CIA Inspection (US), Inc.

COKE DRUM RELIABILITY

Repair, Replace, Retire?

COKING .COM

HOUSTON, TX

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Background on CIA Inspection

- Started scanning delayed cokers in May/93
- On-line inspection technique characterizes internal profile of vessel
- High resolution video inspection of the interior of the vessel
- Complete on-line inspection performed in 4 hour window
- Have performed about 350 inspections throughout the world

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Why Profile Coke Drums?

- Bulges increase stress concentrations
- Focus inspection activities on failure prone areas
- Extend life through knowledge of drum condition
- Anticipate failures before they happen
- Minimize unplanned outages
- Gage rate of deterioration

Owner/Operator's Dilemma

- How to:
  - manage capital asset in responsible and cost effective manner
  - optimize process control to maximize throughput
  - improve reliability and reduce maintenance costs
  - maximize drum life
  - effectively plan for vessel repair/replacement

Coke Drum Failures

- Ultimate failure mechanism is crack initiation in plate-plate welds due to low cycle fatigue
- Almost all cracking occurs on circumferential welds
- Drums fail in a leak-before-break failure mode

Through-wall Crack

Extensive through-wall cracking started from inside

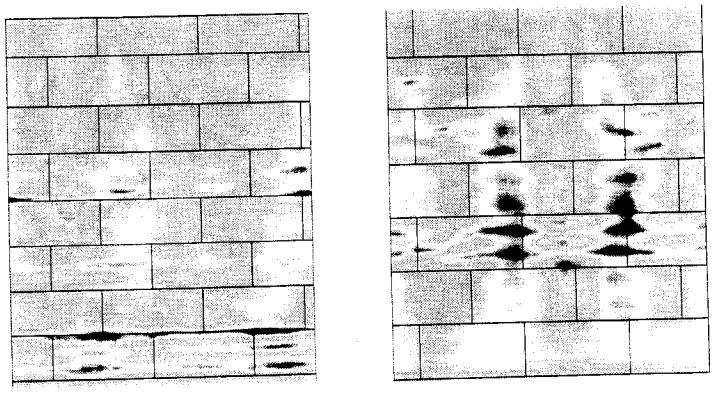
Coke Drum Life Improvement

- Typical questions regarding coke drum life:
  - When are my drums going to fail?
  - How long can we run the drums until the cracking goes through wall?
  - How long will the repairs last?
  - When will I have to repair/replace my coke drums?

Distortion Monitoring

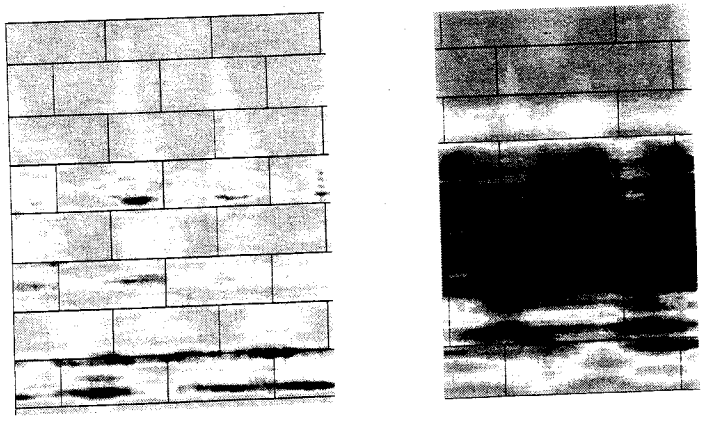
- Regular laser profiling of coke drums allows operators to:
  - Focus further inspection efforts on welds near deformed areas
  - Compare degree of deformity among their different drums
  - Compare change in drum deformities over time
  - Compare site specific results with industry wide trends
  - Model effects of a typical quench cycle using finite element modeling tools

Typical Bulge Maps



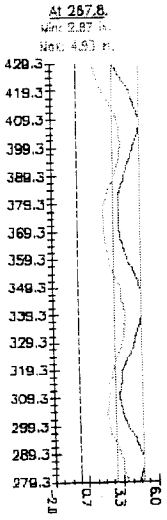
Mid Life Drums

Typical Bulge Maps



Late Stage Drums

Distortion Comparison



- Compare year over year scans using graph scale comparisons
- Red graph line is current scan, green line is last scan
- Blue lines indicate min and max bulge depth and green straight line is nominal
- Elevation marked on left of graph
- Depth size across bottom
- Azimuth at top of graph

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Replacement Decision – A Case History

- Lyondell-Citgo, Houston, TX
- Four coke drums manufactured in 1968, 1 chrome ½ moly, 25 foot diameter, 66 feet tan to tan, 16 hour cycles (end of life), Shot coke
- Numerous repairs and bulges
- Step thickness change from course 1 to course 7 – 1.125" to 0.716" including clad

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Case History

- Since 1995 had used CIA's laser and video inspection service to profile coke drums
- In November 2001, replaced all four coke drums using the vertical plate technology

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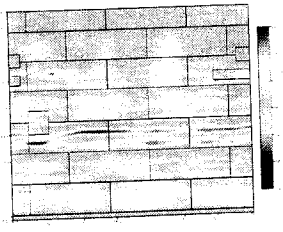
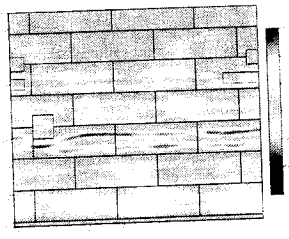
Profile of existing drum

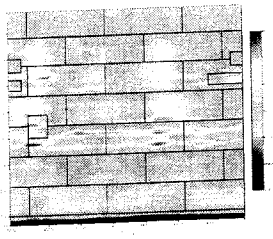
2000



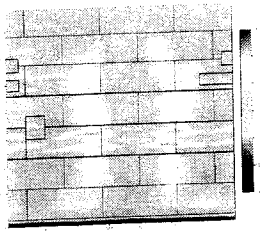
1999



1996



1995



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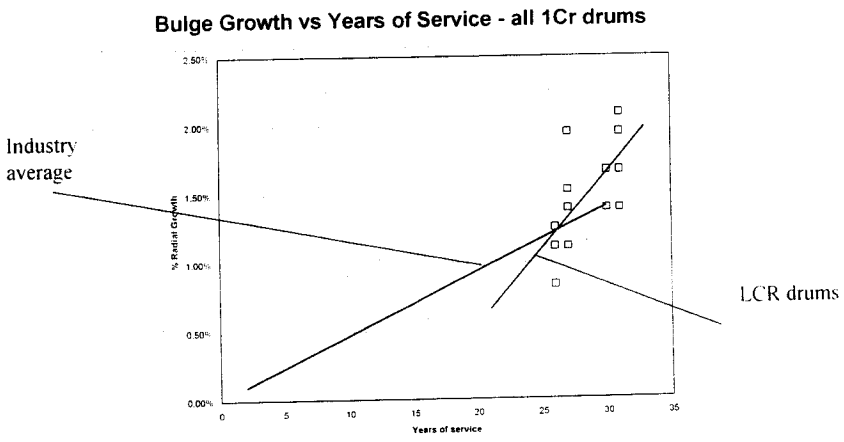
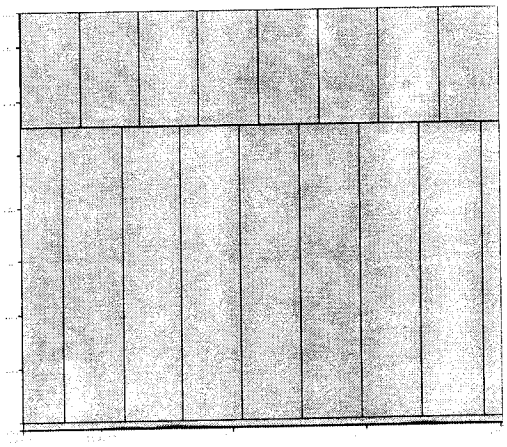
Case History – Drum Trending



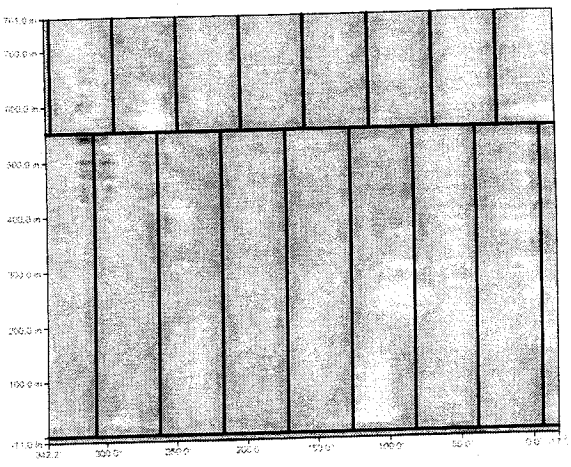
Case History – Vertical Plate Replacement

- Decided to use CBI's vertical plate technology to replace drums from tangent to tangent
- 40 foot plate and 26 foot plate (8 vertical sections)
- Three circ welds in total – bottom tangent to shell, mid tangent at 40 feet and top tangent at dome
- 8 vertical welds – 4 shop welded and 4 field welded

Case History – Baseline Scan 2001



Case History – Follow-up Scan in 2002



Summary

- Coke drum life improvement is a combined approach
- CIA along with its alliance partners can help the site make a repair, replace or retire decision
- CIA with alliance partners can help improve the reliability of your coke drums
- Improved reliability means improved profitability