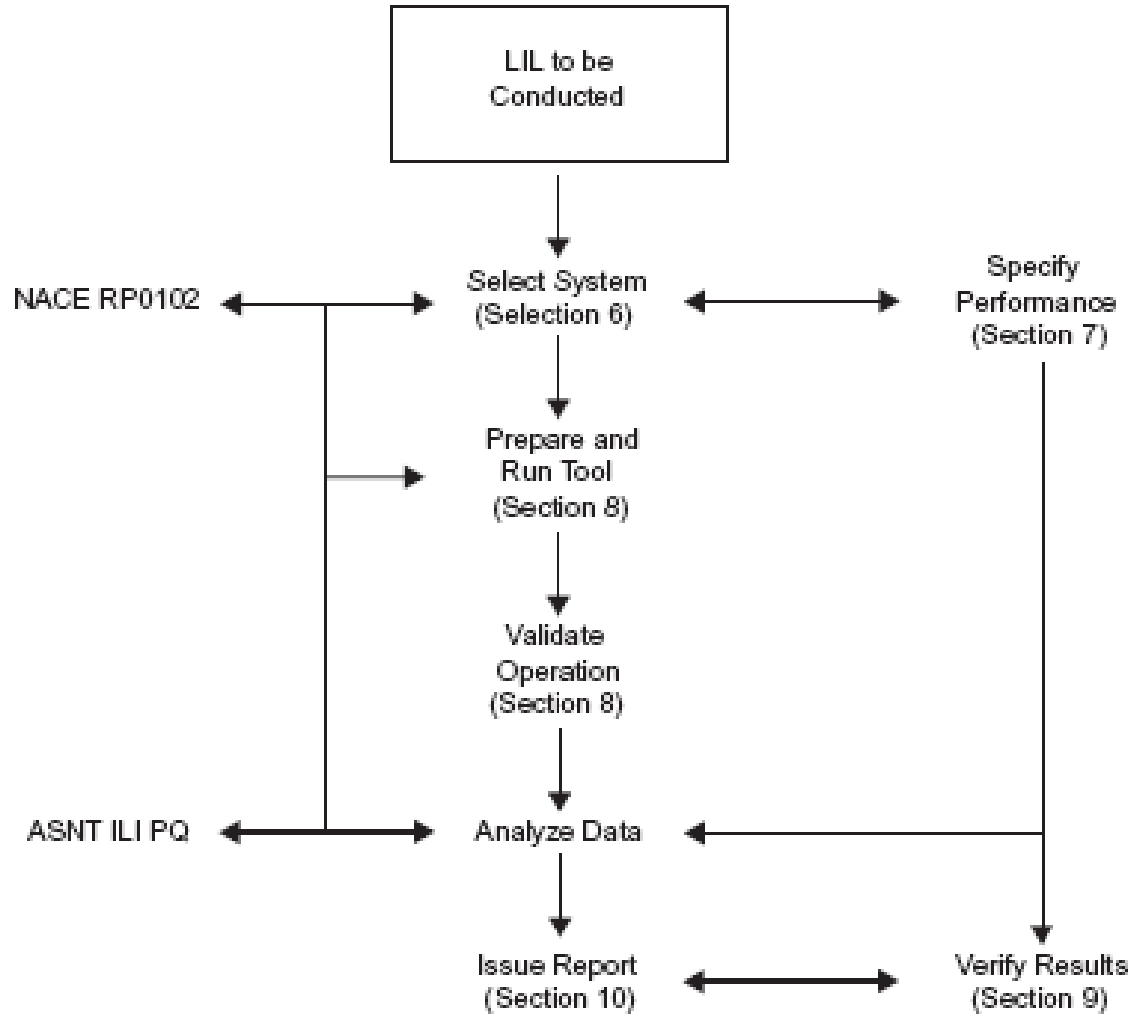


Figure 2—In-line Inspection Process Flow Diagram

ILI Integrity Assessment Flow

- Decide if you can pig
- Write operational plan for running ILI tool
- Select tool(s) for threat(s), follow practices, IMP and SOPs
  - Set out expectations in the service contract
- Run tool and confirm it collected data
- Analyze data and deliver timely ILI report
- Review ILI report, prioritize locations, - response
- Excavate, assess, then mitigate or repair following SOPs –
- Share findings for continuous improvement

- Yellow = ILI Provider   Green = Operator

Parallel Process flows for response & remediation decisions-2

- API 1163 content (comparison to DA)
  - System Qualification (preassessment)
  - In-Line Inspection System Selection (preassessment)
  - Set Qualification & Performance (preassessment)
    - Each Tool Performance Specifications plus
    - Qualifications of Field & Analytical People
  - System Operational Verification (all four)
    - Preassessment, Indirect, Direct & Post Inspection Requirements
  - System Results Verification (after direct examination by client)
  - Reporting Requirements (post assessment)
  - Quality Management System (post assessment and continuous improvement)

API 1163 Fig 1 Inspection Terminology

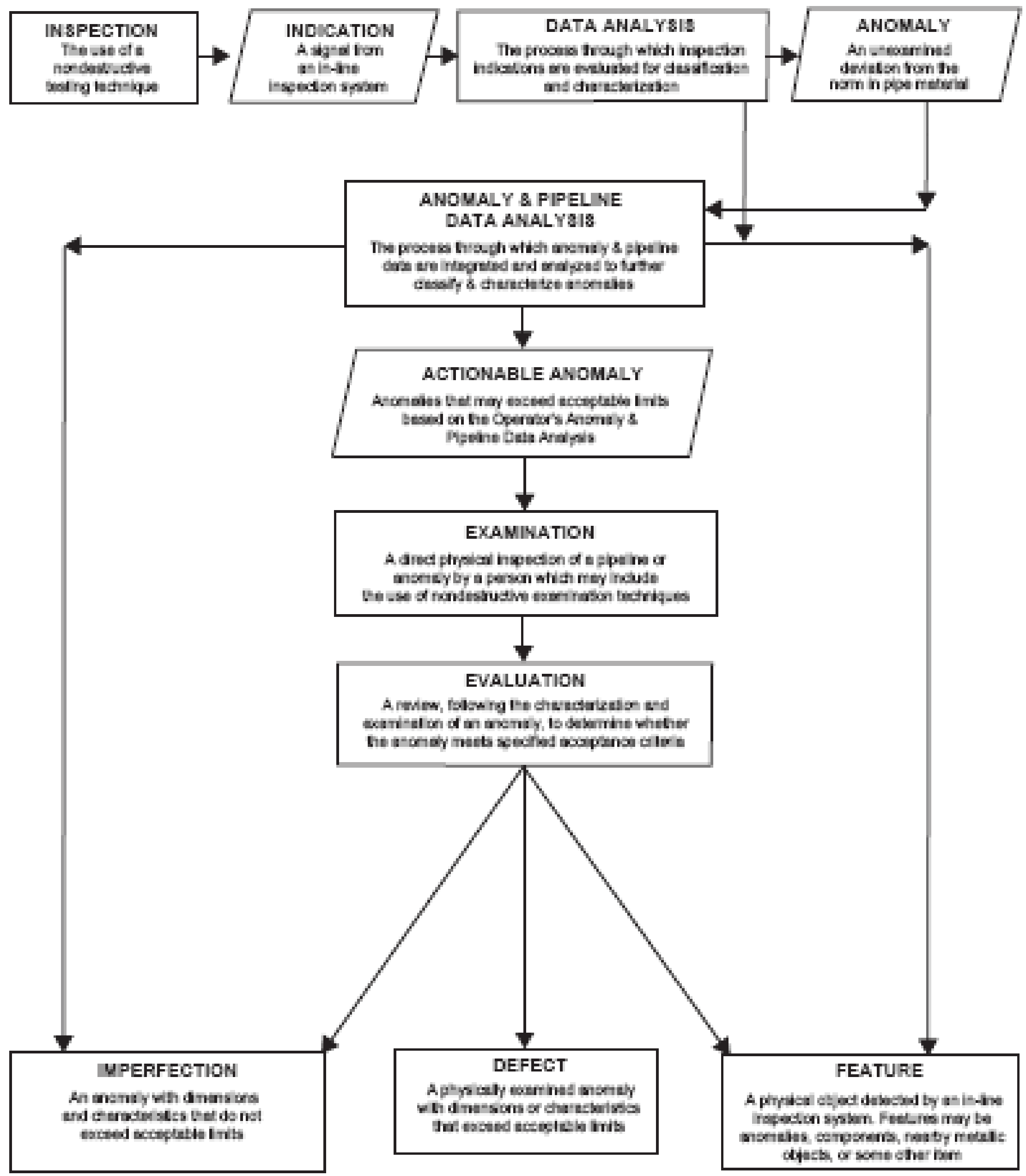


Figure 1—Inspection Terminology

SOPs (IMP) Govern Safety & Reliability

- Response to the ILI report is a prioritized dig list
  - SOP = Dig those that fail B31G + all pits > 80%
  - Dig Response is Scheduled by 192 or B31.8S fig 4
- Remediation decisions are based on actual observations in the hole and fixed while open
  - SOP = repair those that may fail RSTRENG in less than 10, 15, or 20 years
  - Repair or replace with new pipe

DEVELOPMENT OF METHODS AND STANDARDS

John Kiefner
Kiefner and Associates Inc.

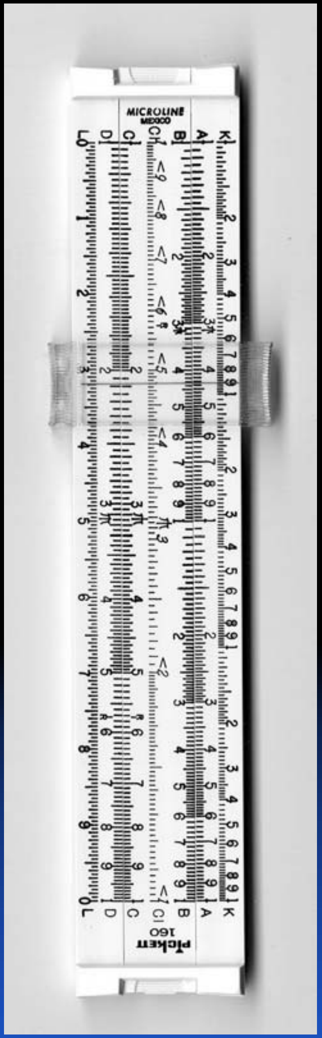
Historical Perspective

Maxey's surface flaw equation – mid 1960s

Maxey's equation adapted for corrosion using parabola to represent area of metal loss – 1969

The concept of effective area calculations - 1969

1969 lap-top computer



RSTRENG based on effective area calculations – 1988

Interim from 1988 to present: LPC-1, PCORRC, API RP 579

Current work by Advantica

Historical Perspective

1960's cleaning pigs, gauging pigs, single-trace caliper tools

1965 magnetic flux leakage (MFL) technology

1977 high-resolution MFL

1982 elastic-wave crack tool

1987 ultrasonic metal loss

1992 angle beam UT crack tool

1997 transverse MFL

Standards and Regulations

- ASME B31G 1984, revised 1991
- API 579-1/ASME FFS-1, JUNE 5, 2007 (API 579 SECOND EDITION)
  - Part 5 - Assessment of Local Metal Loss
- BS 7910 LPC-1, LPC-2, etc.
- **§ 192.485 Remedial measures: Transmission lines.**

  (c) Under paragraphs (a) and (b) of this section, the strength of pipe based on actual remaining wall thickness may be determined by the procedure in ASME/ANSI B31G or the procedure in AGA Pipeline Research Committee Project PR 3–805 (with RSTRENG disk). Both procedures apply to corroded regions that do not penetrate the pipe wall, subject to the limitations prescribed in the procedures.
- **§ 195.587 What methods are available to determine the strength of corroded pipe?**

  Under §195.585, you may use the procedure in ASME B31G, "Manual for Determining the Remaining Strength of Corroded Pipelines," or the procedure developed by AGA/Battelle, "A Modified Criterion for Evaluating the Remaining Strength of Corroded Pipe (with RSTRENG disk)," to determine the strength of corroded pipe based on actual remaining wall thickness. These procedures apply to corroded regions that do not penetrate the pipe wall, subject to the limitations set out in the respective procedures.

Advantica Report #6781

- In general this report carries on the validation of corrosion assessment methods.
- The additional data provided are helpful.
- In most ways, the work reinforces the credibility of the methods used by most pipeline operators.

Advantica Report #6781 Conclusion

- For the majority of the tests investigated in this report, standard assessment methods used by the pipeline industry give conservative failure predictions… Failure predictions on pipe with real corrosion defects were shown to be conservative using the ASME B31G, Modified B31G and RSTRENG methods.

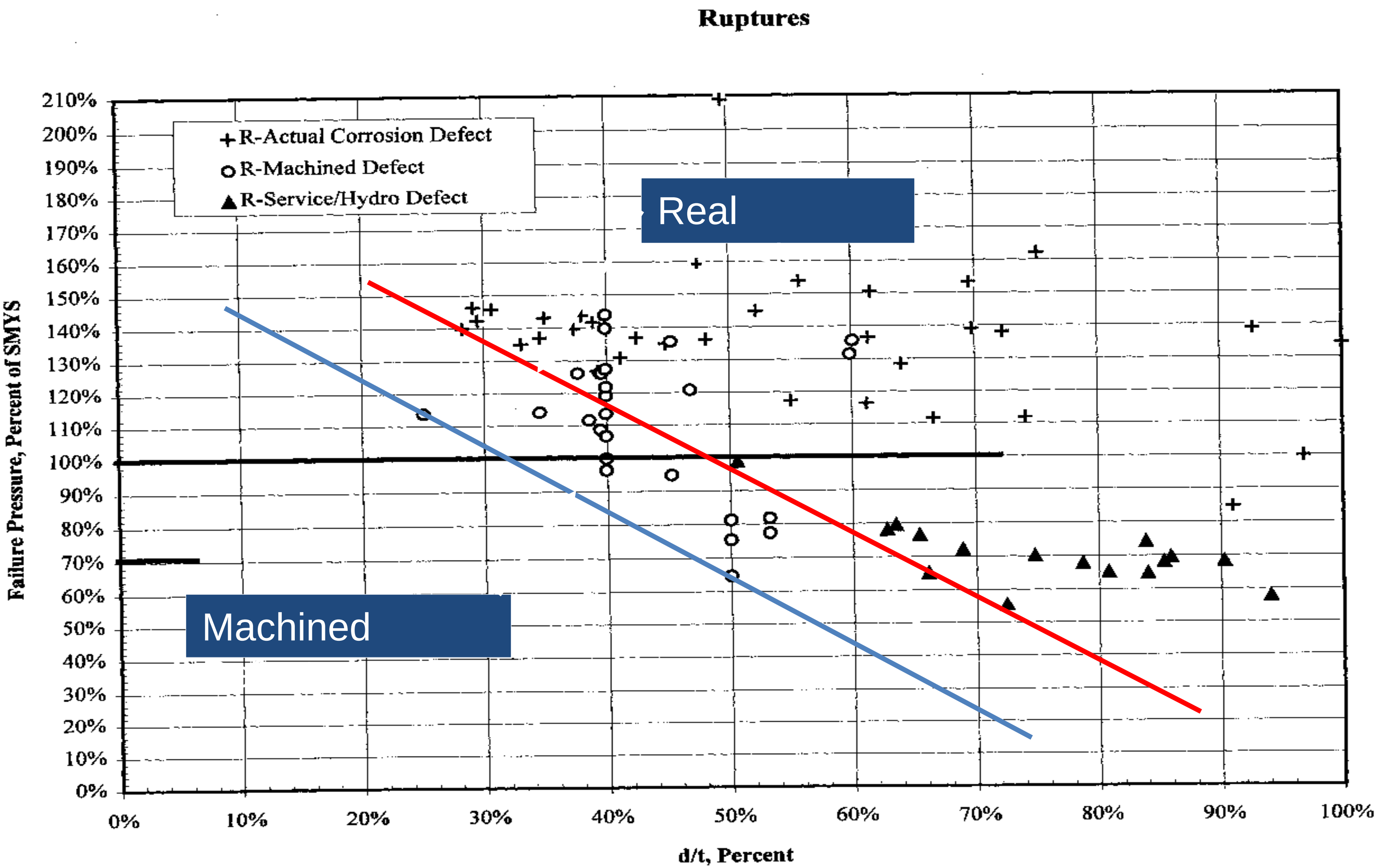
Advantica Report #6781 Recommendation

- The ASME B31G or the Modified ASME B31G methods can continue to be used to rank/screen defects following ILI. This is because both methods predict conservative failure pressures for tests conducted on pipe with real corrosion defects …

Advantica Report #6781, Page 8

- Case 2 based on the recommendation given by each assessment method, requires specified minimum material properties, flow stress, etc.
  - Provides best predictions
- Cases - 1, 3, 4, 5, & 6
  - Actual Material Properties
  - Alternate Flow Stress Estimates
  - Alternate Folias Factors
  - Alternate Cross Sectional Area Estimates

Validation of RSTRENG



Case 2

Assessment Method	P_A/P_f All Test Data		P_A/P_f All Test Data Minus Early Grade B Results	
	Mean	Standard Deviation	Mean	Standard Deviation
ASME B31G	1.534	0.624	1.550	0.642
Modified ASME B31G	1.330	0.348	1.340	0.356
RSTRENG	1.305	0.178	1.322	0.168
LPC-1	1.277	0.335	1.306	0.326
PCORRC	1.295	0.342	1.325	0.334
SHELL92	1.562	0.436	1.592	0.432

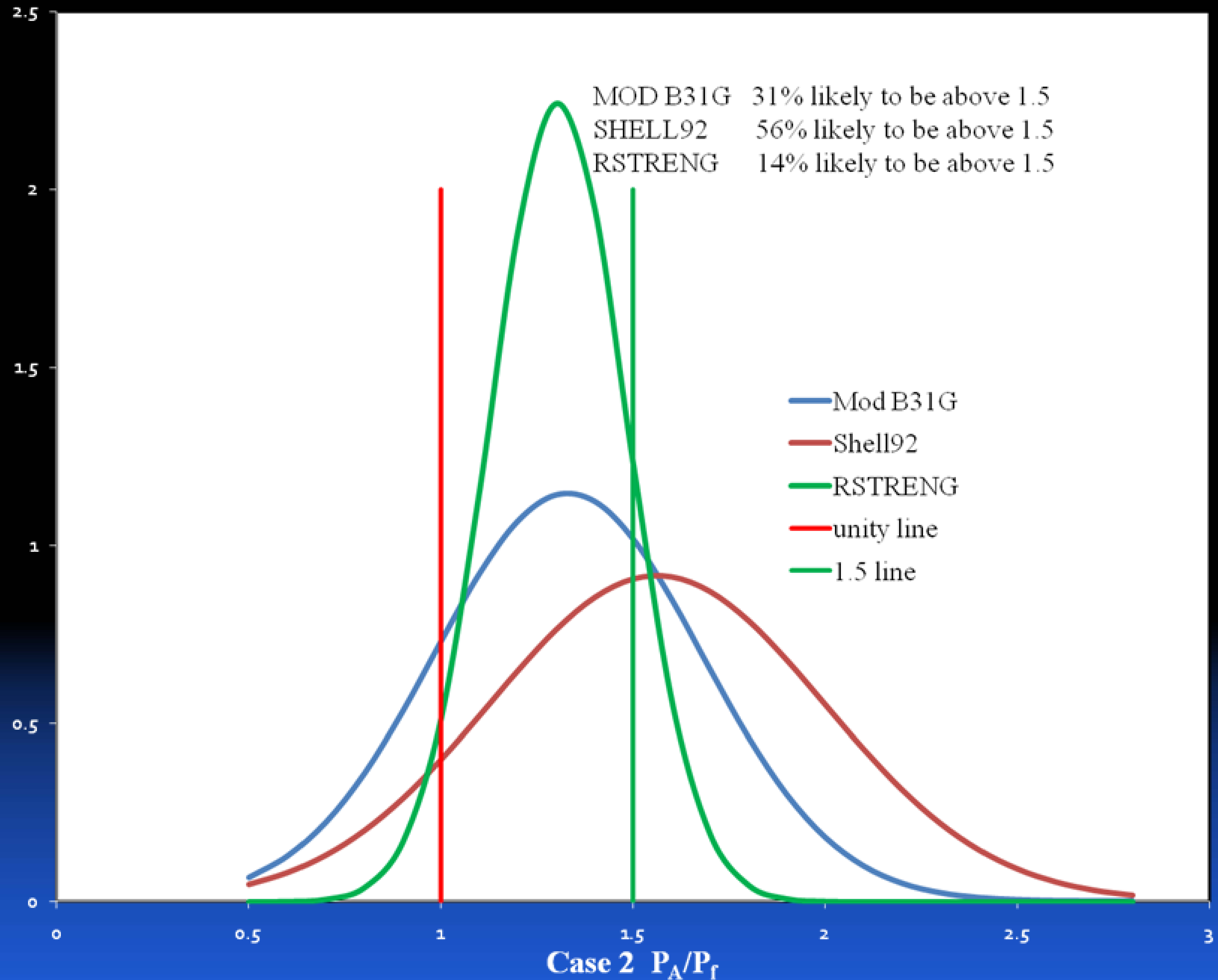
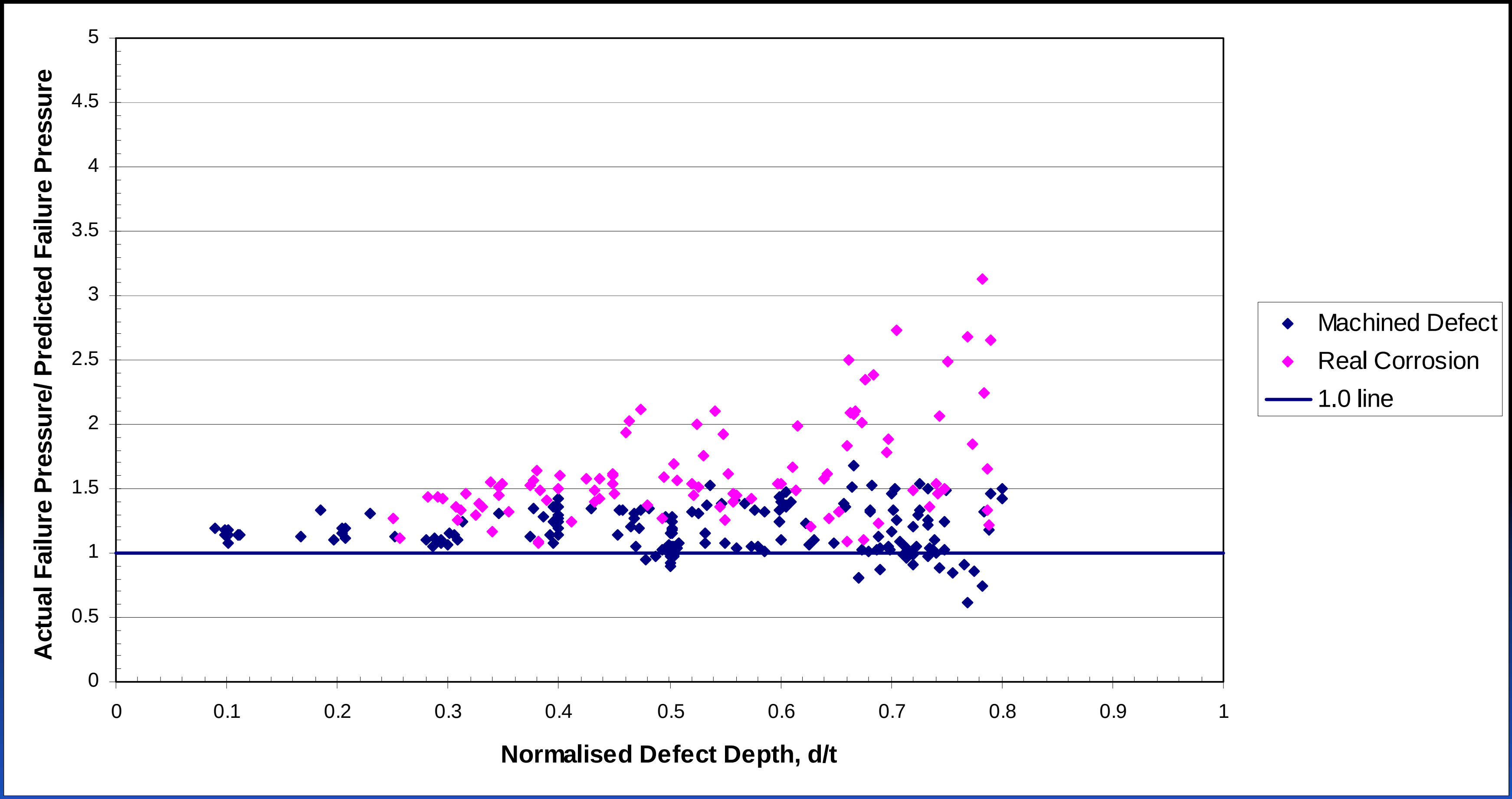

MOD B31G 31% likely to be above 1.5
SHELL92 56% likely to be above 1.5
RSTRENG 14% likely to be above 1.5
Mod B31G
Shell92
RSTRENG
unity line
1.5 line
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
Case 2 P_A/P_f

Figure 23 Case 2 MB31G – real corrosion v machined defects



Advantica Report #6781 Conclusion

- For the majority of the tests investigated in this report, standard assessment methods used by the pipeline industry give conservative failure predictions.

Operator Perspective and Application

Chia-Pin Hsiao

Chevron

Defect Assessment Methods

- Assessment methods such as B31G, Modified B31G, and RSTRENG have excellent performance records

- There is no recorded failures due to non-conservative predictions made by these assessment methods

- Issues associated with high strength pipes (i.e., X80 and above) are different in nature and should be separated from the existing pipeline population

Validation Using Burst Test Database

- A total of 6 cases were studied in the report
- Case 2 – Flow stress based on the recommendation given by each assessment method, using specified minimum material properties – this case represents how these methods are being used in real world

Validation Using Burst Test Database

- Except 2 natural defect cases (old Gr. B pipes with questionable results), all non-conservative predictions made by B31G and Modified B31G are on machined defects with a metal loss area ~ 1.0 – naturally occurred defects have a metal loss area less than 1.0
  - The 2/3 and 0.85 factor used in these two methods are not suited for assessing machined defects with an area loss of 1.0
  - Profile data in PRCI database show a median value of 0.65 (close to 2/3)

Validation Using Burst Test Database

- Calculations were based on 100% SMYS stress level without a design factor – real pipelines are not operated under this condition
  - The safety factor imposed by the design factor makes all predictions conservative
  - A 0.72 design factor translates to a 1.39 safety factor
  - Lower design factors (0.6, 0.5, and 0.4) give even higher safety factors
  - All predictions (on both natural and machined defects) made by these three methods are conservative after taking into account a design factor of 0.72

Perspective

- Almost half a million miles of transmission pipelines in the U.S.
- When inspected, anomalies may be detected
  - Response – what to examine and when
  - Remediation – what, if anything, must be done
- We deal with anomalies everywhere – it's what we do
  - IM programs – in HCA
  - Outside HCA
  - Various class locations
  - Special permits – higher MAOP, class location
  - Higher MAOP operation

More Perspective

- We need a consistent approach
  - The pipe doesn't know what's around it
- We have proven methods
  - Screen with B31G, Modified B31G
  - Detailed analysis with RSTRENG if needed
- Long-term successful application
- Developed, validated and shown appropriate for ≤ X70
- Basis in research – proven in practice

Committed to Real Solutions for the Real Problem

- Concerns about “real corrosion defect” burst predictions in
  - ≥ X80 higher strength pipe
  - Higher Y/T, lower strain hardening exponent
  - Higher D/t
  - Deeper anomalies
- BUT - - -
- This is NOT the pipe we have in the ground
- An X100 line with a 50% anomaly ?
  - The operator has bigger problems than analysis

Panel 3 Summary

- Operators use Well Founded & Validated Predictive Burst Strength Methods
- Appropriately Conservative for Real Defects on Real Pipelines
- Already required by Regulations and Standards (ASME, API, NACE)
- Methods are Periodically Reevaluated & Validated
  - Operators know how to use them
  - Good for all the pipe in the ground today

Industry Workshop Summary

- Today we heard about ILI tools, accuracy, etc., corrosion & growth rates, and models
- All have ranges of accuracy
- RSTRENG and ASME B31G are valid methods for determining the calculated failure pressure of corrosion anomalies and defects
- Models give conservative results on today's pipe
- Short, deep features (> 80% wall loss) with a relatively high FPR should be treated as a near-term leak

Industry Workshop Summary – Continued

- Additional conservatism in application of models and the process. Don't need to layer in more conservatism in each factor and process step
- ASME B31.8S Figure 4 and accompanying material are valid timing of responses to corrosion anomalies found by ILI
- Have not seen evidence of insufficiency
- Over three decades of experience supports this approach