Online Monitoring and Life Extension of Coke Drums

REFCOMM MUMBAI
11–14 November 2019

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Introduction

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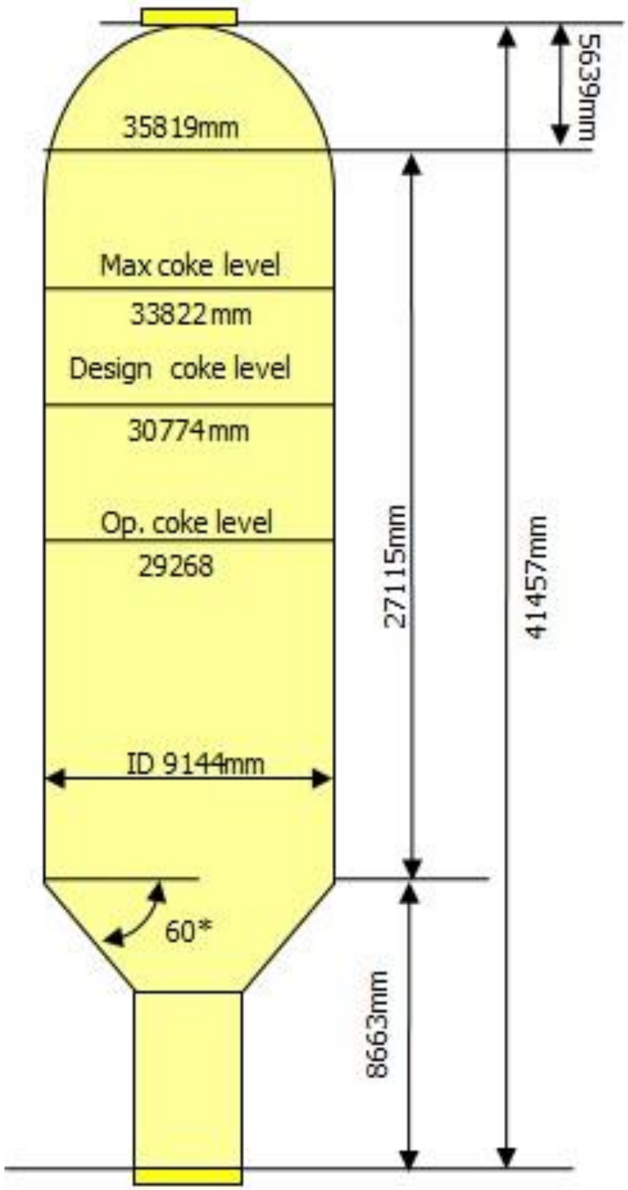
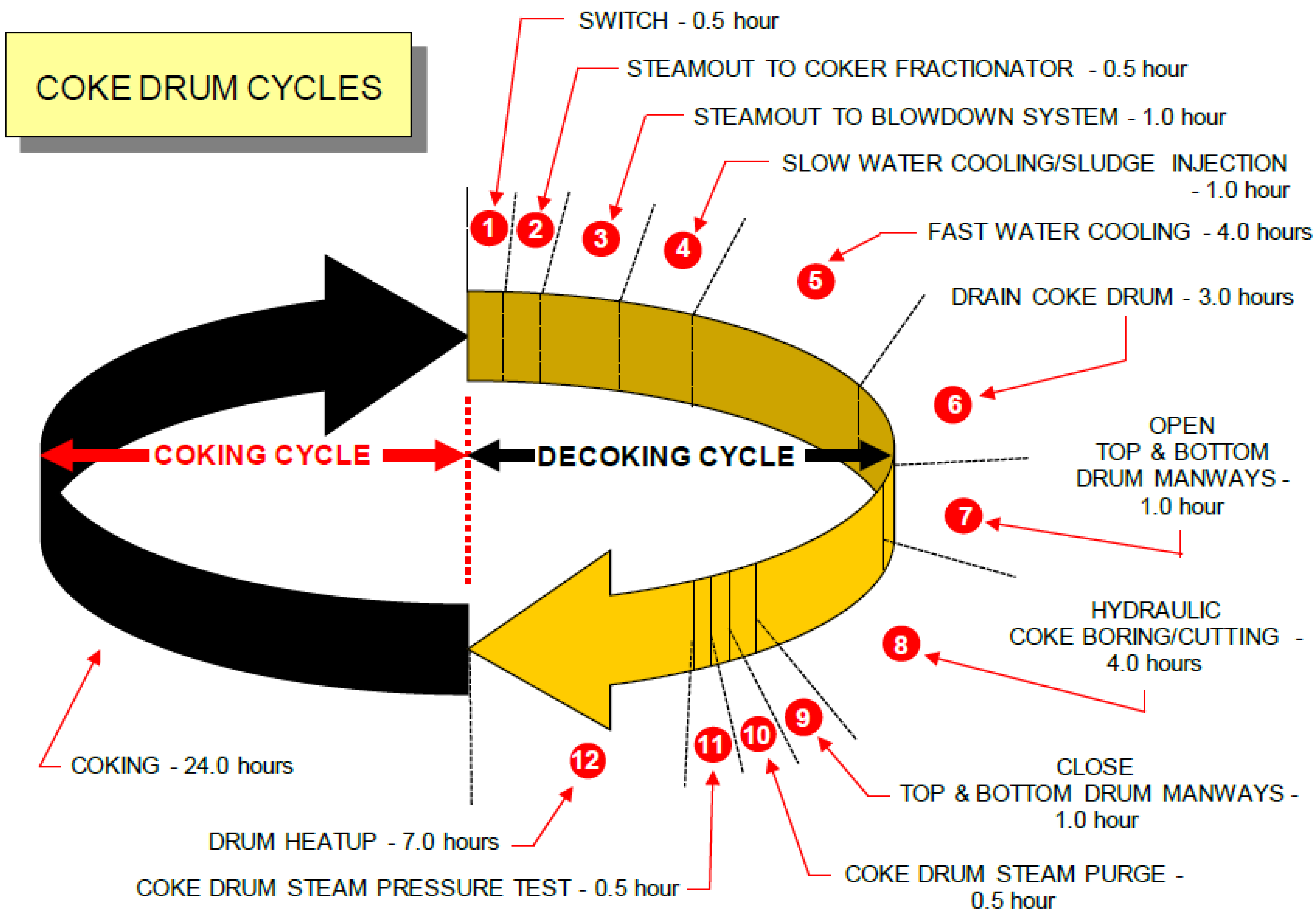
Description	Details
Commissioned in	April 2014
Unit Licenser	M/s Lummus Technology
Capacity	3.0 MMTPA
On-Stream Factor	8000 Hrs/yr (333.33 days)
Turn Down ratio	50%
Design feed TAN	< 0.5
No. of Coke drums	4 nos.
No. of Heaters	2 nos.

Details of coke drums

Description	Details
Manufacturer	M/s ISGEC Yamunanagar
Total length	41457 mm
Internal Diameter	9144 mm / 180 inches
Design coke level	30774 mm
Metallurgy	SA387 Gr 11 CL1 Base + SA240 410S Clad
Cylindrical Shell	10 nos. shell courses
Thickness of cylindrical shell	26 mm to 41 mm with min. 3 mm Clad
Feed entry nozzle	Side feed



Coking and De-coking cycles



Failure modes in coke drums & peripherals

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ONGC MRPL

Location of failures	Morphology	Causes
Shell & weld joints	• Bulging and cracking • Bowing/tilting (banana effect) • Weld cracking at tri-metal joints	• Cyclic thermo-mechanical loading • Uneven heating/cooling • Different thermal coefficient of expansion.
Skirt and concrete foundation failures	• Key hole or weld joint Cracks • Bulging / Buckling • Damage to bolts / structural concrete	• Cyclic thermo-mechanical fatigue • Uneven load distribution • Drum movement /Corrosion/Vibration
Piping failures	• Cracking	• Vibration induced mechanical fatigue

Inspection and monitoring used in MRPL

Techniques	Occasions/Purpose	Results
Laser Mapping and Remote Visual inspection	• Initial inspection • August 2017 • August 2018	• No fabrication damage • Localized bulging-2017 • Band bulging-2018
Strain based Engineering analysis	• Strain analysis with August 2017 & 2018 Laser data	• Identified areas with high propensity of cracking
PAUT/TOFD	• For identifying bulge induced and weld cracking at higher PSI locations.	• Confirmed bulge induced and weld cracking
Internal inspection & DPT/MPT	• April-May 2019	• Data matched with PAUT/TOFD findings

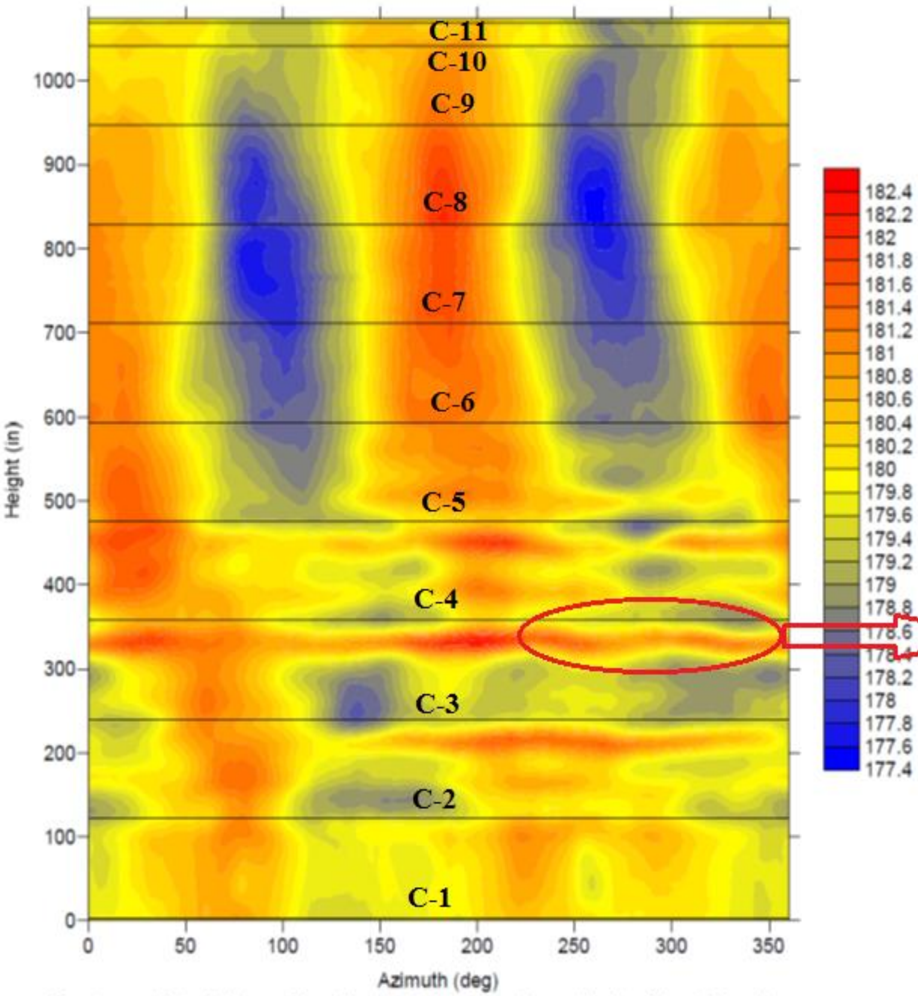
Drum Laser data & severity categorisation

	Drum C	Drum D
Laser data	**Radial growth in mm**	**Radial growth in mm**
2017/2018	33 to 60 mm	24 to 78 mm

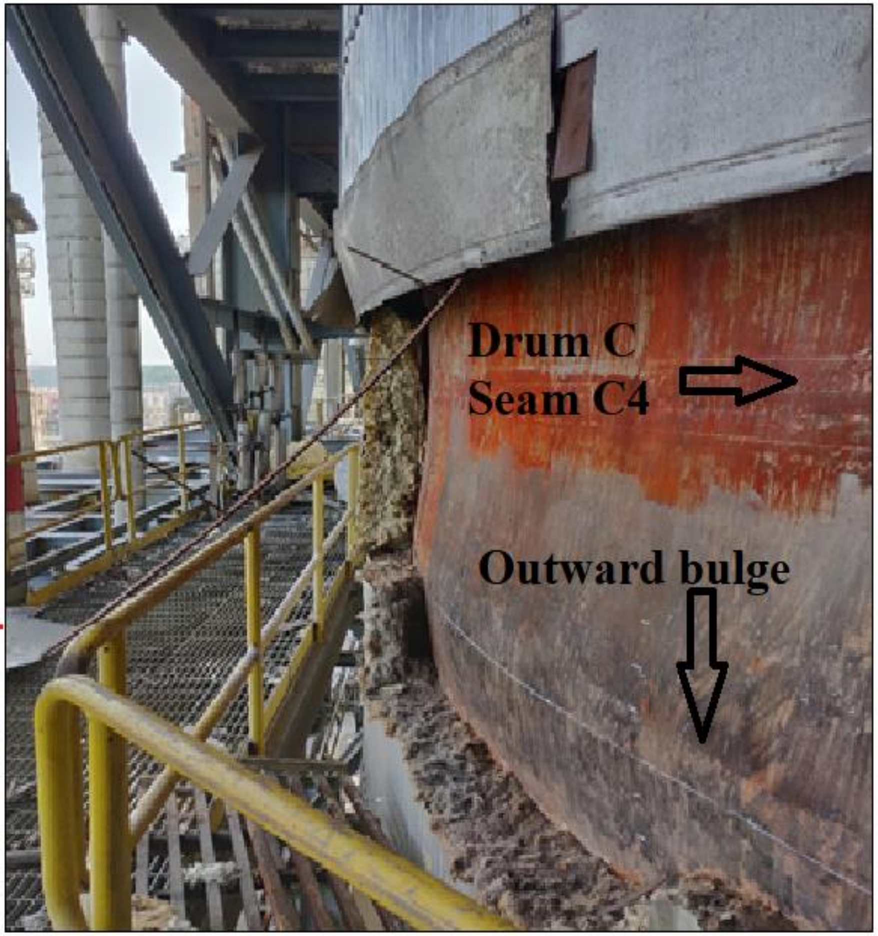
Range for ratio of [(R-Rn)/Rn]x 100	Categorization of severity	MRPL drum severity categorisation
0%-1%	Slight	0-45 mm
1%-1.5%	Moderate	45-68 mm
1.5% >=	Severe	69 and above

R- Actual radius measured by Laser mapping
Rn- Nominal radius of drum

Laser Mapping data of Drum C



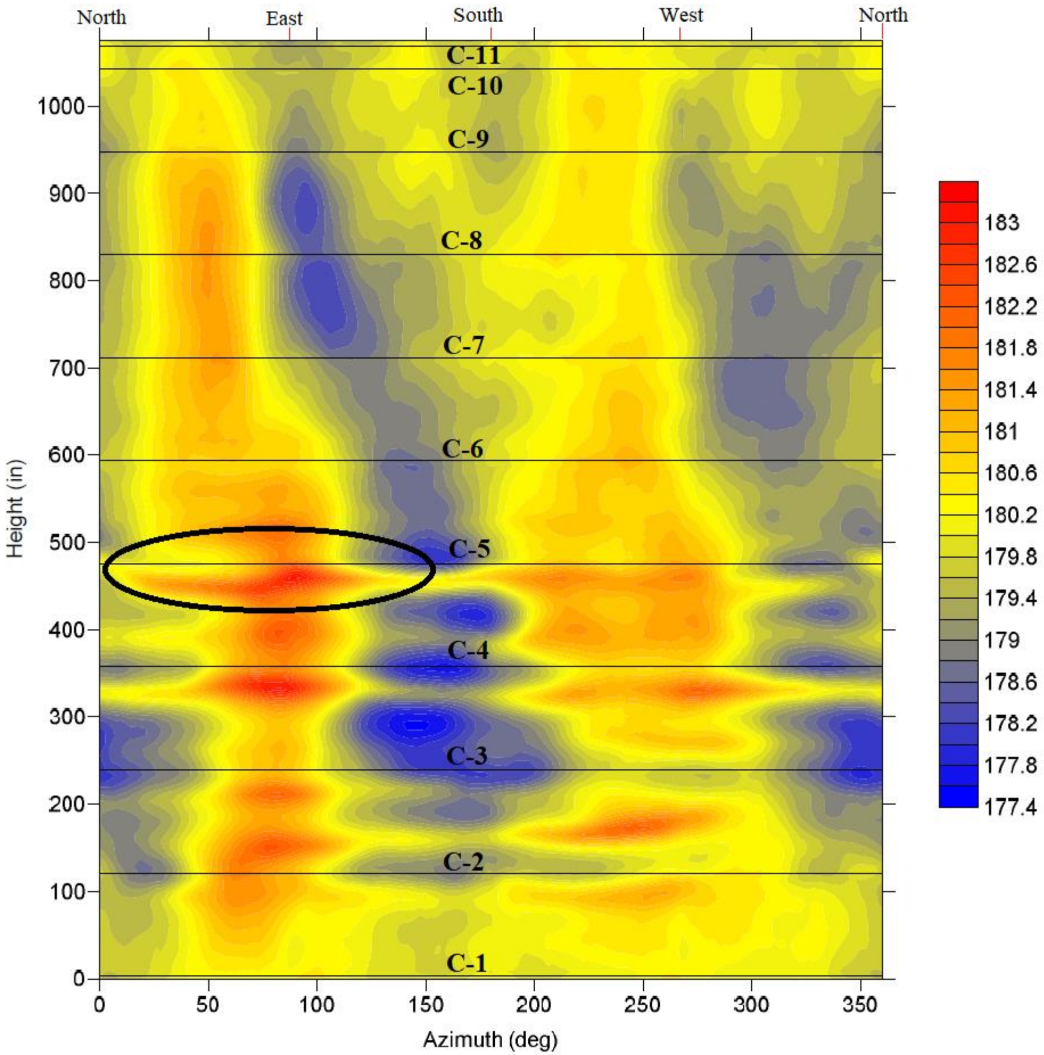
Contour plot of the radius (inches) looking from the inside of the drum



Inward
Outward

Drum nominal radius is about 180 inches (4572 mm)

Laser Mapping data of Drum D

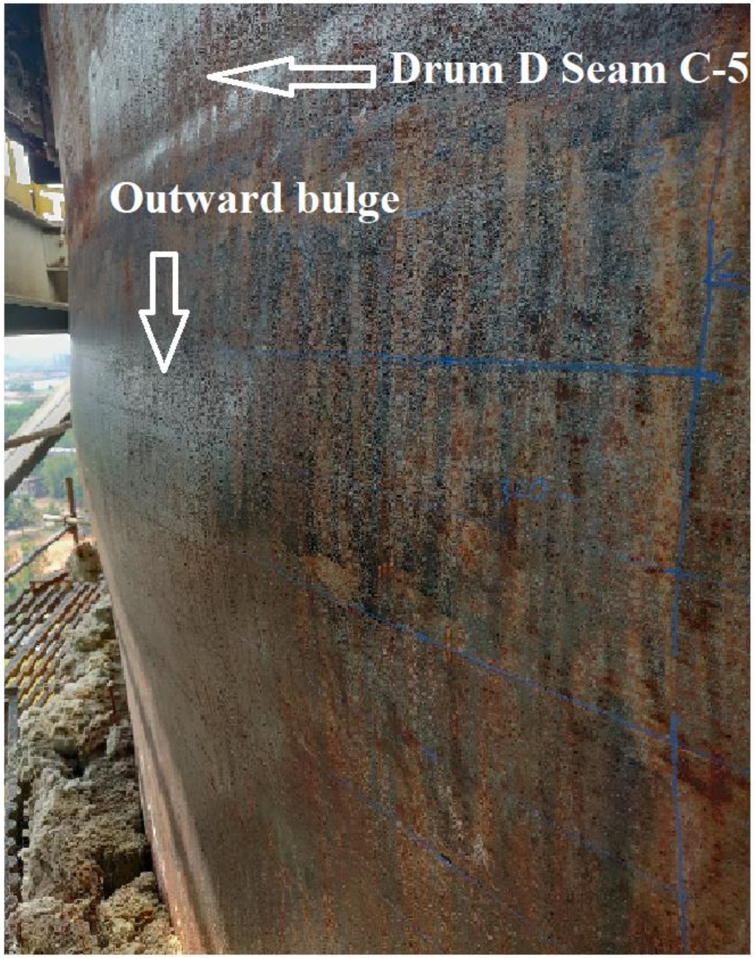


Drum D-2018: Contour plot of radius (inches) looking from inside of drum

Inward

Outward

Drum nominal radius is about 180 inches (4572 mm)



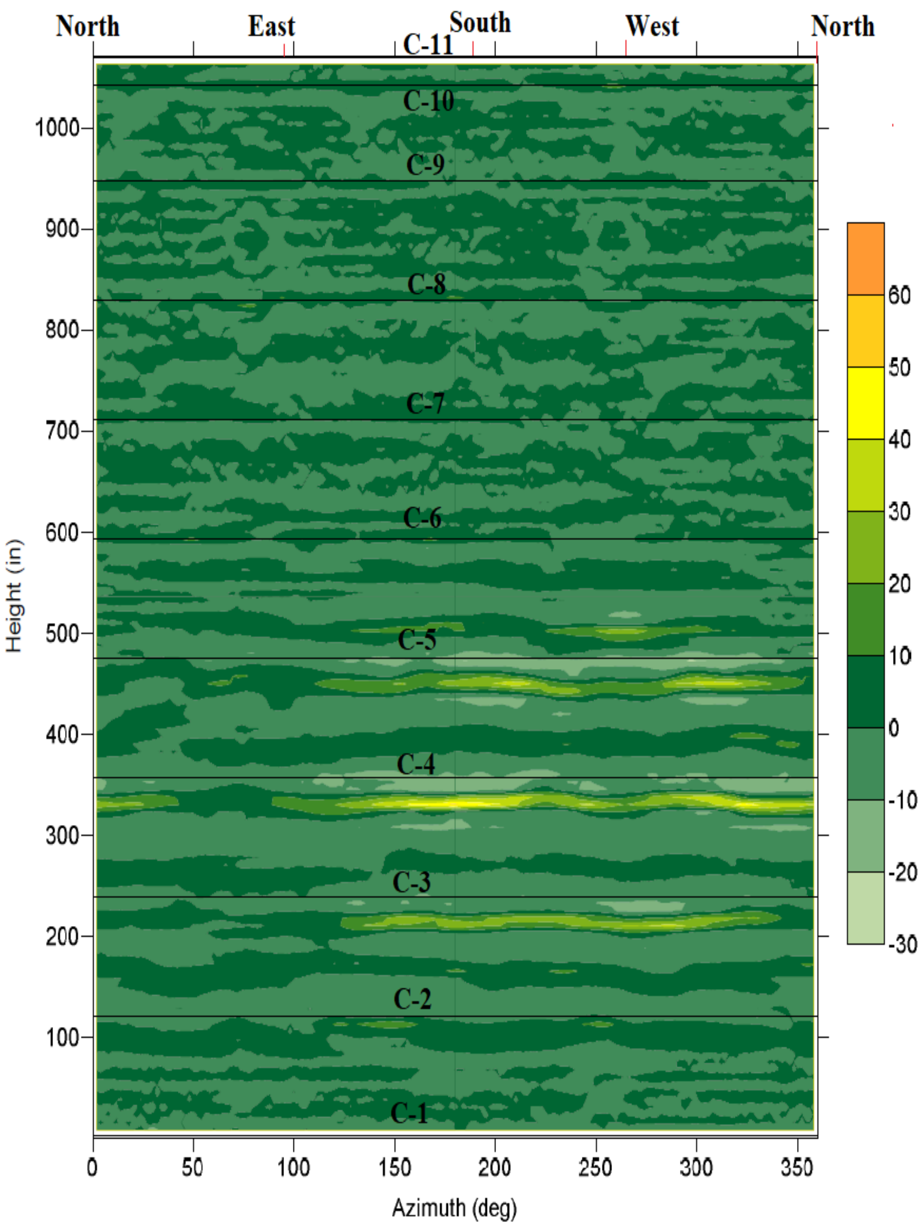
PSI data nomenclature & Drum C, D data

	Drum C		Drum D	
PSI data (%)	**Max (+)ve**	**Max (-)ve**	**Max (+)ve**	**Max (-)ve**
2017 data	(+)45.9	(-)22.2	(+)47.8	(-)29.7
2018 data	(+)51.7	(-)21.3	(+)47.1	(-)25.9

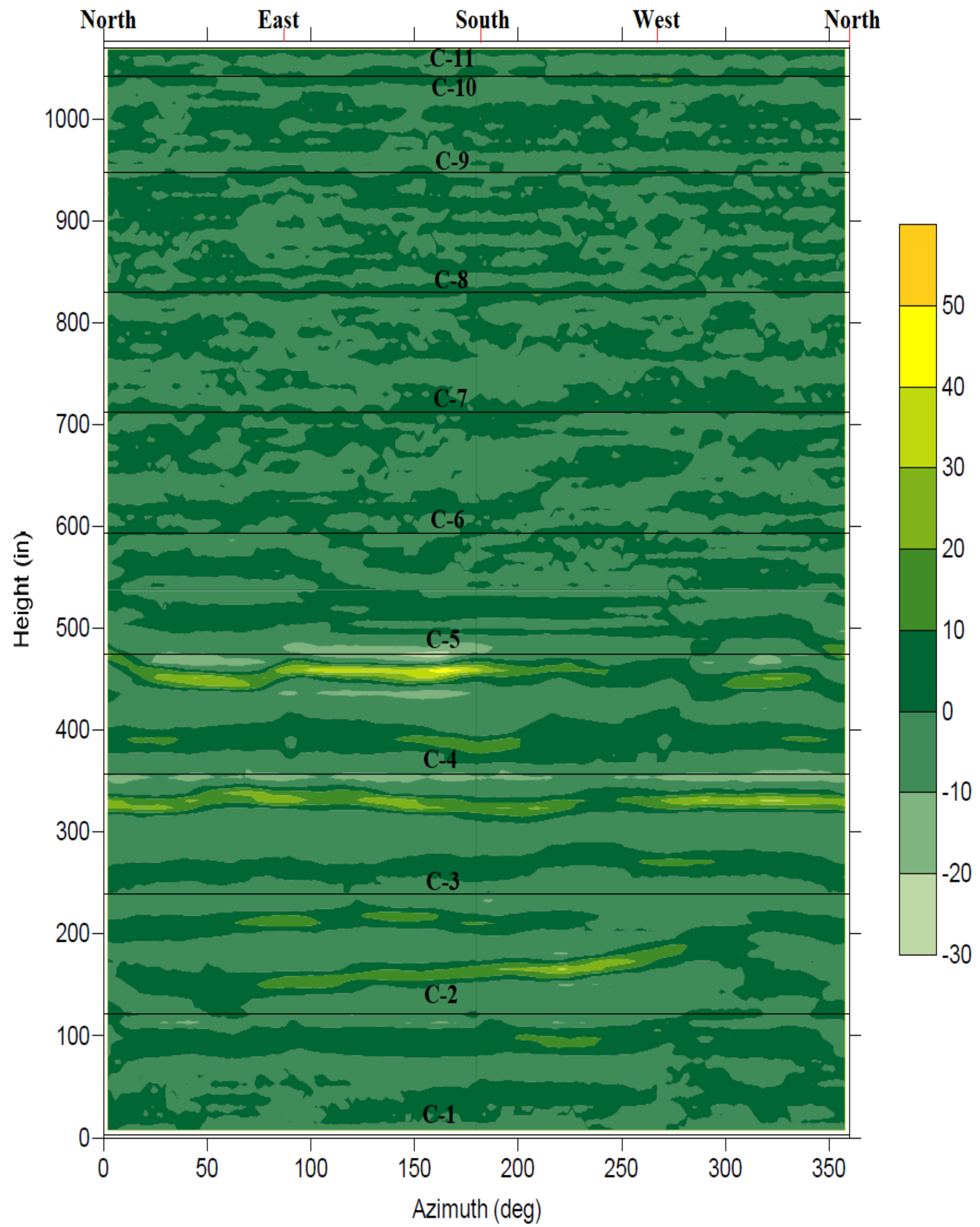
PSI magnitude	Severity Grade	Likelihood of Bulging-Related Cracks	Recommended Frequency of Laser Scanning
80% to 100%	Failure	Likely	6 months to 1 year
60% to 80%	Danger	Probable	1 year
40% to 60%	Concern	Possible	1 to 2 years
0 to 40%	Design	Unlikely	2 to 3 years

Plastic Strain Index (PSI) values	Failure initiation location
Positive (+ve)	Inner surface of drums
Negative (-ve)	Outer surface of drums

PSI plots of Drum C & D



Drum C -2018 : Contour plot of the Plastic Strain Index (%) looking from the inside of the drum



Drum D -2018 : Contour plot of the Plastic Strain Index (%) looking from the inside of the drum

PSI analysis: Conclusion & Recommendation

- Faster deterioration in SA-387 Gr 11 Class 1 drums is attributed to lower strength than Class 2 material typically used in industry.
- Inspection of identified bulging zones from inside and outside surface using Visual, DPT, UT.
- If cracks observed, design and implement high-quality weld overlay repairs at first shutdown.
- Annual laser scanning and strain analysis for bulge assessment

NDT observations

- Inspection performed during de-coking cycles from outside surface
- PAUT using angle shear beam (for locating ID cracks) and zero deg longitudinal beam (for locating clad disbonding) performed.
- PAUT and TOFD performed for circumferential weld seam examination.
- Weld cracking observed at the interface of tri-metal joint.
- Multiple crack like indications observed in shell plate bulge area scanning, in line with PSI analysis data.
- Circ. length of defect 6-760 mm & depth 1.3-8 mm (from drum ID).
- Three category of defects:
  1) up to 50% of clad 2) > 50% and within clad
  3) Depth more than clad thickness and penetrating into base metal

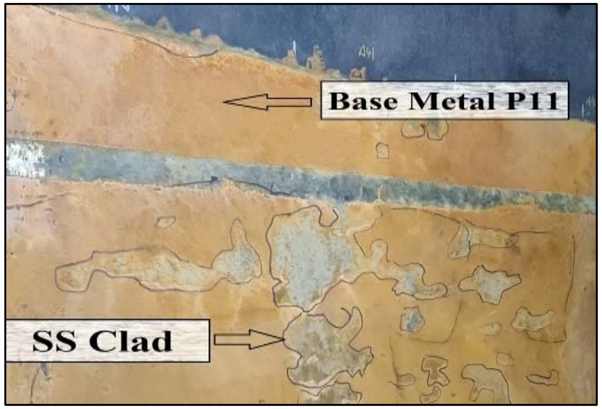
Methodology for AWO repair

- Initial inspection, repair area defect confirmation and marking
- Recording of initial data
  1) Grid thickness-for overlay thickness check
  2) Dimensional check-for distortion check
  3) Hardness check
  4) MPI of outside surface for ruling out OD defects.
- Clad removal by arc gouging without pre-heating & finish grinding
- $CuSO_4$ check, PMI and DPT of the finished surface.
- Grit blasting prior to welding to meet SA-3 & primer application
- Fixing of Pre-heating/Post heating pads on drum outer surface, AWO track fixing and machine sequencing.
- Preheating, sealing of clad interface and 1st layer AWO welding

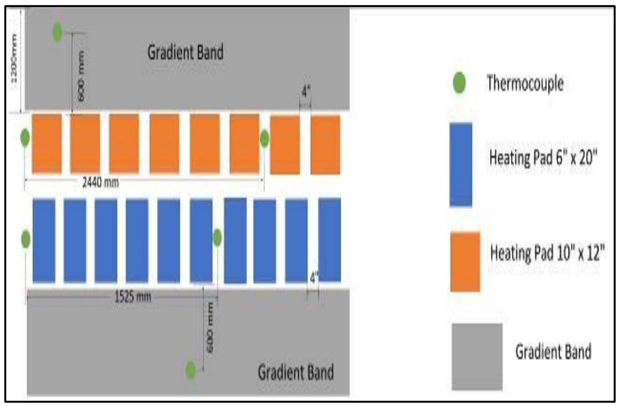
Methodology for AWO repair

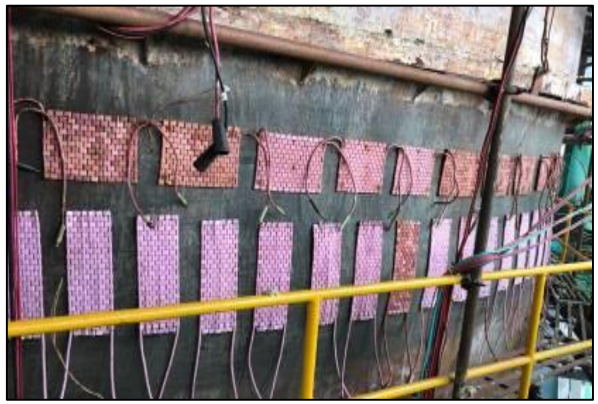
- Visual inspection of finished 1st layer, switching off preheating and data collection
- Visual inspection of finished 2nd layer (final layer), including taper at the interface.
- DPT of the interface and post heating.
- Visual inspection and DPT after post heating.
- Removal of AWO tracks and DPT of tack welds after grinding on inner and outer surface (for thermocouple locations)
- PAUT from outer surface of bulge area and PAUT and TOFD for weld seam area.
- Visual inspection and DPT of the insulation support cleats and outer surface of the drums.

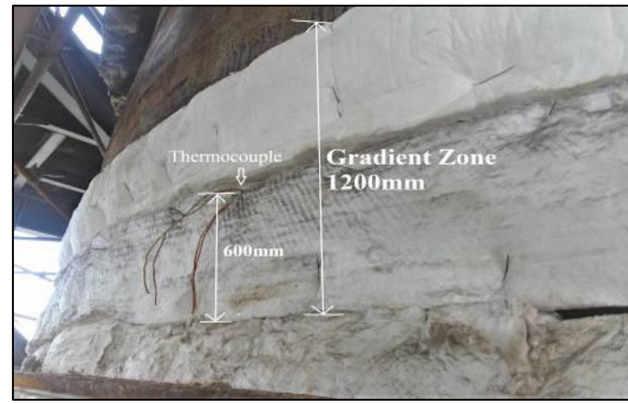
Details of job execution

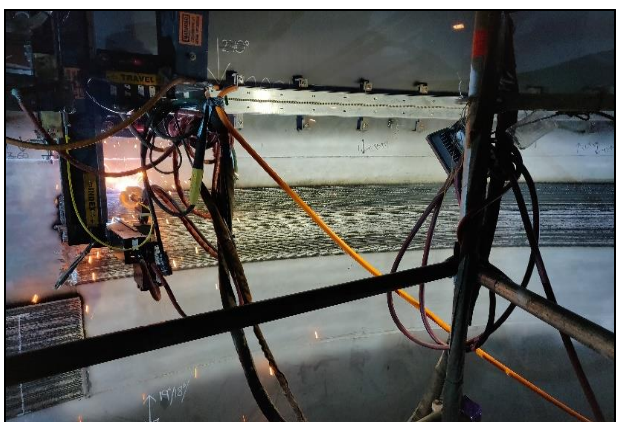


Details of job execution

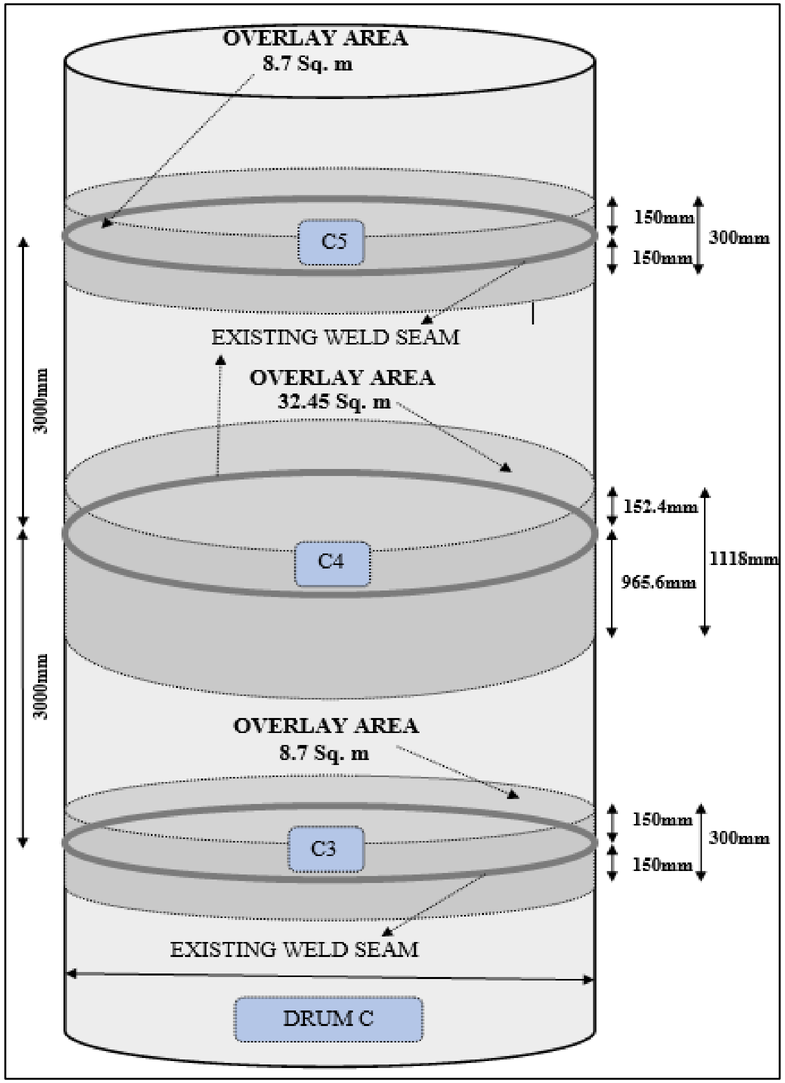


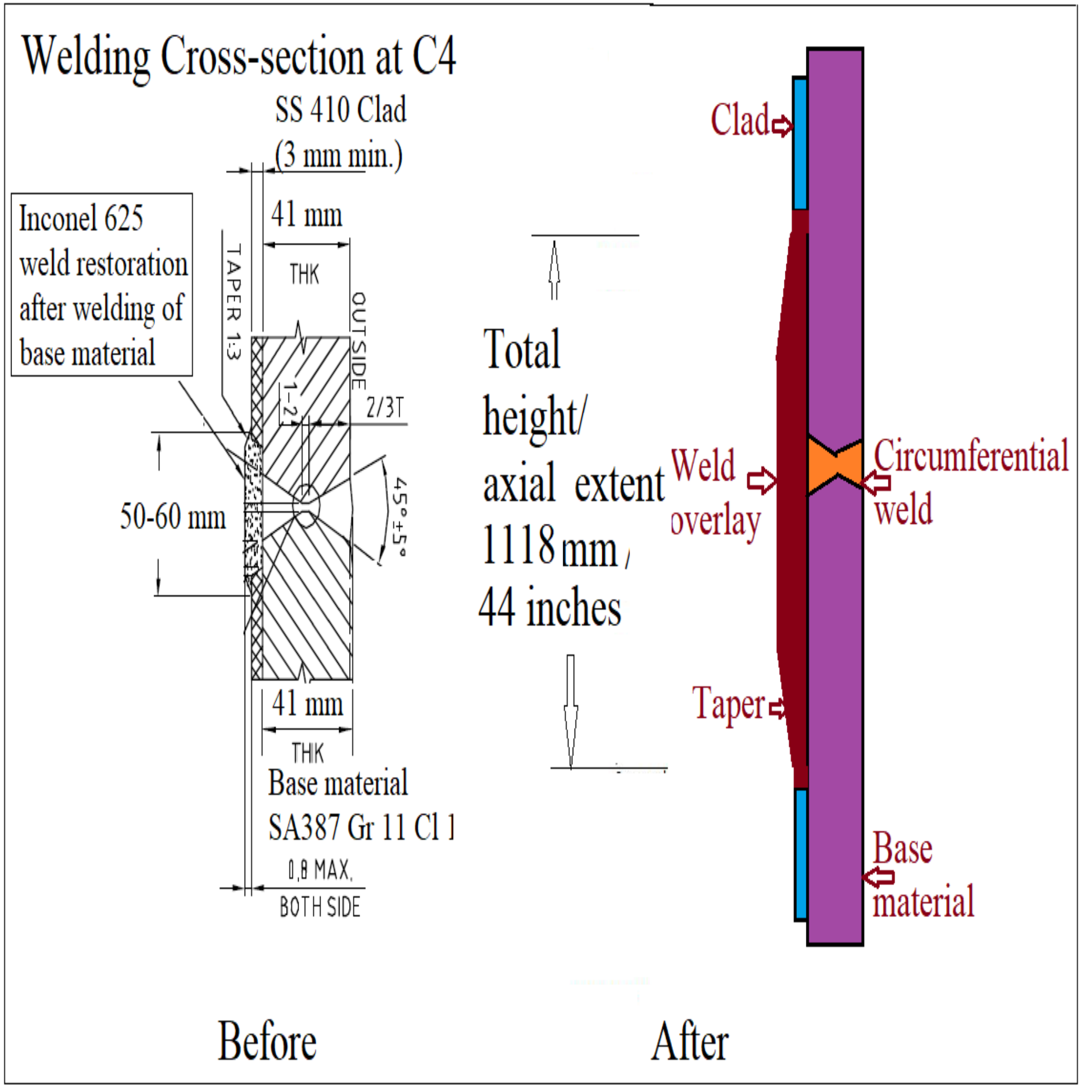




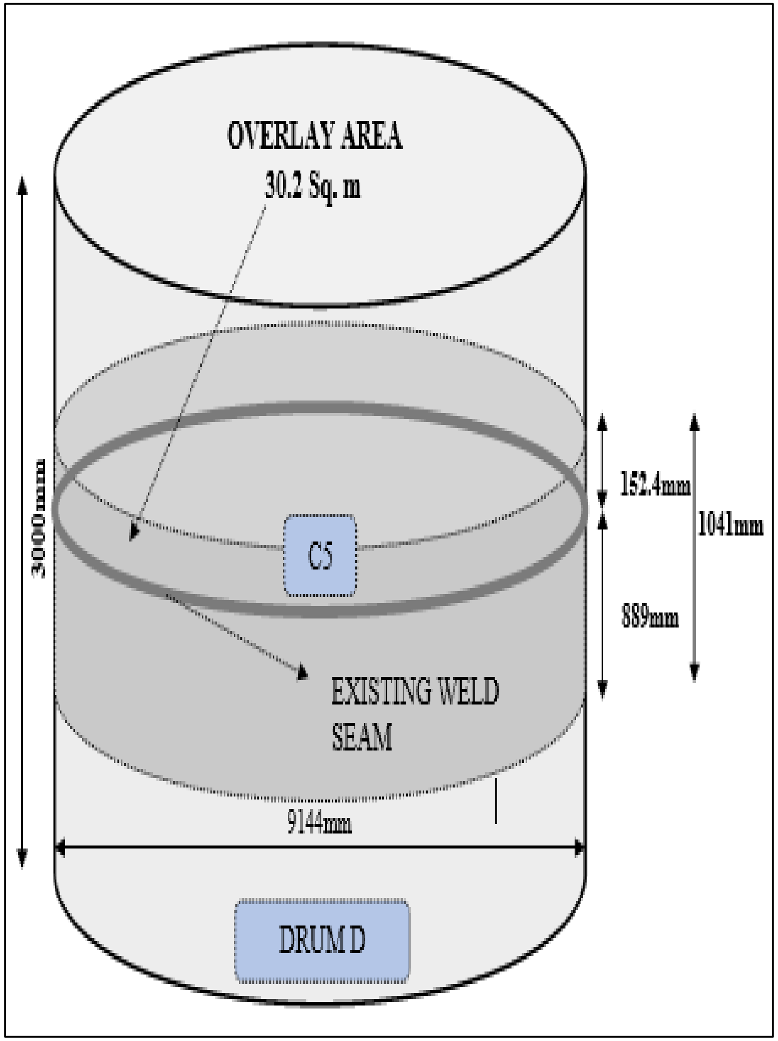


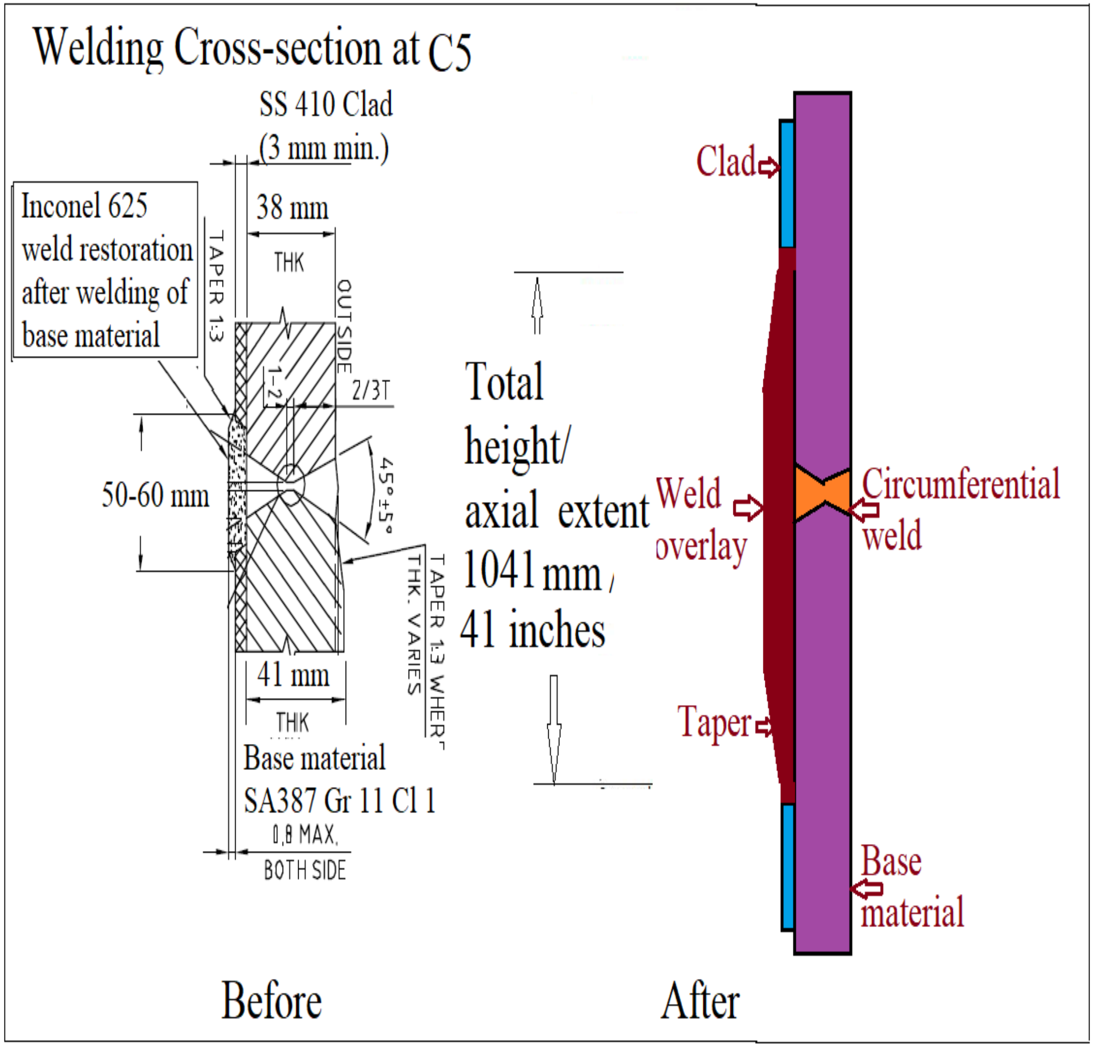
Drum C overlay extent





Drum D overlay extent





Summary and Conclusion

- Due to cyclic service of the drums, regular monitoring is essential
- Laser mapping is the starting point, followed by engineering analysis based on bulge severity
- Results of engineering analysis to be confirmed by further NDT to decide on need for repair action
- Full circumferential band repair using AWO is recommended over patch repair of bulges
- Multiple elevation repairs requires planned sequencing of jobs
- Inspection of outer surface of drums is highly recommended post AWO

Thank You

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