Restoration of Product Fractionator at Riyadh Refinery

By Asem Mojali

NTRODUCTION

This technical paper describes problems/issues, challenges faced, steps followed and actions taken by the restoration team for the product fractionator column (R215-V18) restoration work at Riyadh Refinery.

The restoration was needed due to the fire incident on 19 March 2021 in localized areas within Riyadh Refinery, in the hydrocracker unit (HCU), resulting in damage to multiple equipment.

The work involved the following major activities: demolition of damaged components, internal and external inspection, internal and external modification, surface preparation and reapplication of paint, installation of insulation and reinstallation of new platforms and ladders. The scope also includes nondestructive examination (NDE), pre-commission, mechanical completion and turnover to proponent.

PRODUCt FRACTIONATOR

A fractionating column or fractional column is an essential item used in the distillation of liquid mixtures to separate the mixture into its component parts, or fractions, based on the differences in volatilities.

The product fractionator feed is heated to the desired temperature in a fired charge heater, and then enters the lower section of the product fractionator column. The fractionator column is a steam stripped column with various side cut draws depending on the desired products.

The Riyadh Refinery HCU is divided into two major sections: reaction section and fractionation section (Figure 9). The reaction section is a two-train process consisting of four reactors in each train (2 x desulphurization hydrocracker reactors and 2 x hydrocracker reactors). The fractionation section consists of a debutanizer and a fractionator. Product from the vacuum distillation unit (VDU) and vacuum gas oil (VGO) provides feed to the HCU. Distillates and gasoline stream from the reaction section are fed to the fractionation section. The fractionation section mainly consists of a debutanizer column (R215-V16) and a product fractionator (R215-V18). Final products from the fractionation section are light naphtha, heavy naphtha, kerosene, light diesel and heavy diesel.

The HCU is at Riyadh Refinery's Area G and is designed to receive low value, heavy feedstock from the tank farm, DEMEX unit, VGO and VDU, and produces high value products such as liquid petroleum gas (LPG), light naphtha, heavy naphtha, kerosene, light diesel oil (LDO) and heavy diesel oil (HDO).

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EMERGENCY RESPONSE and DEMOLITION

Upon notification of the incident, the project management team (PMT) mobilized the necessary resources immediately to perform emergency restoration tasks on a priority basis. The design consultant and construction contractor teams were also mobilized to support the PMT.

Emergency Response

- All stakeholders visited the plant for visual assessment of the damages to the equipment.
- The design consultant developed the assessment scope of work to ensure a common understanding of the column damage assessment process among all stakeholders.
- The design consultant developed 56 CWPs to help define the scope of work for the construction contractor.
- ZPEC was mobilized to perform damage assessment and refurbishment of the column. ZPEC scope included all the inspections, testing, fabrication, welding and installation of pressure part components.

Demolition

- ES along with the PMT, the construction contractor and ZPEC identified the fire zone elevation of the column and developed inspection plan for the complete column.
- The construction contractor mobilized the scaffolding team to perform the demolition of damaged items including external piping, platforms, ladders, pipe supports and insulation.
- The construction contractor demolished the damaged internals.
- The construction contractor also demolished the stripping section sleeve at the bottom of the column as result of corrosion issues.
- The construction contractor demolished all the instruments (thermowell, pressure transmitters, flow and temperature elements, relief valves, cables, etc.) attached to the product fractionator.

ASSESSMENT and EvaLUATION

ES with IU support created a core team for column damage assessment and prepared an inspection plan to be followed by the construction contractor.

Assessment

- The design consultant mobilized their 3D laser scanning team and performed the 3D scan of the complete area, including the fractionator column. This provided an initial indication of column shell distortion as a result of the fire damage (Figure 1).
- ZPEC under the supervision of the construction contractor mobilized their team to perform the assessment, inspection and restoration works of the complete column in accordance with the inspection plan.
- ZPEC through their laser subcontractor verified the verticality, circularity and displacement of the column and recorded the readings at different elevations (Figures 2 and 3).
- Anabeeb, a subcontractor to the construction contractor was mobilized to perform the inspection of all internals. Anabeeb identified 16 trays, two chimney trays and two seal pans as fully damaged, which required replacement. Some trays had partial damage due to the fire incident and other trays had corrosion issues as shown in Figure 6.

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• Saudi Aramco procured and used air freight to ship all internals materials identified by Anabeeb as damaged.
• Original external piping material ASTM A155 C55 manufacturing is discontinued in 1978, instead API 5L grade B was approved by CSD for procurement.
• ES released final report with the findings and mitigation plan on 1 June 2021.
• Assessment of damaged field instruments which includes but not limited to emergency isolation valves, control valves, analyzers and field instruments (approximately 500) was carried out in two weeks time. The assessment also includes junction boxes and damaged cables. The activity was completed jointly by the design consultant, PMT and P&CSD.
• A major challenge was identified during the assessment of the control valves. This challenge highlighted the lack of specification sheets for existing control valves. The design consultant carried out reverse engineering for these valves using the name plate data.
• As-built of the process connection for the field instruments was done during the site assessment as drawings were not matching the actual field condition.

Evaluation and Analysis

• ZPEC performed the FFS analysis in accordance with ASME FFS-1 and submitted the report for CSD review and approval. Specific focus was on the major shell imperfections identified in the final assessment report (Figure 4).
• ZPEC performed the FEA analysis of the whole column as part of FFS analysis considering discontinuity at the major imperfections (Figure 5). The FEA report was reviewed by CSD and the design consultant.
• The FEA report concluded that the equipment was safe for re-use and continuous operation.
• Overhead piping stress analysis was performed to identify the pipe support types, allowable nozzle loads. Additional pipe supports were added where applicable.

RESTORATION

After demolition, assessment and equipment design analysis, restoration works were executed on priority basis with some of the works executed in parallel based on material and personnel availability.

• ZPEC performed all the restoration work on the column as per assessment findings and mitigation plan issued by ES.
• Ladders and platforms in the fire zone were fabricated and installed by ZPEC.
• Anabeeb installed all the internals including the new replaced trays (16), chimney trays (two) and seal pans (two). Some parts of the partial damaged tray were salvaged and installed on other damaged trays to save time and cost.
• The stripping section sleeve at the bottom of the column was replaced with a new improved design and with material upgraded to SS 410S from carbon steel (Figure 7).
• All external piping attached to the product fractionator was prefabricated and installed by the construction contractor.
• All existing pipe supports were replaced with new pipe supports. Additional pipe supports as per piping stress analysis were welded to the column.
• Figures

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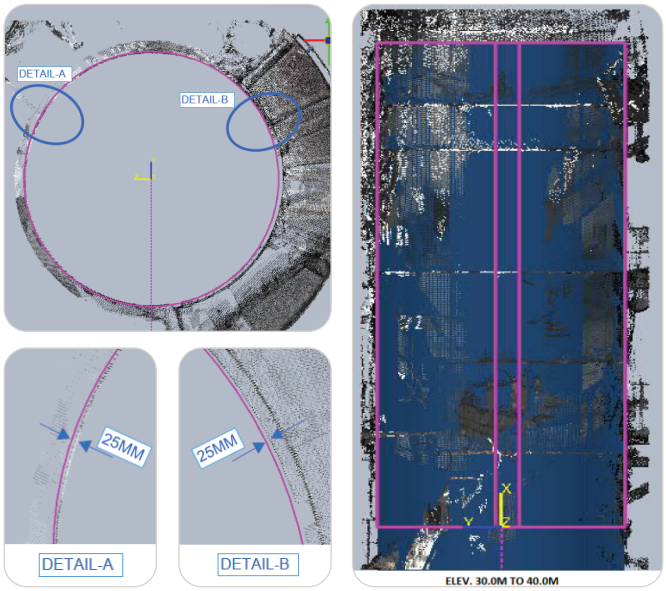


Figure 1. *Laser scanning images elevation and plan views.*

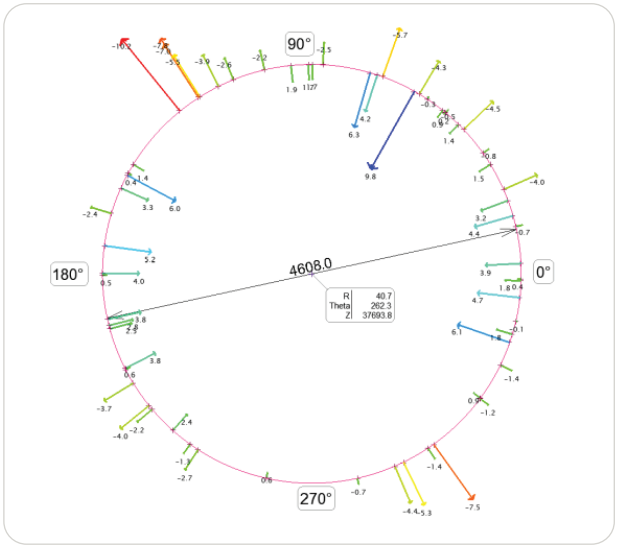


Figure 3. *Circularity & displacement of the shell @ EL +37694 mm*

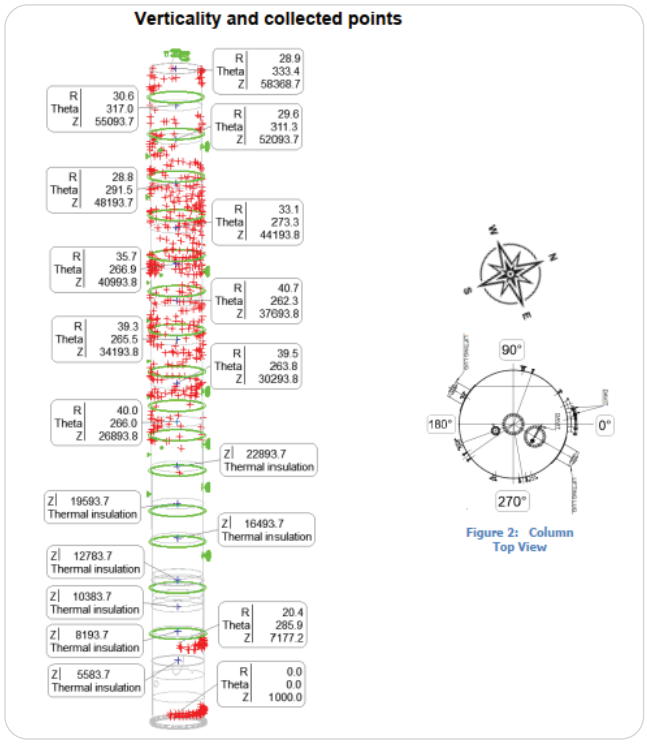
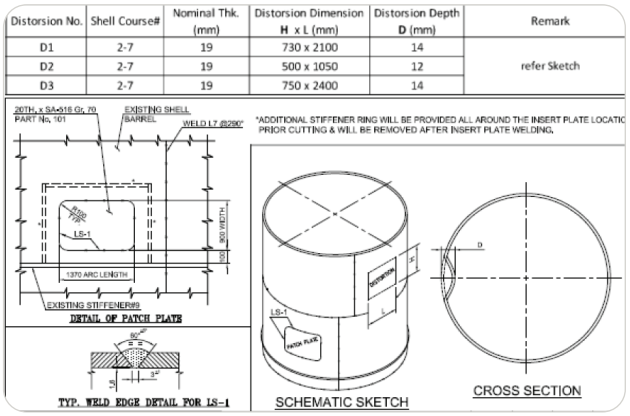


Figure 2. *Column verticality overview*



Distorsion No.	Shell Course#	Nominal Thk. (mm)	Distorsion Dimension H x L (mm)	Distorsion Depth D (mm)	Remark
D1	2-7	19	730 x 2100	14	refer Sketch
D2	2-7	19	500 x 1050	12	
D3	2-7	19	750 x 2400	14	

Figure 4. *Major shell Imperfections observed in three locations.*

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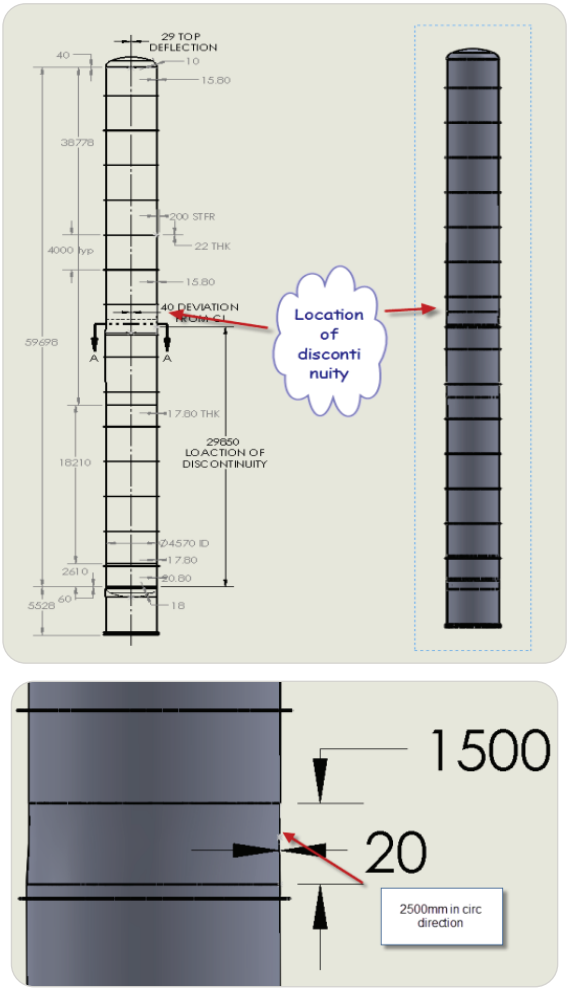

Figure 5. Distorted cylindrical section

Figure 6. Sample corroded internal parts

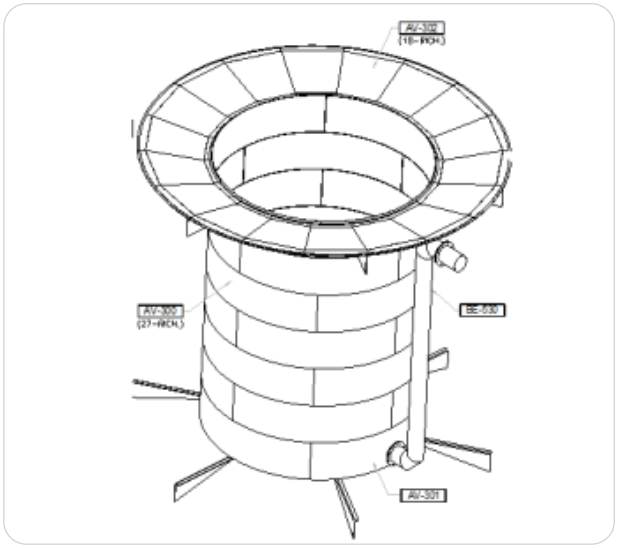

Figure 7. 3D View stripped section sleeve

Figure 8-1. Column after restoration

Figure 8-2. Column after restoration

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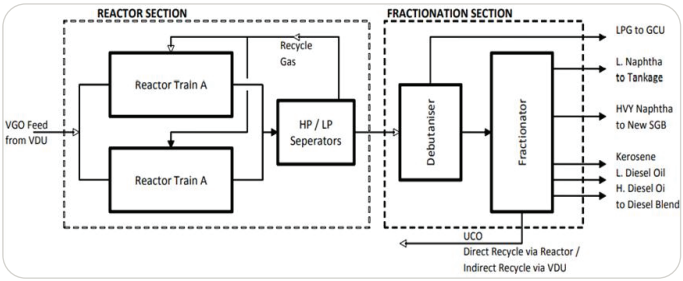

Figure 9. Block flow diagram – reactor and fractionation section

CHALLENGES

The restoration team encountered many challenges, some of which are listed below:

- As this was emergency restoration, schedule was the biggest challenge and the restoration was successfully executed ahead of schedule.
- Multiple contractors, subcontractors, Saudi Aramco personnel working in limited space. Sequencing the assessment and restoration activities safely with minimum impact to the schedule.
- Procurement of replaced materials to arrive at site on time.
- Non-availability of required materials.
- Working at heights.
- Personnel availability due to ongoing COVID-19 pandemic.
- Personnel affected with COVID-19 outbreak and infections.

MAJOR Milestones

- Project start: 20/Mar/2021
- Demolition works completion: 08/May/21
- Inspection and Findings report: 01/June/21
- Internals procurement: 04/July/21
- Pressure parts repairs completion: 20/July/21
- Internals installation completion: 26/July/21
- External surface prep. & insulation: 28/June/21
- External Piping installation completion: 23/July/2021
- Instrumentation installation: 25/July/2021
- Testing completion: 27/July/2021
- PMCC Completion: 04/August/2021
- Handover to Refinery: 04/August/2021

CONCLUSION

- Product fractionator column assessment damage and restoration were done in an organized and professional manner.
- All stakeholders worked as one team with common goal of restoring the equipment and bringing the refinery back on stream as quickly as possible.
- Major milestones achieved on the project are listed in the section 8. All issues were handled in a persuasive and expeditious manner.

Figures 8-1 and 8-2 show the column after successful completion of restoration works.

DEFINITIONS, ACRONYMS, ABBREVIATIONS

PMT: Project Management Team
CSD: Consulting Services Department
P&CSD: Process & Control Systems Department
ES: Engineering Services
IU: Inspection Unit
Design Consultant: GES+ Contractor Jacobs ZATE
Contractor: Construction Contractor ARCC
ZPEC: Fabricator, Zamil Process Equipment Company
VDU: Vacuum Distillation Unit
VGO: Vacuum Gas Oil
HCU: Hydro Cracker Unit
LPG: Liquid Petroleum Gas
LDO: Light Diesel Oil
HDO: Heavy Diesel Oil
DEMEX: Demetalization Solvent Deasphalting
SOW: Scope of Work
CWP: Construction Work Package
FFS: Fitness For Service
FEA: Finite Element Analysis
TBA: To Be Advised