Reliability Ranking and Life Extension of Coke Drums

Bobby Wright, PE
Charles Becht V, PE

We Solve Problems

Engineering From An Owner's Perspective

REFCOMM®
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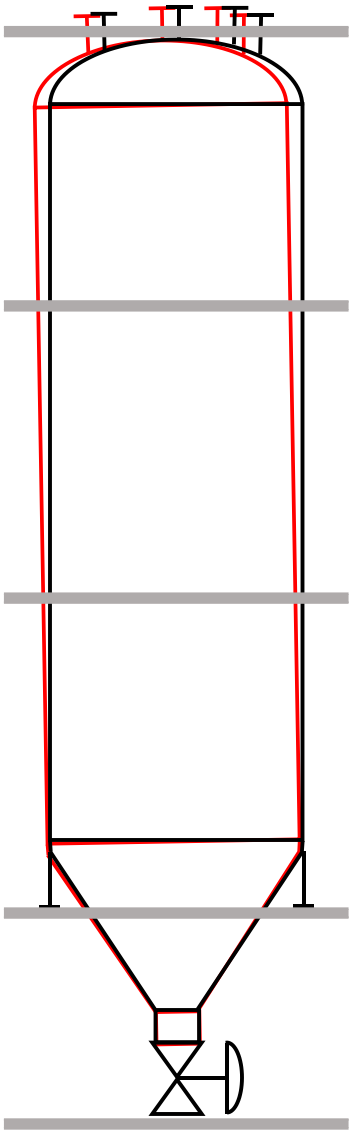
30 September–3 October 2019

Introduction

- Coke Drums are batch operated, the reliability and profitability are heavily influenced by how they are operated every day.
- US coker operation today is heavily influenced by “opportunity” crudes and running 10-16 hour cycles
- Industry needs:
  - an approach for ranking and optimization of process & operations versus reliability and profits
  - a tool to allow better **planning for maintenance, TAR** and **capital spending** at the refinery and across many different sites.
  - Reliable life extension of the coke drums and entire unit

Why Coke Drum Reliability Matters



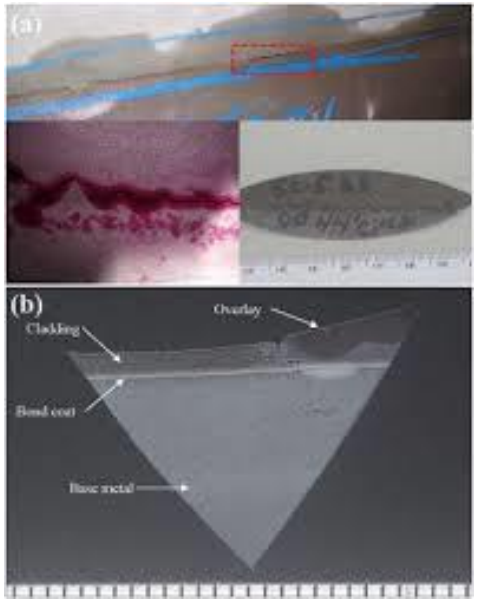
Approach - Critical Factors

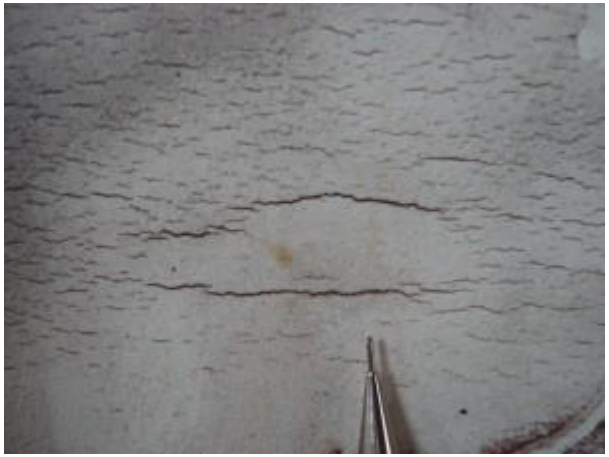
- Estimated drum life is set by a combination of critical factors, specific for each drum
- Critical factors are needed for different drum regions:
  - Shell - girth seams
  - Skirt-to-shell junction
  - Skirt
- Factors:
  - Design, maintenance and inspection practices.
  - Operations and Process – switch and quench severity
  - Observed damage – existing condition
- Critical factors drive assessment **predicts** and **extends** **useful life of the drums (If you actually do something!)**

Critical Factors Cause Cracking and Bulging

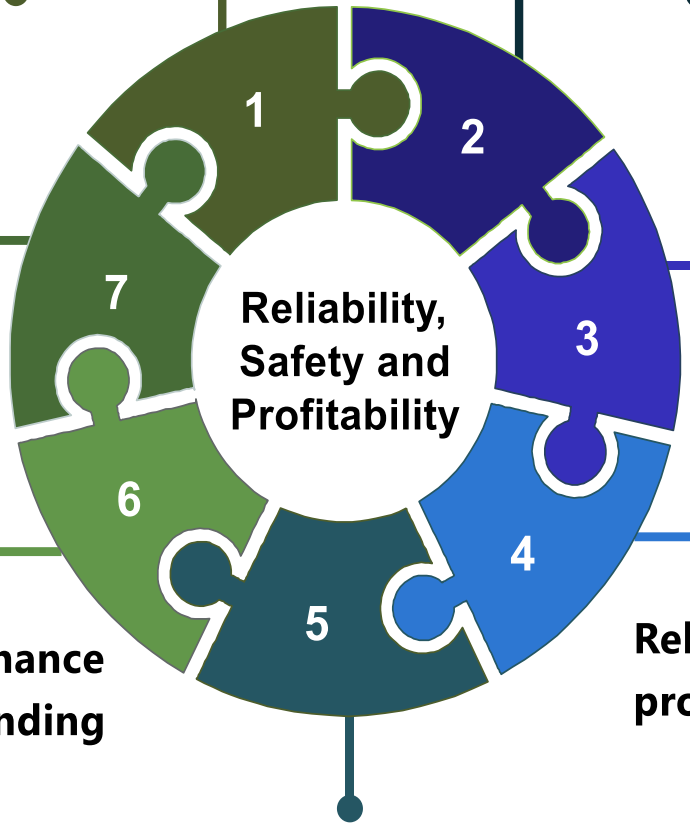
Shell - Bulging

Bulging





Approach with Site Personnel



SME's - process, operation, inspection, mechanical for site review

Present operating & process practices condition

Measure local stresses and temperature gradients - HMS

Reliability "score" ranking provides guidance on damage

Optimize daily operations versus drum damage

Proactive planning maintenance and capital spending

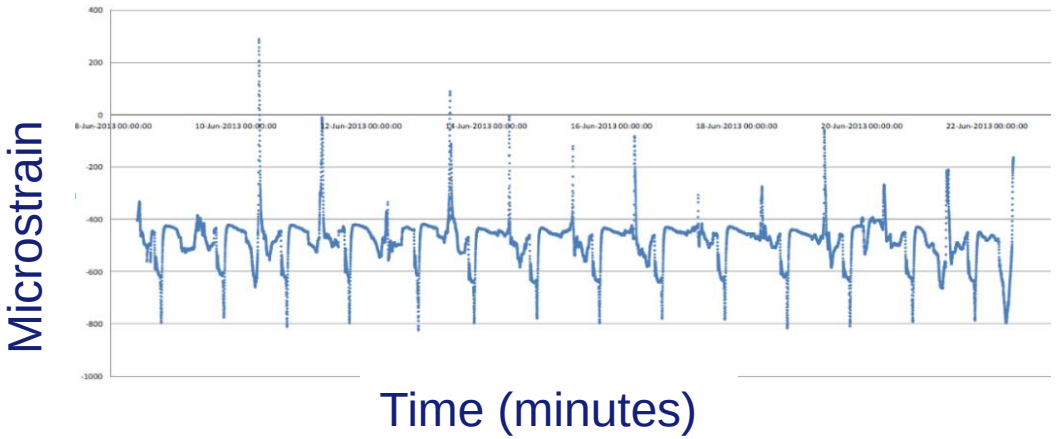
"Actionable" plan for inspection, maintenance and repairs

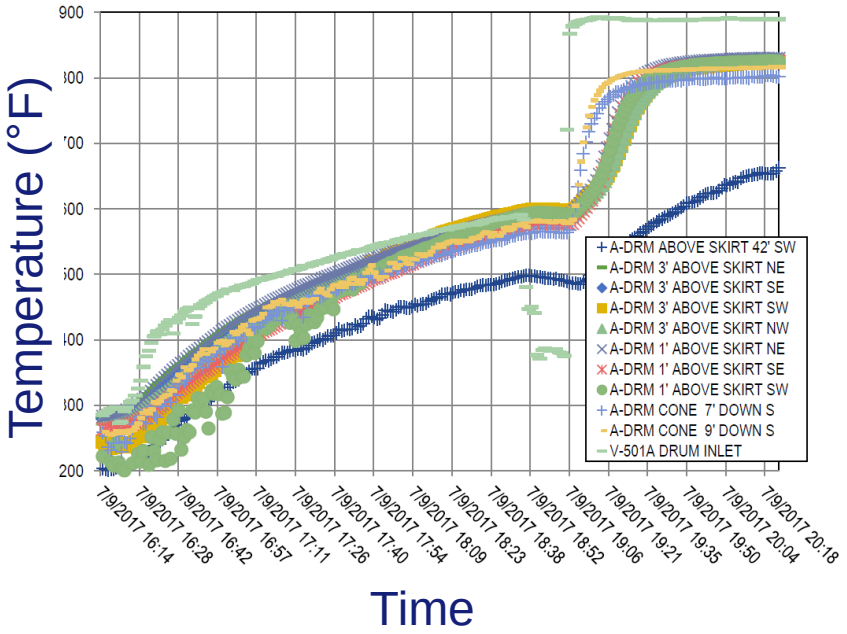
Critical Factors - Process and Operations

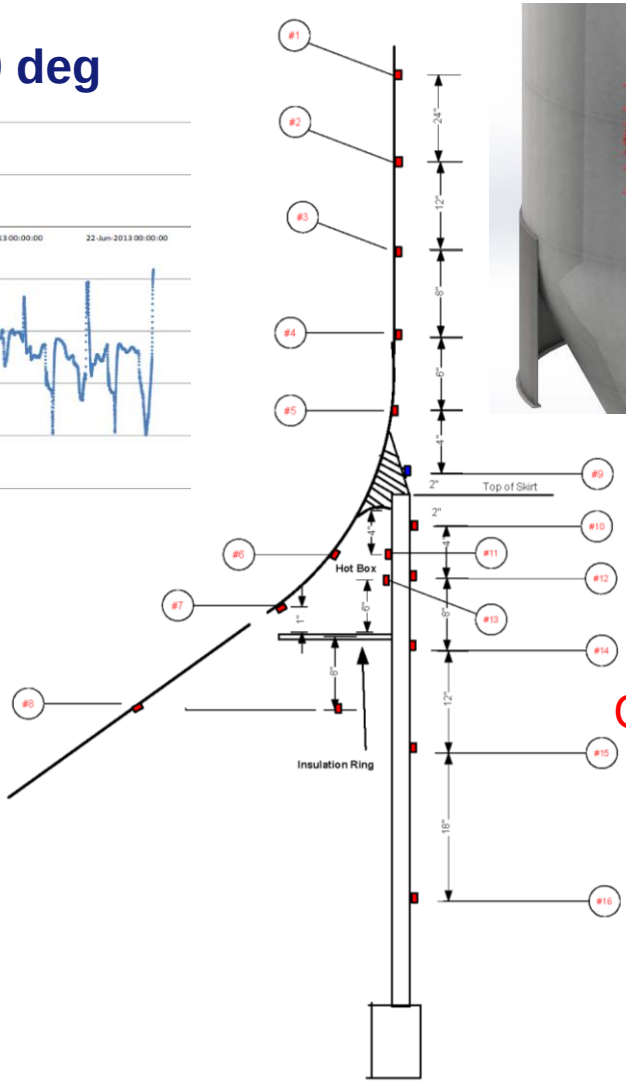
- Operating review is not just about data – it is an opportunity to **Optimize Process and Improve Daily Operation**
- Steam and water flow rates are reviewed and optimized for both operation / process efficiency and to reduce damage, cracking, and bulging.
  - Allow better conversion of feed, minimize hot spots
  - Improve consistency through better understanding
    - Inconsistent switch and quench procedures can cause significant stress and fatigue damage in shell and skirt.
- Measuring “actual” drum thermal gradients and strain gauges is imperative.
  - Accurately measure local drum response, linked to operation.
  - Evaluate effect of inlet types: side, dual, bottom, center.
  - Relate operations to stresses & damage.
- Closing the loop by teaching and training “inexperienced” operators.

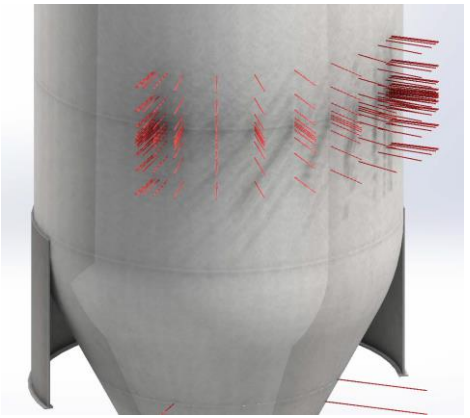
Health Monitoring Systems (HMS)

Axial Strain: Skirt-to-Shell Junction, 0 deg



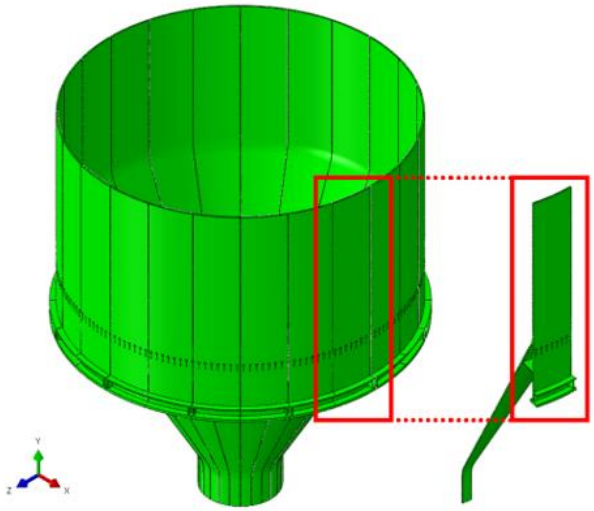


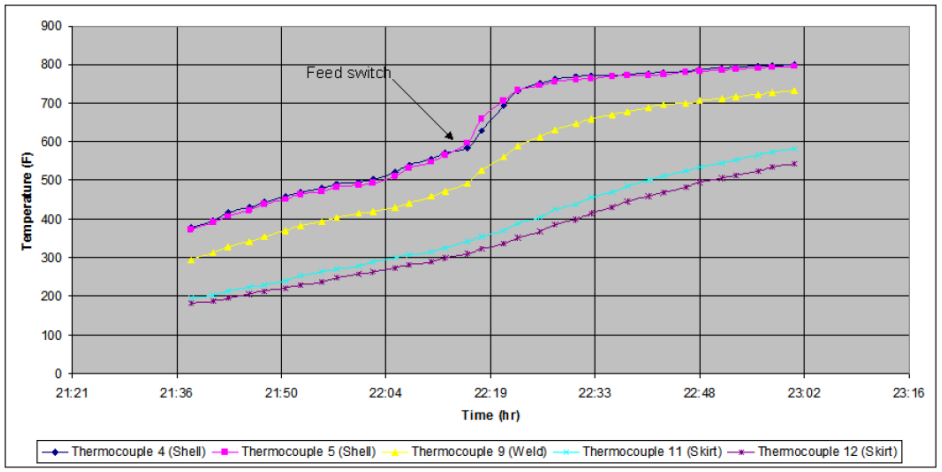


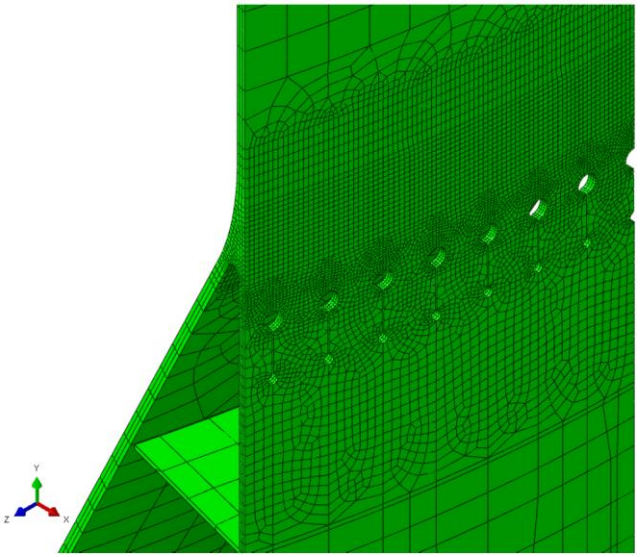


Thermocouple and Strain Gage Locations

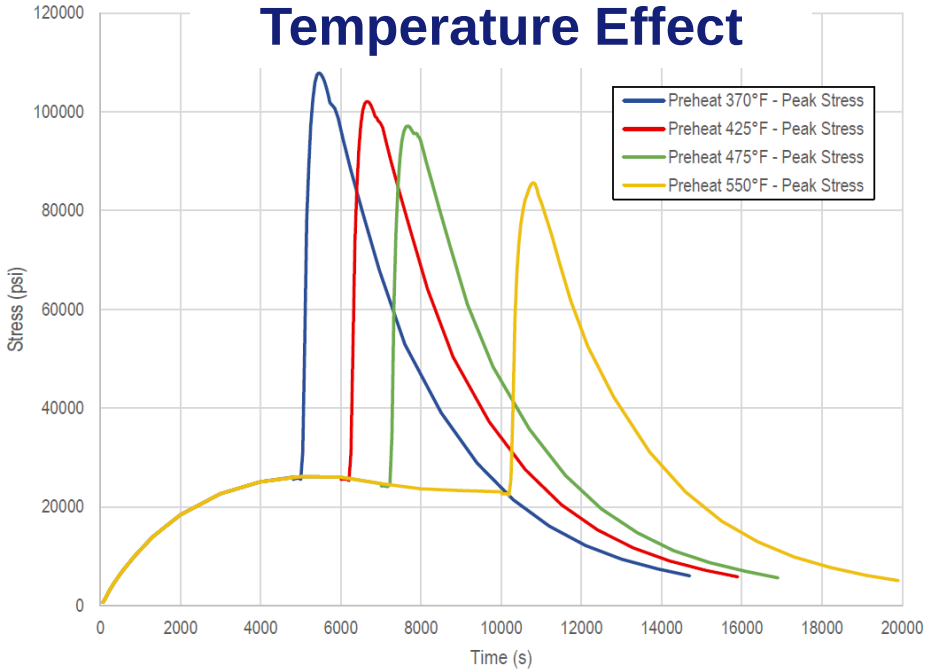
Critical Factors – Switch Temperature



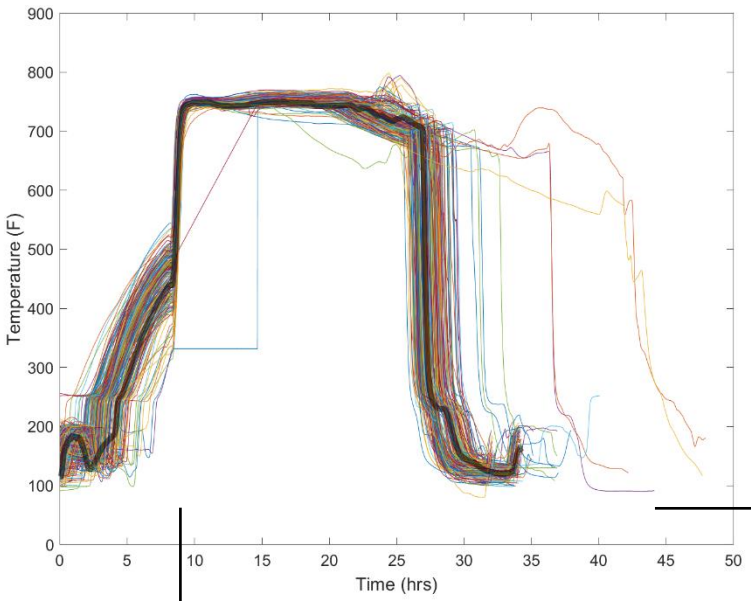


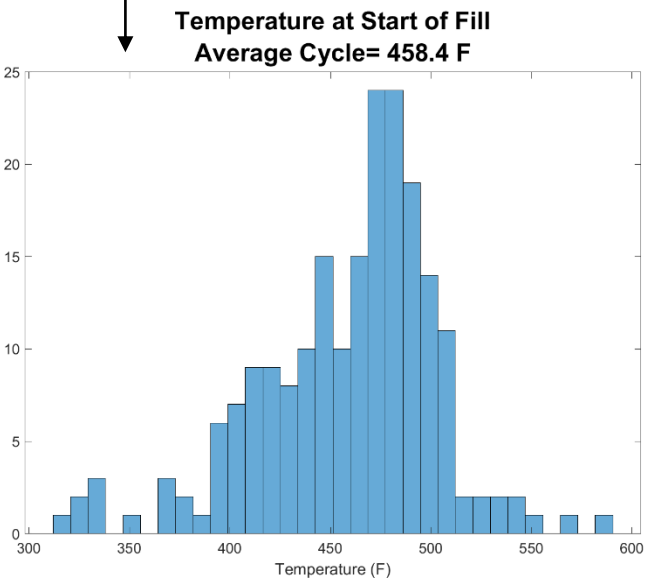


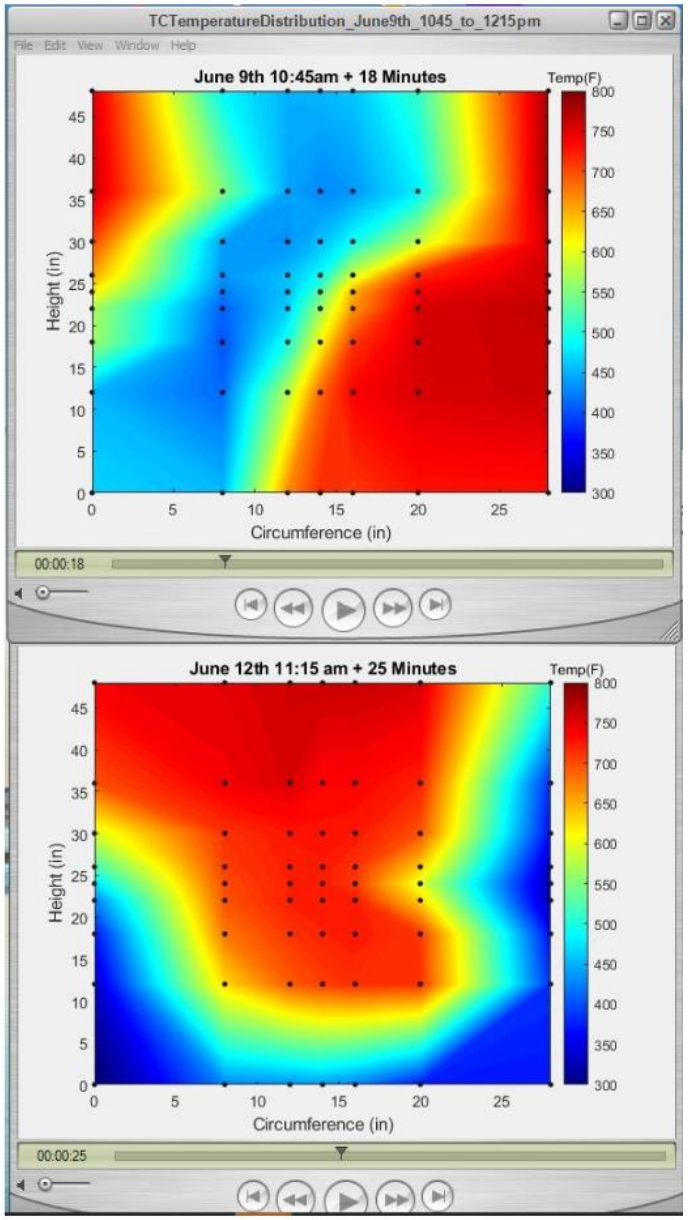
Preheat/Switch Temperature Effect



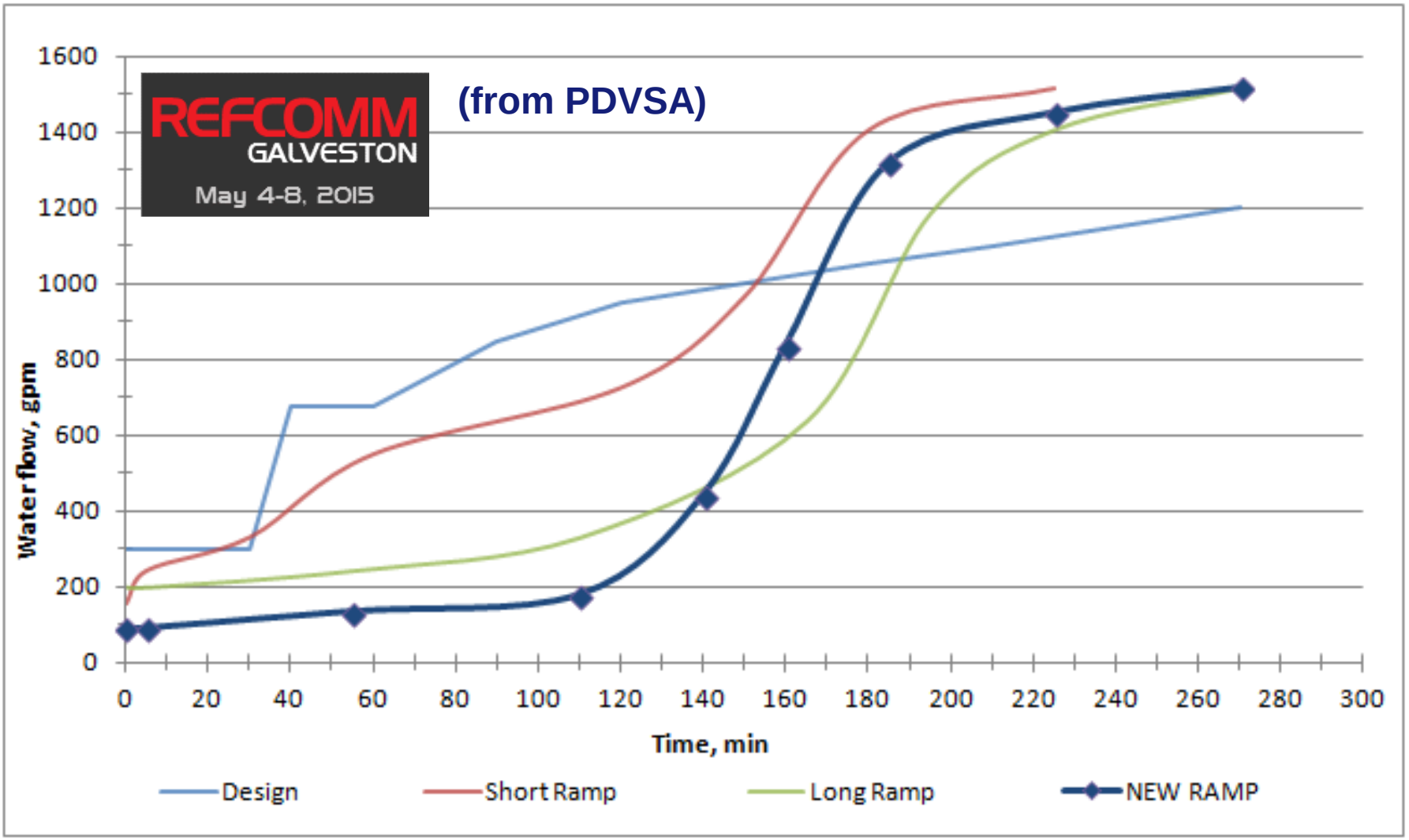
Critical Factors - Operating Data







Critical Factors – Improved Quench

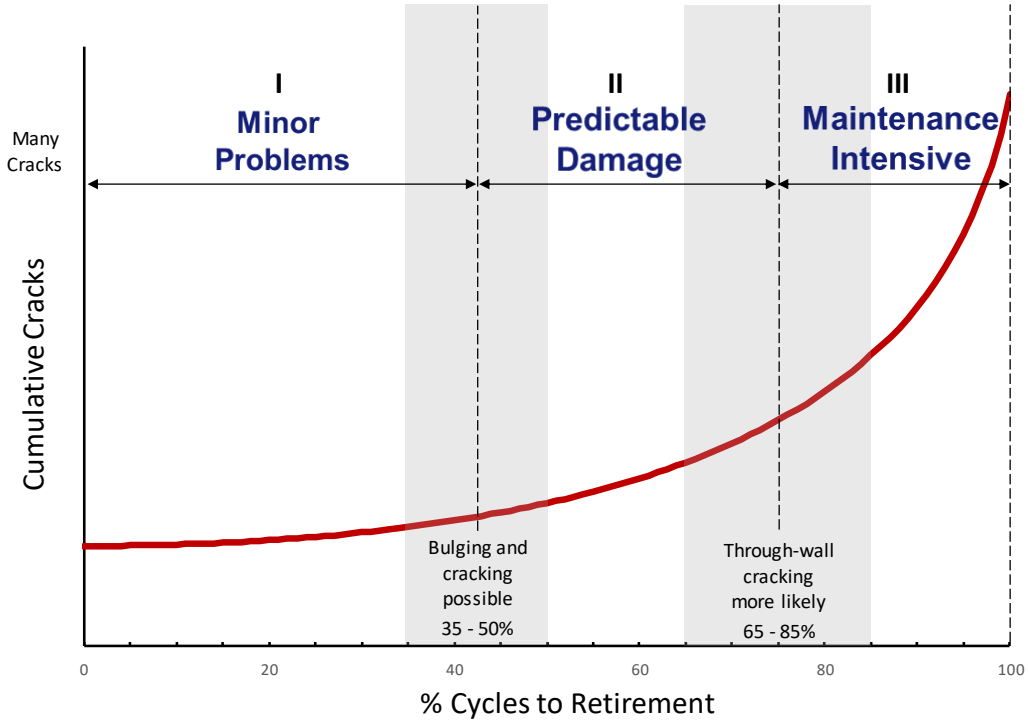


Pulling It Together

- Critical factors are combined to estimate fatigue life
- The combination is based on calibration to numerous case histories
  - Time to initial cracking and bulging
  - Time to first through-wall crack
- Maximize the reliability of the drums and minimize the lost opportunities
  1. **Provide near, mid, long-term** recommendations TAR(s)
  2. Reduce cyclic stress magnitude, damage, going forward
  3. Strategic and proper mechanical repair of damage

Case History - Drum Assessment Tool

1. Idea is that there are defined stages of coke drum life
2. Analysis tested/ultimately calibrated against industry and Becht data
3. Critical Factors: Shell, cone and skirt, welds, switch and quench, cracking, bulging, cycle length, coke type, inlet nozzle type, thickness etc.



- **Stage I**: Minor Problems
  - Proactive maintenance
  - Baseline and routine inspection
- **Stage II**: Predictable Crack Growth
  - More inspection
  - Planned repairs
  - Additional shutdown time required
- **Stage III**: Maintenance Intensive
  - More frequent shutdowns
  - Higher risk of unplanned outages

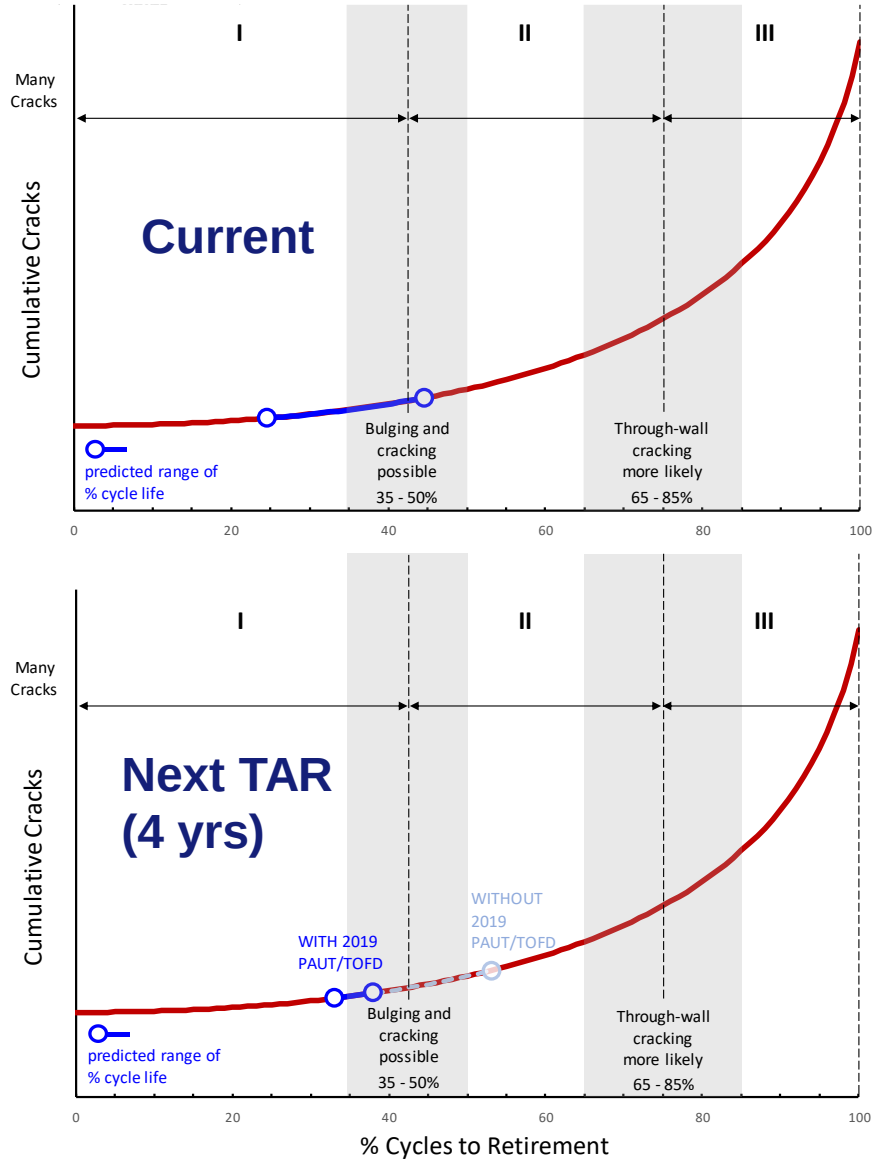
Goal Planned Spending versus unplanned

Case History - Girth Seam Results

- Results are provided as “quantitative”
- But goal is **forward-looking** 1-2 TARs out

Year	Accumulated Cycles	Retirement Life Fraction Consumed*	Comment
0	0	0.00	
11	2275	0.39	Current state
15	3103	0.53	TAR
18	3723	0.64	Reduce run length to help ensure no through-wall cracking
21	4344	0.75	
24	4964	0.85	Plan for replacement
27	5585	0.96	Likely replacement

* Based on retirement cycle life estimate of 5,830 cycles corresponding to no supplemental PAUT/TOFD inspection



Deliverables

1. Process/operations GAP analysis and review
2. Inspection/Reliability GAP analysis and review
3. Critical Factors Ranking and Risk Prioritization
4. Things to optimize or improve from 1 & 2
5. Update Best Practices
6. Develop action plan and TAR plan for next 2 TARs

Summary

- **Optimization** of drum performance to meet production, reliability and profitability goals **$$$$**
- Can **extend** useful drum life
- **Brings people together – Best Practices**
  Integration of inspection, maintenance, process and operations personnel for better decisions
- **HMS** findings must be continually **update**d and **incorporated**
- **Proactiv**e planning for **maintenance, TAR and capital spending** across one or multiple sites based on risk

Special Thanks

- **Mike Kimbrell**
  - 40 years experience – Becht Coker Process SME
  - **Formerly BP** - Process and Operations SME Coking worldwide
- **Mitch Maloney**
  - 40 years experience – Becht Coker Process SME
  - **Formerly ExxonMobil** – Process and Operations SME Coking Worldwide
- **Dave Dewees, PE**
  - 18 years experience - Becht Mechanical SME
  - Fatigue, high temperatures, thermal-stress analysis, crack growth
- **Bob Brown, PE**
  - 30 Years experience – Senior Fellow - Becht Mechanical SME and FFS Specialist
  - Fatigue, high temperatures, thermal-stress analysis, crack growth
- **Ranjan Nadarajah, PhD, PE**
  - 30 years experience - Becht Delayed Coking SME
  - **Formerly ExxonMobil** Mechanical coke drum SME
- **Clay White**
  - 36 years experience - Becht Materials and Corrosion SME
  - **Formerly Phillips 66** - Director Pressure Equipment Mechanical Integrity
- **Chuck Becht V, PE**
  - 15 years experience – VP Engineering
  - Fatigue, high temperatures, thermal-stress analysis, crack growth
- **Bobby Wright, PE**
  - 39 years experience – Becht Manager Refinery Services
  - **Formerly Tosco** and 29 years coke drum reliability

THANK YOU

Bobby Wright PE
Manager Refinery Services
bwright@Becht.com
281-723-4940

Charles Becht V, PE
Vice President, Engineering
CB5@becht.com
908-727-0976