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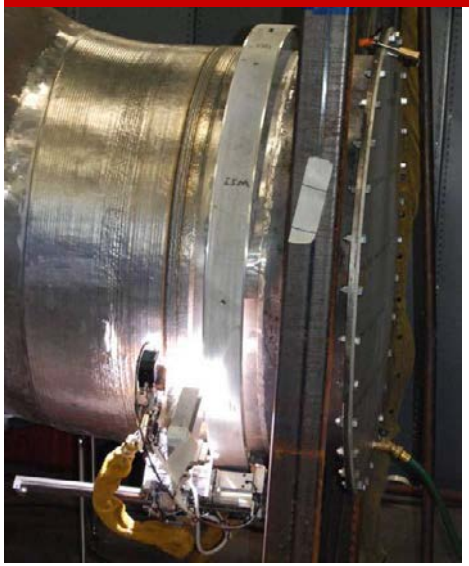
Coking.com®

MORE PRODUCTION - LESS RISK!



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Coke Drum Repair

October , 2011
Dusseldorf

By Cyril NARJOZ, Technical director Europe (CNarjoz@wsi.aquilex.com)
& Pedro AMADOR, SVP (PAmador@aquilex.com)

aquilex corporation

- North America
  - aquilex WSI NUCLEAR SERVICES
  - aquilex WSI
  - aquilex HYDROCHEM
  - aquilex SMS
- International
  - aquilex WELDING SERVICES B.V.
  - aquilex ARABIA

aquilex WELDING SERVICES B.V.

Corporate Headquarters
Atlanta Georgia

- Founded in 1978: orbital welding for nuclear ind.
- 1985: non nuclear services
- 1996: First projects executed in Europe
- 1998: offices in Rotterdam
- 2002: WSI joins Aquilex group
- 2004: creation of shop in Poland
- 2008: AWS move to Hellevoetsluis (NL)
- 2010: Creation of Aquilex Arabia (KSA)

European Headquarters
Hellevoetsluis The Netherlands

<u>Key figures</u>:

- Annual Sales 2010: 264M$ (incl. AWS: 21,7M$)
- Human Resources: WSI: 210 persons + ~1100 welders
  AWS: 28+71 persons + ~50 welders
- Equipments Resources: WSI: more than 300 welding robots
  AWS: ~50 welding robots
- Over 300.000m² of overlay experience

European Shop
Radom Poland

Technology. Safety. Result. for your outages

Industries Served

Broadly serving the Energy Sector with
Superior Technology delivered by Highly Trained Craft

Technology. Safety. Result. for your outages

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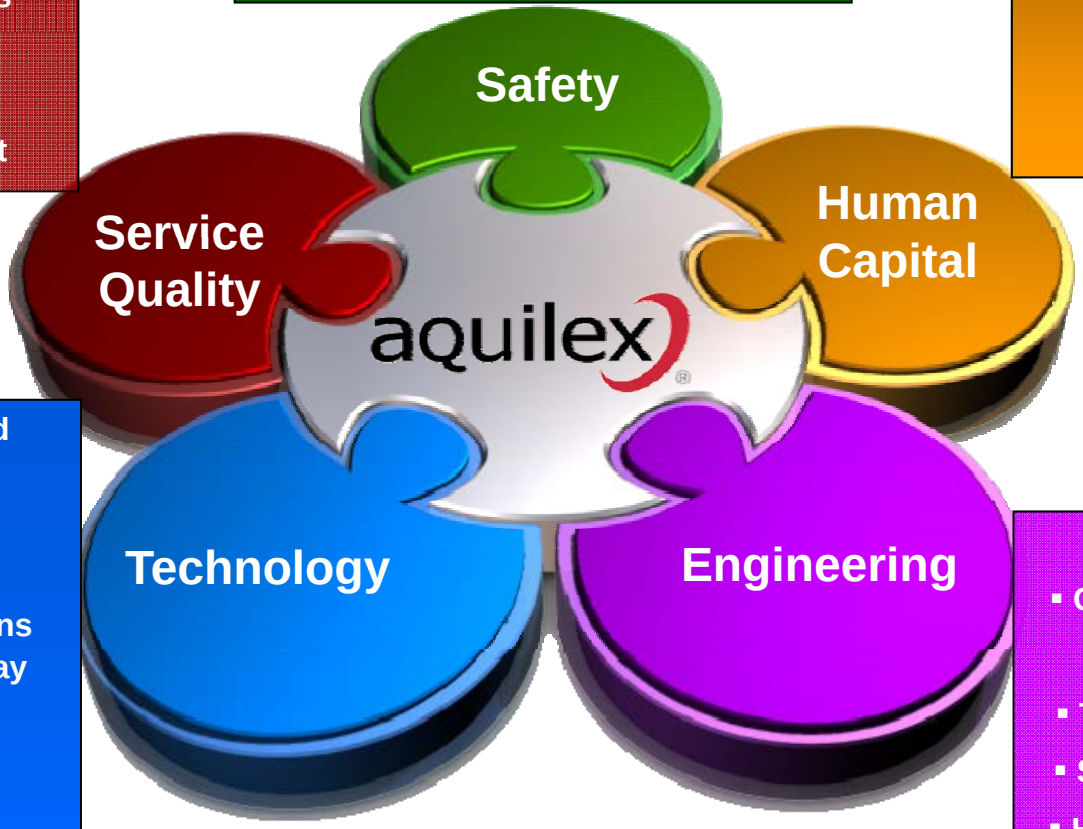
- 24/7 Emergency Response
- Global Deployment
- Seamless Commercial Platform
- Managed Services
- Continuous Improvement
- Lean Management

- TRIR 0.44…nearly 4M man-hours
- Behavior Based Safety Process
- Leadership/Accountability Focus
- Cross Industry Experience
- Industry Leading Technology

- 4000 Strong and Growing
- Continuous Investment:
  - Enhanced Skills
  - Safety
  - Supervision
  - CDP



- 100+ First-of-a-Kind solutions
- Multiple Patents
- Safety
  - Remote Operations
  - Out of Harm's Way
- Quality
  - First Time
  - Consistency
- Productivity
  - Eliminate Fatigue
  - Shorter schedule

- Metallurgy
- Chemical Engineering
- FEA capability
- Tooling Development
- Software Engineering
- Hardware Engineering
- Welding Engineering

Technology. Safety. Result. for your outages

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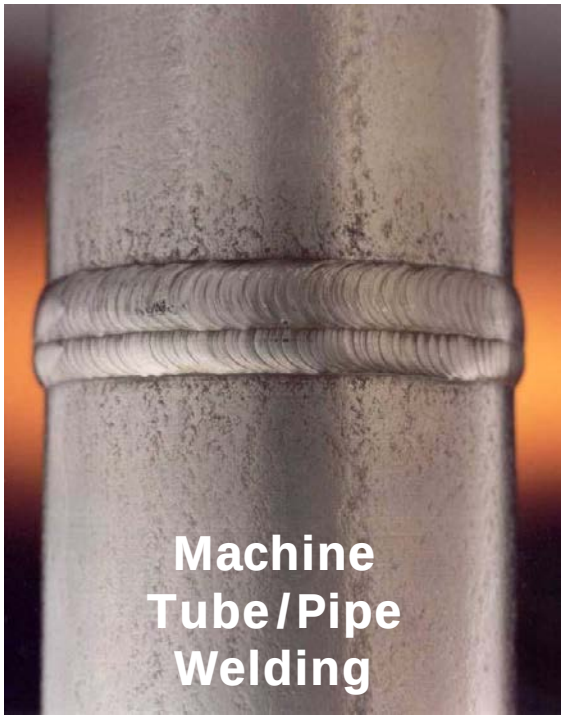
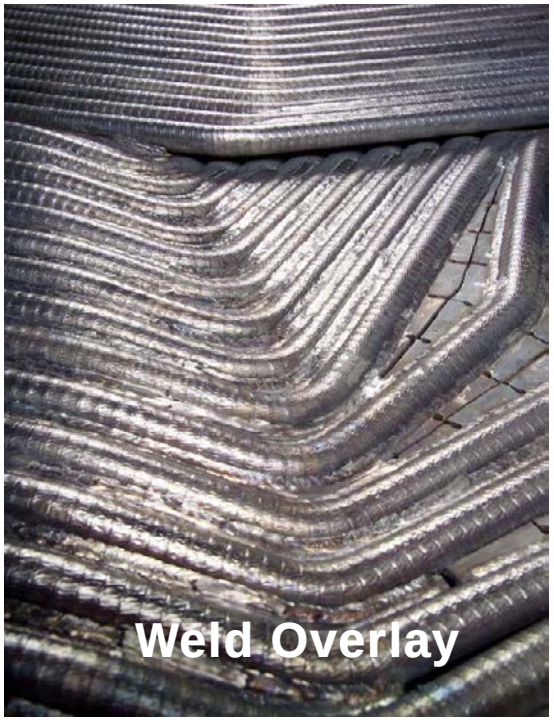
Specialty repair solutions that use technology and automation to deliver better results.





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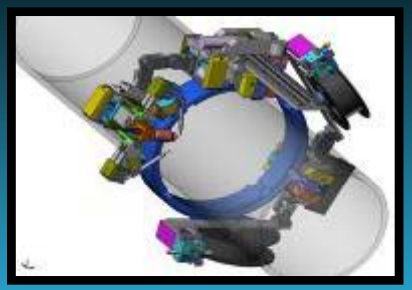
Technologies

Tooling Engineering

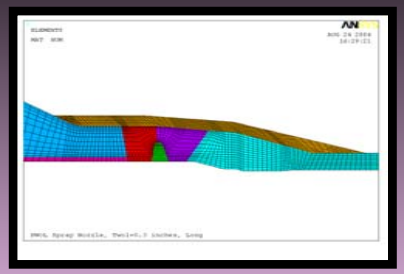


- Mechanical Systems
- High Definition Video
- Controls
- OEM Modifications

Materials & Welding

- Codes & Standards
- Welding Processes
- Corrosion Coatings
- Metallurgy

Project Engineering



- Solution Design
- Application Eng.
- Field Engineering
- Process Procedures

Operations Support

- Fleet Maintenance
- Mobilization Staging
- Site Technicians
- System Testing

- FEA Modeling
- Integrated 3D CAD
- Controls Simulation

- Mockup/Training Center
- 300+ Traveler Library
- 1050+ Welder Certifications

- 600+ Procedures
- Temperbead, E/C, etc.
- Level 3 NDE Capability

- 180 Automatic Systems
- 75 Semi-Auto Systems
- 40 Remote Vision Sets

Applied Engineering Excellence

Technology. Safety. Result. for your outages

Topics

- Typical Coke Drum Repairs
- Locations of defects
- Examples of Repair Methods
  - Bulge Repair with Temperbead
  - Skirt to Shell weld Repair Utilizing Temperbead
  - Skirt replacement and Shell Repair
  - Repair / Restore Corrosion with Automatic Weld Overlay
- Moving Forward

Coke Drums

- API - 80% of all coke drums in operation are experiencing cracking
- Cracking occurs within 5 to 7 years
- Most are Cracking and Bulging
- Why are they cracking and/or bulging
  - Operating on shorter cycles
  - Running different feedstocks
  - Weren't designed for low cycle fatigue or compressive strength of coke

Coke Drum Repair Types

- Cracking (Partial and Through Wall)
  - Circumferential seam
  - Skirt to Shell welds
  - Shell plate cracks
- Bulging
  - Circumferential Seams
  - Shell Course
- ID Erosion/Corrosion
  - Delamination/wear of cladding

Typical Skirt Cracking

Company	Location	Shell Cracking	Bulge Mitigation	Skirt Repairs	Knucke Repairs	Cladding Repair	Qty	Repair Date
ExxonMobil	Baytown							
Chevron Corp.	Pascagoula						1	Sep-10
ConocoPhillips	Sweeny						4	Mar-09
Citgo Petroleum Corp.	Lake Charles							
Valero Energy Corp.	Port Arthur						1	Mar-10
Marathon Petroleum Co. LP	Garyville						1	Oct-09
Motiva Enterprises LLC	Norco						4	Oct-09
Chalmette Refining LLC	Chalmette						1	Oct-08
National Cooperative Refining	McPherson							
ExxonMobil	Joliet							
Flint Hills Resources	Rosemount						2	9-10
ConocoPhillips	Billings						1	2/6/2008
ConocoPhillips	Carson							
Chevron Corp.	El Segundo						4	10/1/2010
ExxonMobil	Torrance						12	8/12/2010
Shell Oil Products US	Martinez						2	10/1/2007
BP	Carson						6	5/2/2009
Suncor	Ft. MacMurray Upgrader						1	Sep-08
Suncor	Ft. MacMurray Upgrader						1	Jun-09
Suncor	Ft. MacMurray Upgrader						1	Sep-10
Suncor	Ft. MacMurray Upgrader						1	Jun-11
Suncor	Ft. MacMurray Upgrader						1	Sep-11
Suncor	Ft. MacMurray Upgrader						1	Oct-11
		19	**12**	**20**	**2**	**13**	**42**	

Coking Cycle

Some Key Points of the Coking Cycle

Hot vapor fills drum, which grows larger

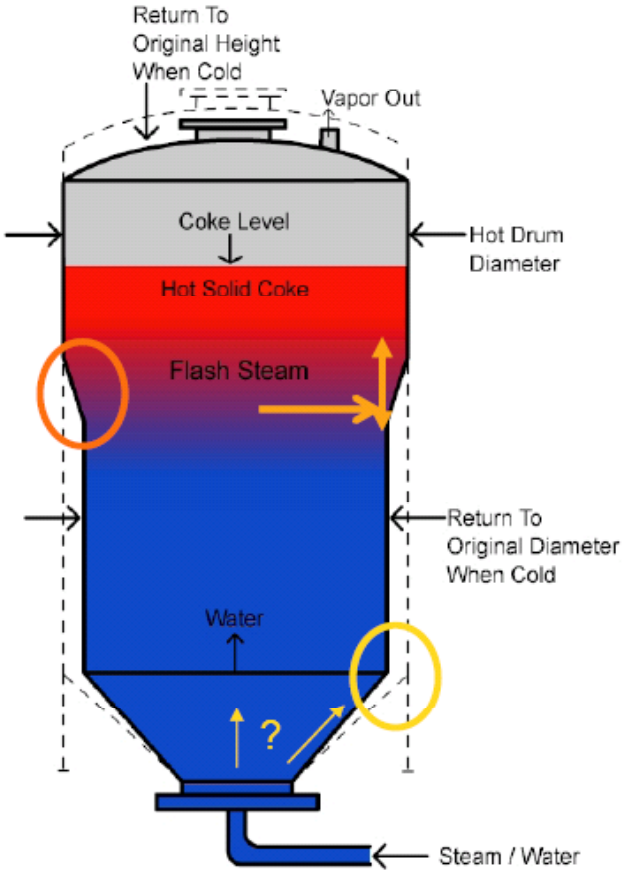
Hot oil (900F) fills the drum and hardens as it cools, cracks and releases vapor

Steam is used to remove volatile vapor

Water enters from bottom to cool the coke bed, becomes steam and flows up the center or outside along the walls

The coke drum contracts in diameter and height as it cools and “crushes” the coke

Eventually water can form and fills the drum



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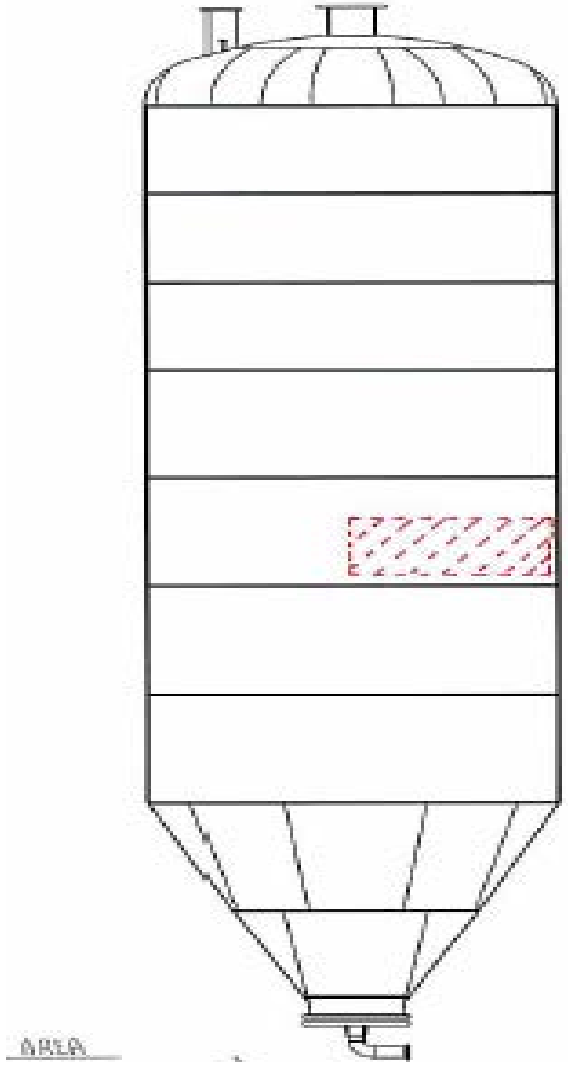
Bulge Repair of Coke Drum Utilizing Temperbead

Basic data

- 8 Coke Drums
- Material: SA 263 Grade C
- Wall Thickness: 22.3mm
- Diameter: Ranging from 7925mm to 9755mm.
- Height: Ranging from 20m to 29m
- One of the Cokers was experiencing excessive bulging due to fire in drum



Refinery in Canada

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Bulge Repair of Coke Drum Utilizing Temperbead

Bulge Severity and Growth

- Customer used Stress Engineering's BIF to **evaluate bulge severity** of the drum surface.
- Result were intended as a guide to **rank bulges** for inspection priority as a function of their likelihood to incubate cracking.
- BIF factor **correlates** the geometric bulging patterns of past cracking histories, developed from data from other coke drums, compared to the bulges on the coke drum being evaluated.

BIF	Internal Cracking Likelihood
≥ +2	Severe
+1.5 to +2	Very High
+1 to +1.5	High
+0.75 to +1	Medium
0 to +0.75	Low

Of the eight drums reviewed, 1 Drum was identified with the most severe bulging at 2 Locations. We name them Bulge A & Bulge B.

Courtesy of Stress Engineering Services Inc.

Refinery in Canada

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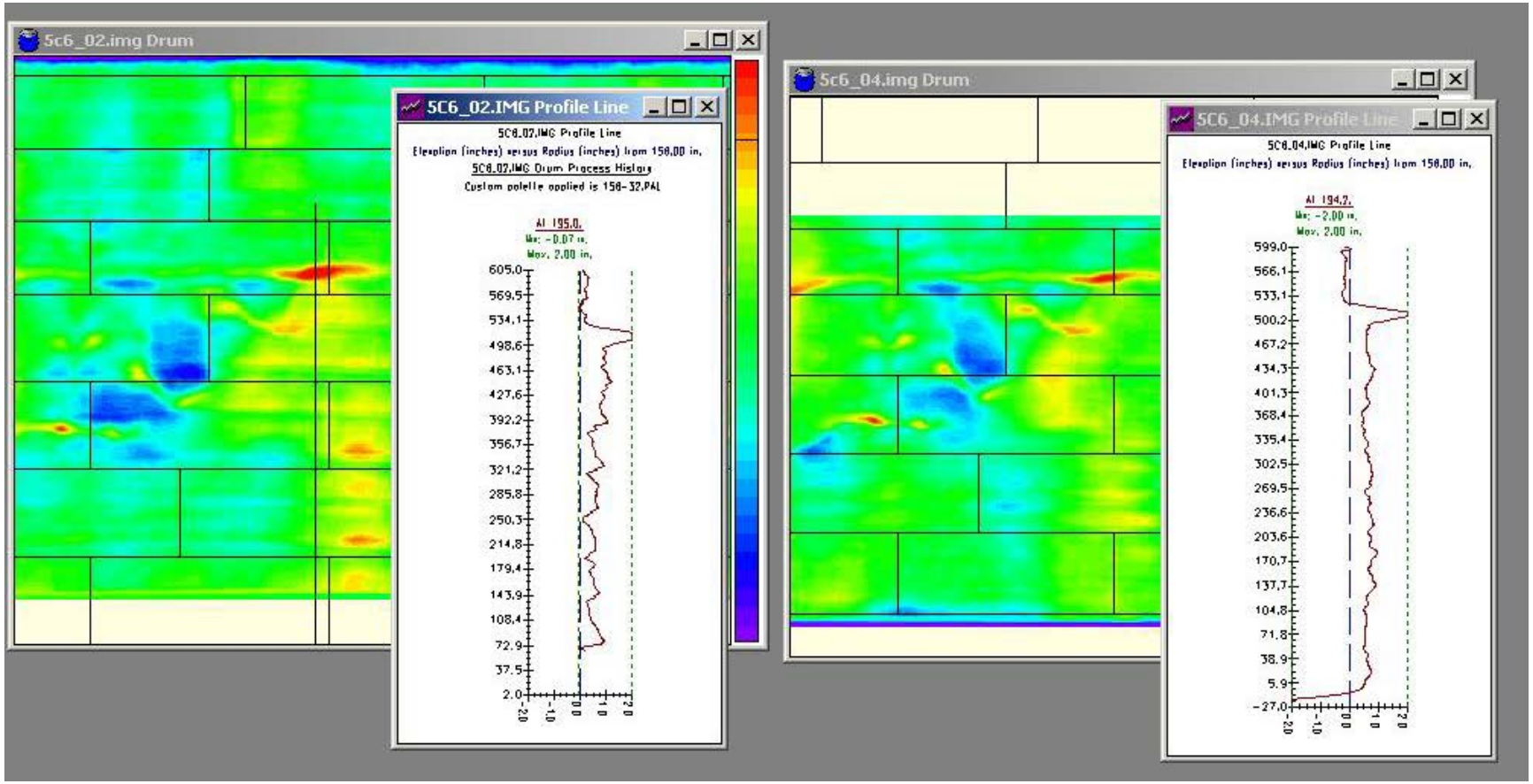
Bulge Repair of Coke Drum Utilizing Temperbead

Compare 2002 and 2004 Bulges



Courtesy of Stress Engineering Services Inc.

Refinery in Canada

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Bulge Repair of Coke Drum Utilizing Temperbead

FEA Performed

- Stress Engineering performed FEA to validate overlay as a mitigation of the problem
- Results Showed overlay reduces the stress on the bulge
  - Bulge peak hoop stress was reduced by 43% and 49% respectively on weld ID and OD
  - Bulge peak axial stress was reduced by 43% and 49% respectively on weld ID and OD
- The life of the repaired bulge is controlled by the hoop stress at the taper
- Increased Life Expectancy of Coke Drum by over 3X

Refinery in Canada

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Bulge Repair of Coke Drum Utilizing Temperbead

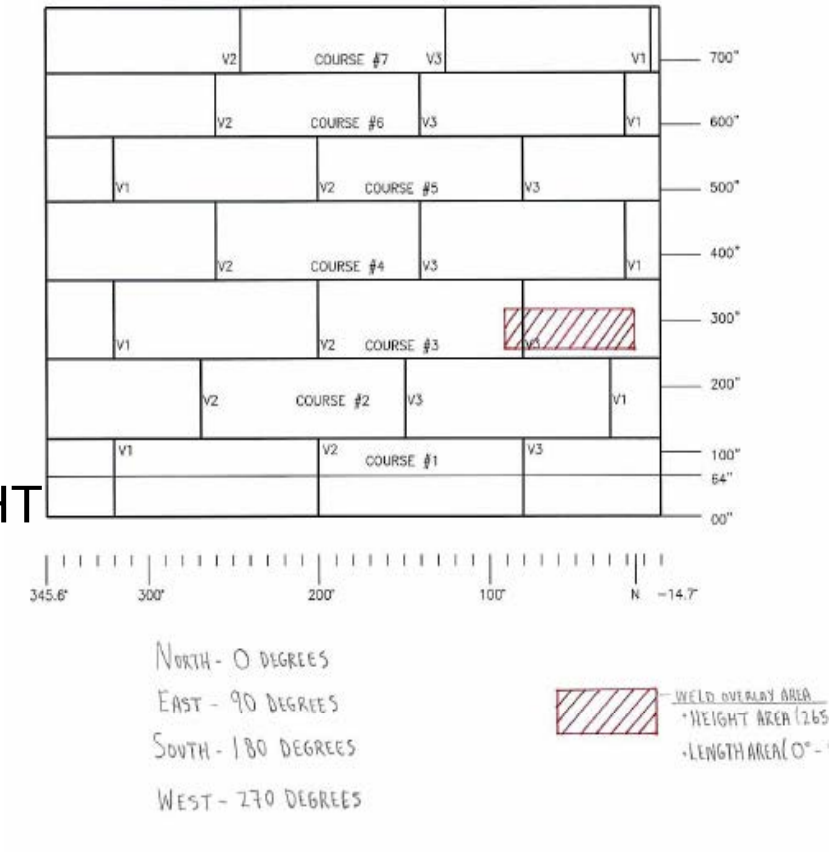
Bulge Overlay

- Bulged area overlaid: 6.5m x 2m

- Applied Alloy 625, 9mm thick (2 layers), overlay utilizing temperbead utilizing (2) PLC controlled Unifuse Weld Systems

- Temperbead eliminated the need for PWHT

- Post Soak of 450º F(233C)for 2 hours to eliminate any potential for hydrogen cracking



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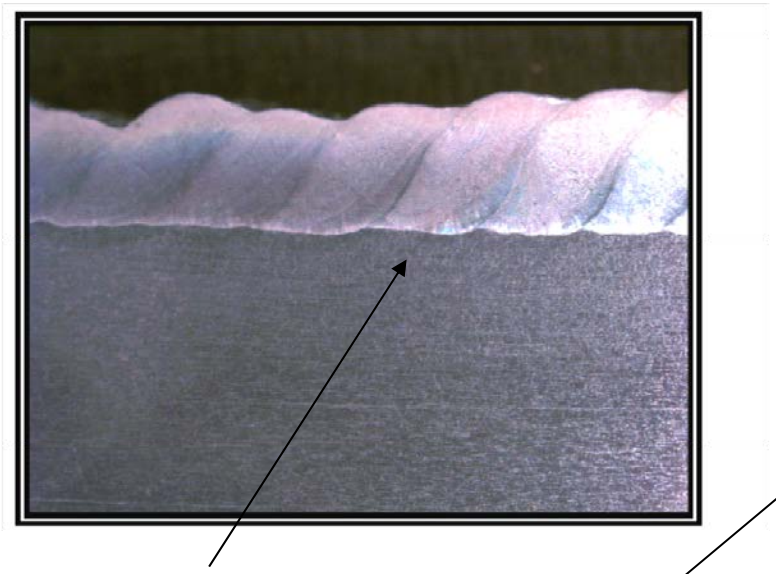
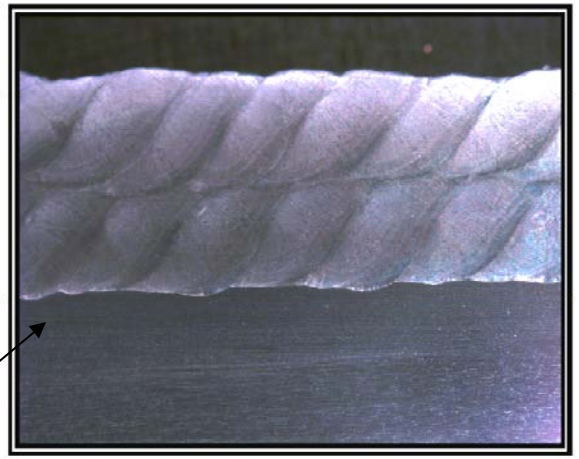
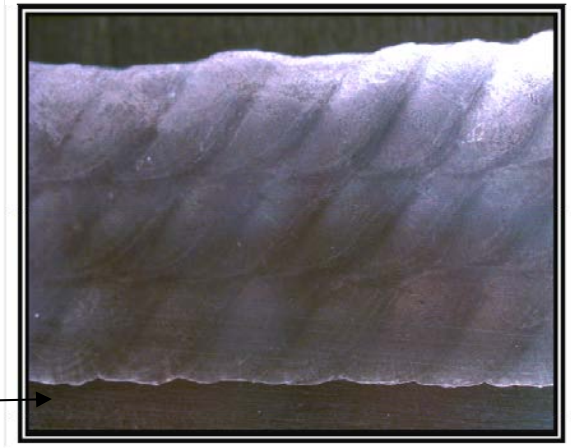
Bulge Repair of Coke Drum Utilizing Temperbead

Temperbead Welding



HAZ created by 1st weld layer





HAZ is tempered by deposition of successive layers

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Bulge Repair of Coke Drum Utilizing Temperbead

Conclusion

- Assessment by Stress Engineering quantified remaining life of bulge, and validated overlay process
- Overlay extended life of drum (bulged area) by 3X
- Unifuse® Overlay controls enabled temperbead application and increased productivity

Refinery in California

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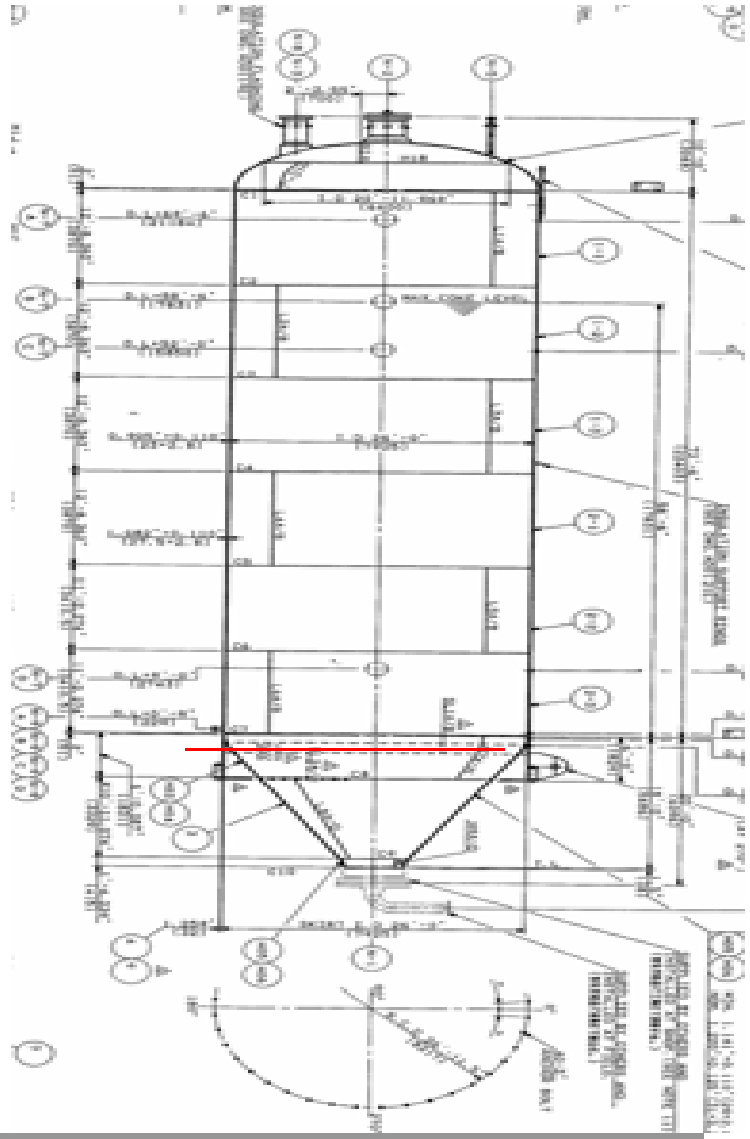
Skirt to Shell Weld Repair Utilizing Temperbead

Skirt Cracking

- 2 - Coke Drums
- Tower details:
  - SA-387-Grade 11 material
  - 31.7m tall
  - 8m ID
  - Original wall thickness 31.75mm
- Turnaround inspection:
  - 2003 T/A repaired weld seams in Coker # 2
  - May 2006 found many indications approximately 5mm deep, 25mm long, throughout the entire circumference of the weld seam in both drums



Refinery in California

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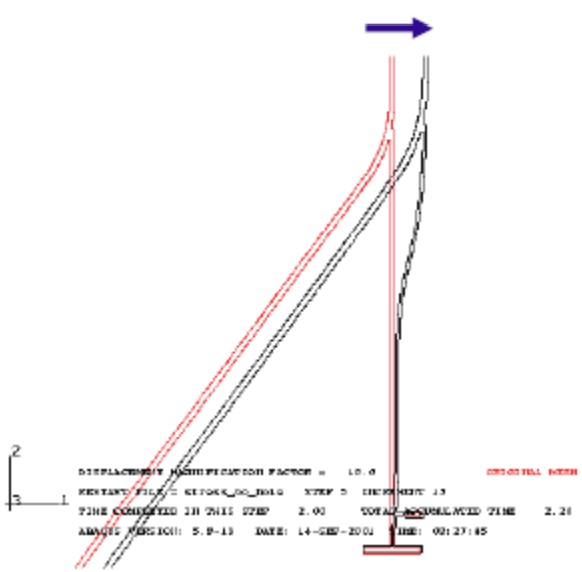
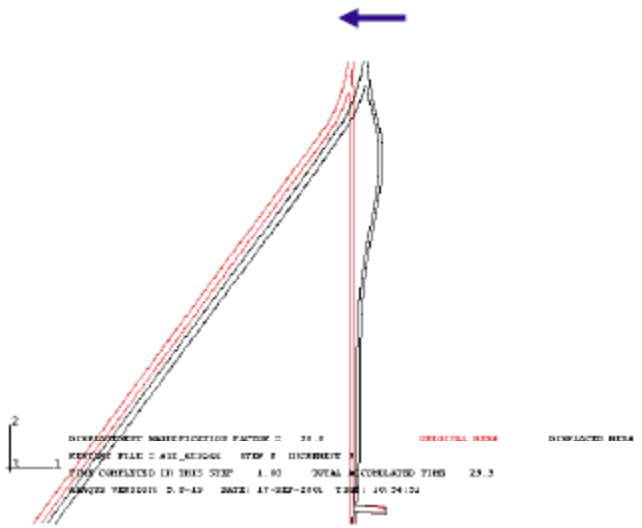
Skirt to Shell Weld Repair Utilizing Temperbead

Skirt Cracking

During Quench - Skirt is Pushed and then gets Pulled by Knuckle

DISPLACED SHAPE AT THE END OF FILL





DISPLACED SHAPE 1 HOUR INTO QUENCH

**Courtesy of Stress Engineering*

(MAXIMUM STRESS DURING QUENCH OCCURS HERE)

Refinery in California

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Skirt to Shell Weld Repair Utilizing Temperbead

Customer Challenge

Client options:

- Stick Welding:
  - Already had contracted with local general contractor to gouge and re-weld, and it was going to take 3 outages to complete.
  - 3 Outages x 5 days = 15 Days required
- Automated Welding :
  - Utilize Temper bead technique
  - Work on both Coke Drums simultaneously
  - Eliminate PWHT

Refinery in California

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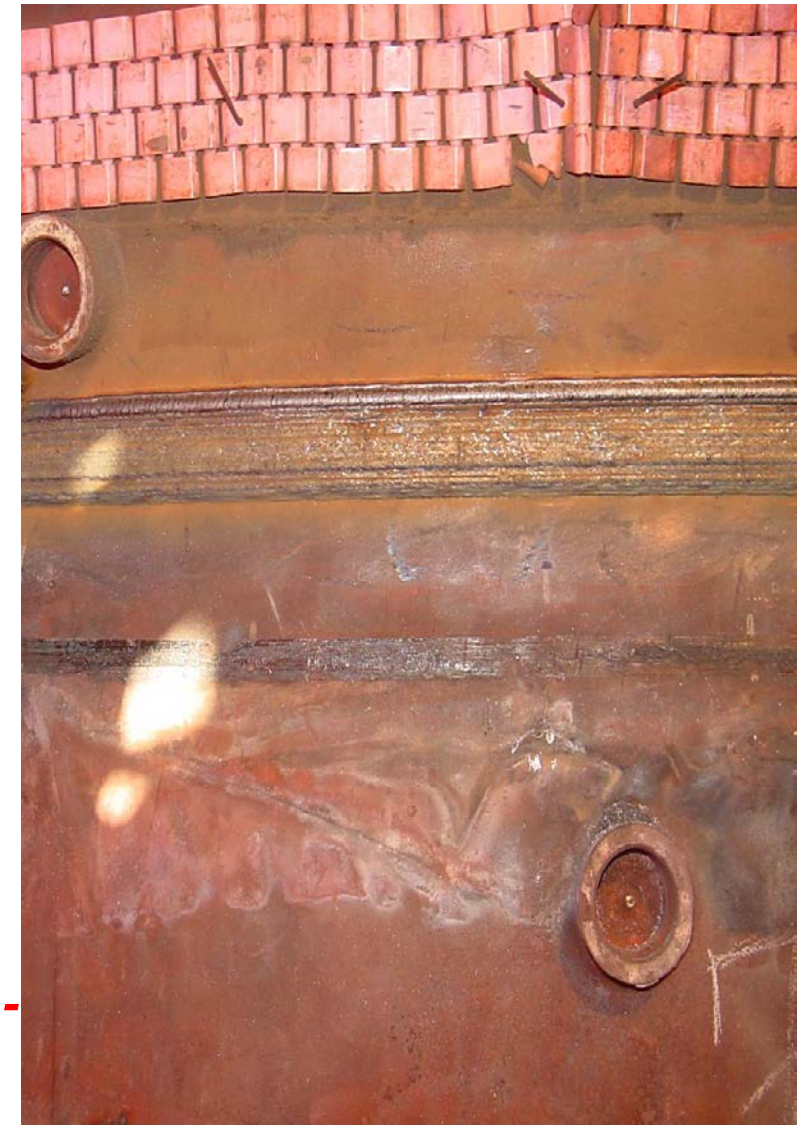
Skirt to Shell Weld Repair Utilizing Temperbead

WSI Approach

Engineered Repair Design:

- Utilizing 8 Automated Weld Systems
- Machined and Re-Welded Circ Seam using Temperbead WPS
- Post Soak used, eliminated PWHT
- UT Shear Wave acceptable
- 5 day Schedule for the welding of both Coke Drums
- Savings $$$
  - Customer avoided 10 days of Downtime

- ***Recently inspected after 1000 cycles - no cracks reported***



Refinery in California

Skirt to Shell Weld Repair Utilizing Temperbead

Schedule

- Schedule was developed with the integrated team: Operations, Maintenance, Safety, Engineering, and Corporate Executives.
- Project Team reviewed and approved the entire plan…Repair and Safety
- This was an emergent project completely mobilized within 2 weeks of notification

Refinery in California

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Skirt to Shell Weld Repair Utilizing Temperbead

Customer's Challenge

- 12 Drums
- Material: SA 387-12-CL2
- Drum Thickness: 1.377"
- Height: 90' Tan - Tan
- Diameter:18'5" ID

- Customer was experiencing cracking below skirt to shell weld. Changed the skirt design (key hole slot) to reduce stress on skirt to shell weld.

Refinery in Southern California

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Coker Weld Overlay Project

Project Overview

- T/A to Retrofit (4) four Coke Drums to accept new Delta Valves
- Coke Drum Material: SA387, Grade C, 1 ¼ Cr ½ Mo, 25mm thick
- Perform repairs to existing 410 explosion bonded cladding by applying over 115sqm of Inconel 82 Overlay in cone section above bottom nozzle
- Schedule: 10 days for all four drums total completion

Refinery in Southern California

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Coker Weld Overlay Project

Customer Challenge

- (2) Large projects occurring in Coker (Installing Delta Valve's and Overlay work)
- Schedule: 10 days

Project Planning

- Provided Planner to coordinate schedule and activities with others
- Developed detailed ventilation plan so other contractor personnel can continue to work while WSI performed our scope
- Provided crew of 8 Indirect personnel for entire project and 8 weld operators per coke drum working two shifts
- All work performed under WSI "R" stamp and QA program

Refinery in Southern California

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Coker Weld Overlay Project

WSI Solution

- Utilized 4 ***Unifuse*** PLC controlled Automated Weld Systems per drum (16 systems)
- Met customer's 10 day schedule
- Took on additional scope during the T/A
- Safety: Zero lost time accidents

Moving Forward

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Identify Potential Repair Scenarios for Cokers

- Skirt Repairs
- Bulge Mitigation
- Partial Crack
- Through wall Crack (External or Internal)
- Cladding Restoration
- Knuckle Cracking
- Delta Valve Replacement
- Piping Repairs

Select Repair Process and Fillers for Each Scenario

- Repair NDE Practices
- Through Wall Groove Weld Repair with PWHT
- Temperbead Repair with or without PW Bake-out
- Temporary Repair (non-code)
- Window Replacement
- Others?

(Discuss PH and PWHT)

Questions & Discussion……

Thank you very much for your attention

For further information please contact:

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