Asset Integrity Management: World’s Largest Polymer Injection Projects

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- Overview of Mangala EOR Polymer Injection Project
- Key Features of Mangala EOR Polymer Injection Project
- Complexity of Mangala EOR Polymer Injection Project
- Challenges
- Goals of Improved Quality Operating Platform
- New Approach
- Innovation
The Mangala EOR project is a project of national strategic importance which is expected to produce an incremental 74 million barrels till 2040, thus contributing significantly to the Oil production of the Nation.
The Central Polymer Facility (CPF) is among one of the largest centralized polymer injection facilities in the world, 5 trains producing 80,000 barrels of Polymer Mother Solution at a high viscosity of around 3000cP.
All together 30 KM of Buried Pipe line of DSS material externally coated with 3LPP
Total Number of Well Pads: 15
Total Number of wells: 125
CS Pipes: 18 Km
DSS Pipes: 19.5 Km
Total Inch Dia: 125000
HT Cables: 5 Km
LT Cables: 220 Km
Instrument Cables: 179 Km
Manual Valves: 7100 Numbers
ESD Valves: 120 Numbers
CV: 138 Numbers
Key features of Mangala EOR- Polymer Injection Project

Microbubble Floatation technology deployed in the form of two Skim Tanks in order to separate the Polymer from the Production Fluid. Welding Inch dia piping: 62000

The Central Polymer Facility (CPF) is among one of the largest centralized polymer injection facilities in the world, producing 80,000 barrels of Polymer Mother Solution at a high viscosity of around 3000cP

- Distributed geographically across 15 locations in the desert region.
- 15 innovatively Modularized Substations catering to power requirements.
- Overhead Line using ACCC Conductors.
Complexity of Mangala EOR- Polymer Injection Project

- Extensive Duplex Stainless Steel onshore buried pipelines- First of its kind in handling Non Newtonian Fluid application in deserts.
  - 14” NB X Sch. 10S X 3LPP LSW DSS line pipe and @ 4.2 Km Feed Water pipeline from MPT to CPF
  - 8” NB & 4” NB X Sch 10 X 3 LPP Seamless DSS line pipe @ 25 Km Concentrated Polymer Fluid
- DSS above ground piping:
  - 6” NB, 4” NB, 2” NB Seamless above ground piping @ 20 Km of running length for Polymer Fluid & 125000 Inch Dia
- Installations and Commissioning @ 214 Pumps (Vertical Centrifugal Pumps, Vertical Progressive Cavity Screw Pumps, Horizontal Centrifugal Pumps, Positive Displacement Diaphragm Pumps, Horizontal Progressive Cavity Pump, Booster Pumps, Injection Pumps)
- Simultaneous management of 3 EPC Packages, 4 Non EPC Packages and 50 other contractors. Adopted Strategic Partnership Model with Contractors and Vendors – One Team – One Vision - One Mission.
- The Project achieved 10 Million Man-hours without any LTI – world class HSE performance by it self.
- The project spanning across 3 years, starting from conceptual design to start-up.

Construction of two Produced Water Treatment tanks (28 M Dia X 12 M Height X Glass Flake Vinyal Ester Internal coating) which acts as a skimmer unit for separating oil from produced water. Microbubble Floatation is the first kind of technology utilized by CIL to give treatment to produced water. Skim Tank consists of 5 chamber and multiple internals with acute angles and its design code is API 650
Internal Coatings: 5600 Meter Sq.
Complexity of Mangala EOR- Polymer Injection Project

- **Magnitude of Systems Completion of Mangala EOR Projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Project Description</th>
<th>CCC Signed</th>
<th>MCC Signed</th>
<th>SAC Signed</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOR1</td>
<td>CPF</td>
<td>146</td>
<td>146</td>
<td>146</td>
</tr>
<tr>
<td>EOR2</td>
<td>OHL &amp; Pipeline</td>
<td>39</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>EOR3</td>
<td>WellPad Modifications</td>
<td>558</td>
<td>558</td>
<td>558</td>
</tr>
<tr>
<td>EOR4</td>
<td>Polymer Storage Yard</td>
<td>39</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>EOR5 (Phase 1 &amp; E House)</td>
<td>MPT Modifications</td>
<td>56</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>EOR6</td>
<td>E-House</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>EOR7</td>
<td>220 KV Grid Switchyard</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1070</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Total man-hours deployed during project execution (Company employees) – 3,19,380
- Total number of man hours deployed during project execution (Contractor Employees) – 10,020,983
- Total Number of TPI Man-Hours – 1,70,000
- Total number of engineering deliverables of review and approve category – 18000
- Total number of QAP/QCP/ITP review and approve category - 1300
How to confirm completion assurance of more than 1000 systems?

How to assure design delivery as per specification?

How to assure facilities construction as per specification?

How to assure flawless delivery of the products and services delivered by Vendors?

How to ensure defect free construction?

How to standardize punch point categorization?

How to manage enormous documentation like O&M, MDRs, Certificates and ITRs?

How to avoid repetitive paper works and signoffs?

How to optimize data and records management?

How to digitize the whole handover process?

All above challenges being delivered as a success with implementation of TQM and CAMS during design and build stages of the projects – Improved Quality Management Platform
Goals - Improved Quality Management Platform

Conventional Quality Management System Focuses on

- ‘The agreed Scope’ - ✓
- ‘On time Delivery’ - ✓
- Stays within ‘budget’ - ✓
- HSEQ performance is “ZERO Injury” - ✓
- Project Success Factors” - ✓

Additional Goals

- Web based system
- Right first time
- On-time Commissioning and start up with Zero punch points
- Focus on Business KPIs (production)
- Stable and sustained first cycle of operation
- Meets Design Intent of reliable operations

Improved Quality Operating Platform provides systematic approach to ensure Design Completion, Supply Chain Management, Construction completion, Mechanical Completion and transfer the ownership from Construction to Commissioning and then to Operations as per CIL Gated Process with inbuilt integrated QMS.
Project Quality Audits (PQAs) objectives

- To ensure compliance to established Project Quality System requirements (PQP)
- Identify Non-Conformances
- Recommend Corrective and Preventive Actions, Close out Non-Conformances in compliance to QMS

1 Ready For Start Up review is to give assurance to management that constructed facility complies with all required Quality, Health, Safety & Environmental standards, Procedures, Statutory requirements
New Approach - Improved Quality Management Platform

**Engineering Assurance**
- Engineering Management
- Detailed Design
- Procurement Engineering
- Construction Packs
- As Builds
- Procurement
- Expediting
- Vendor Quality Control
- Vendor MDR approval

**Procurement Assurance**
- Construction Management
- pre-commissioning
- Commissioning
- System Handover

**CAMS**
- Construction Management
- System Handover

**Concept & FEED Assurance**
- Operations Emerging Scoping
- Front End Engineering
- Projects Management
- Projects Controls
- Assurance
- Governance
- Project Closeout

**Design Management**

**Procurement Management**

**Construction Management**

**Commissioning Management**

TQM (QA/QC, Inspection, PHSERS, RFSU, Audits & Reviews)

Improved Quality Management Platform (TQM+CAMS)
Completion Assurance Management Systems - Gated Process

CAMS is a gated process that allows a controlled handover between signatory authorities with the options to reject handover if the information is insufficient, incorrect or incomplete.

ITRs Type Check List: Civil - 22, Piping - 9, Instrumentation - 90, Electrical - 63, Mechanical - 40, F&G - 15, Telecom - 98, Safety - 9
Completion Assurance Management Systems

To login user must enter window’s ID & password
Process Flow- Project Completion Management System

Initiation

- Process Start
  - Project Identification and access control
  - Data Entry
  - Upload marked up System/ Subsystem P& ID's
  - Upload approved Tag list & Link to Data base
  - Upload Pre defined Checksheets for each Tag and Link to Data base
  - Upload Pre defined Completion Certification Formats

Construction

- Update the status of the systems and subsystems
  - Submission of all completed "ITR A" for Subsystems
  - Walkthrough & Raise Punch Point with categorization of A & B
  - Liquidation of Punch points
  - Submission of construction completion dossier for subsystems without any Cat "A" Punch points
  - Issue of Construction Completion Certificate with Exceptions.

Pre-Commissioning

- Submission of all completed "ITR B" for Subsystems
  - Tri party walkthrough & Raise Punch Point with categorization of A & B
  - Liquidation of Punch points
  - Submission of Mechanical completion dossier for subsystems without any Cat "A" Punch points
  - Issue of Mechanical Completion Certificate with Exceptions.

Commissioning

- Commissioning Activities
  - Issue of System Acceptance Certificate (SAC) to Operations with complete Dossier
  - RFSU (Ready For Start Up)
  - Start Up, Performance Test & Final Acceptance by Operations
  - Liquidation of Punch points
  - Submission of Mechanical completion dossier for subsystems without any Cat "A" Punch points
  - Issue of Mechanical Completion Certificate with Exceptions.
  - Start Up, Performance Test & Final Acceptance by Operations
  - Process End
# Responsibility Matrix of CAMS

<table>
<thead>
<tr>
<th>Item</th>
<th>Contractor</th>
<th>CIL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITR-A</td>
<td>• QA/QC In charge</td>
<td>QA/QC team</td>
<td>Contractor QA/QC shall issue after completion of Construction which will be accepted by CIL-QA/QC &amp; PMC -QA/QC team.</td>
</tr>
<tr>
<td></td>
<td>• Construction Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Commissioning Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Certification Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCC</td>
<td>• QA/QC In charge</td>
<td>• QA/QC In charge</td>
<td>CCC shall be issued after closing all the ITR-A and Punch points of the related subsystem.</td>
</tr>
<tr>
<td></td>
<td>• Construction Manager</td>
<td>• Construction Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Commissioning Manager</td>
<td>• Commissioning Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Certification Engineer</td>
<td>• Certification Engineer</td>
<td></td>
</tr>
<tr>
<td>ITR-B</td>
<td>• Commissioning Engineer</td>
<td>• Commissioning Engineer</td>
<td>After completing all pre-commissioning works for the related subsystems</td>
</tr>
<tr>
<td>MCC</td>
<td>• Construction Manager</td>
<td>• Construction Manager</td>
<td>MCC Shall be released after</td>
</tr>
<tr>
<td></td>
<td>• Commissioning Manager</td>
<td>• Commissioning Manager</td>
<td>• Completing all the ITR-B</td>
</tr>
<tr>
<td></td>
<td>• Certification Engineer</td>
<td>• Certification Engineer</td>
<td>• Punch Points Shall be given by CIL representatives for each subsystem after walk downs &amp; shall be liquidated by Contractor</td>
</tr>
<tr>
<td>Item</td>
<td>Contractor</td>
<td>CIL</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| PHSER V Audit | • Construction In charge  
• Commissioning Manager | • Construction In charge  
• Commissioning Manager | This audit shall confirm that Construction is complete and the project is ready to enter the commissioning stage. |
| ITR-C       | • Commissioning Manager                                                  | • CIL Commissioning Manager  
• CIL Operations Team representatives | All activities related to commissioning like load trial, cause and effect checks, leak checks, inertization, SAT, function checks. |
| SAC         | • Construction Manager  
• Commissioning Manager  
• Certification Engineer | • Certification Engineer  
• Commissioning Manager  
• Installation Manager | System Acceptance shall be accepted by CIL after verifying all dossiers and Punch point liquidation. |
| RFSU Audit  | • Construction Team  
• Commissioning Team  
• Engineering Team  
• Project Team | • Construction Team  
• Commissioning Team  
• Engineering Team  
• Project Team  
• Nominated Audit Team | • Ready for Start-Up Audit shall be carried out by nominated Audit team (external or internal).  
• After clearing the Audit team observation and satisfying the audit checklist then clearance for RFSU shall be given for hydrocarbon introduction. |
# Punch Point Criticality Form

## Appendix A: Punch Point Criticality Criteria and Rating Calculation Form

<table>
<thead>
<tr>
<th>Criticality Rating Criteria</th>
<th>Points</th>
<th>Remarks</th>
<th>Override</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effect on Production and Operation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Reduction</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Loss</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Personnel Safety</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Minor Injury</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Major Injury</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Multiple Injury and Fatality</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hazard to Environment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate with non lasting effects</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major with long lasting effects</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fluid</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innocuous</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Hazard/ Temperature/Pressure</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Hazard/ Temperature/Pressure</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Hazard/ Temperature/Pressure</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Structure Integrity/Flange Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate with non lasting effects</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major with long lasting effects</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Corrosion / Erosion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate with non lasting effects</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major with long lasting effects</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Detection and Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate with non lasting effects</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major with long lasting effects</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 - Less Critical  
2- Moderate Critical  
3- Most Critical  
4- Extremely Critical
# Quantum of ITRs and Certificates for M EOR Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Sub-System</th>
<th>ITR SUMMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOR1</td>
<td>146</td>
<td>A-ITR Scope</td>
</tr>
<tr>
<td>EOR2</td>
<td>39</td>
<td>9782</td>
</tr>
<tr>
<td>EOR3</td>
<td>558</td>
<td>1065</td>
</tr>
<tr>
<td>EOR4</td>
<td>39</td>
<td>20758</td>
</tr>
<tr>
<td>EOR5 (Phase 1 &amp; E House)</td>
<td>56</td>
<td>1188</td>
</tr>
<tr>
<td>EOR6</td>
<td>210</td>
<td>1897</td>
</tr>
<tr>
<td>EOR7</td>
<td>22</td>
<td>11426</td>
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Quantum of ITRs and Certificates for M EOR Projects

<table>
<thead>
<tr>
<th>A-ITR Scope</th>
<th>B-ITR Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>46892</td>
<td>19664</td>
</tr>
</tbody>
</table>
- First Time Implemented Improved Quality Operating Platform
- Unique approach integrating conventional QMS
- Achieved efficient flow of material and information - Right time
- Combination of Continual and Staged Improvement - Radical Change
- A structured improvement method that follows a standard approach and uses standard tools.
- Improved Operating Platform - Learning, Thinking, Planning, Brain Storming and Implementation, maximize team participation, set realistic goals, measure improvement and implement controls.
- Enhanced End-user Satisfaction
- Integrating of TQM+CAMS mind set of teamwork and CIL "can do attitude" will be leading to a radical changes with innovation.