



# **Delivering Execution Excellence to Mega Petrochemical Projects**

L&T Hydrocarbon Engineering (LTHE) is an engineering, procurement, fabrication, construction and project management company providing integrated 'design-to-build' solutions for large and complex Offshore and Onshore hydrocarbon projects worldwide.

A wholly-owned subsidiary of Larsen & Toubro Limited (L&T), the Company continues to draw on the parent Company's organisational strengths and experience.

The Company caters to the needs of its client base in multiple geographies.

# Integrated **Project Execution**

The Company's end-to-end capabilities across the hydrocarbon value chain cover upstream oil & gas processing, refining, petrochemicals, fertiliser, cryogenic storage including LNG and pipeline sectors. Our project management teams efficiently execute all projects, meeting the most stringent targets of safety, quality, cost and time.

Global projects benefit from three decades of the Company's in-house capabilities in engineering, procurement, fabrication, construction and commissioning (EPCC).

We also execute projects on a License + EPCC package basis, depending on customer's requirements. These projects are executed through alliances with process licensors.

Engineering	Advantage
Customer focus and responsiveness	Proven track record and trusted industry leader
Cost-optimal solutions through integrated approach	Strong commitment to Quality and HSE
Dedicated project management resources	Technology focus and specialized design & engineering expertise
Supply Chain Management with sourcing expertise	Innovative construction with cutting edge technology
Capability for mobilization of large resources and quick ramping-up	Extensive IT-enablement for virtual, single-office operations

The L&T Hydrocarbon

# LINEAR ALKYL BENZENE PROJECT

Large Scale Petrochemical Complex in KSA

Farabi Petrochemicals Company is one of the world's leading producers of paraffins and linear alkyl benzene.

Project Name	Normal Paraffin & Derivatives Complex Project
Project Location	Yanbu, The Kingdom of Saudi Arabia
Plant Capacity	235,000 MTPA n-Paraffin
Santa Caral	120,000 MTPA Linear Alkyl Benzene
	82,600 MTPA Speciality Oils
Total -	30,000 MTPA Sulfonated Asphalt
ANT FLORE	33.6 MTPD Sulphuric Acid
Client	Farabi Petrochemicals Company
Licensor	UOP/ Technithon/ MECS
Project Scope	Engineering, Procurement, Construction & Commissioning (EPCC)
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# PROJECT CHALLENGES

- The schedule was 32 months from start to start-up.
- The footprint of the Greenfield project was large, with an area 1800m x 430m comprising 19 process units, 16 utility units, and offsite facilities.
- A large number of tagged equipment (approx. 1000) had to be procured.
- HCIS 2017 regulations, which were released after contract award, had to be implemented.
- Multiple interfaces with different contractors; Tie-in for Products, Raw materials & Utilities; integration

of client supplied proprietary UOP items (rotary valve, internals, ACSS, PEP skid) - without affecting overall project schedule - had to be undertaken. • A huge workforce (approx. 7000 at peak) of people from different nationalities had to be mobilized. This also included local Saudis as part of the Saudization norms • Permits and RC (Royal Commission) approvals for executing jobs, construction and commissioning

- had to be obtained.
- Eight tie-ins from different customers from the adjacent plants within Yanbu

Farabi Petrochemicals Company, as a part of its ambitious growth plan, wanted to establish a new n-Paraffin and Linear Alkyl Benzene facility in the Yanbu industrial area of the Kingdom of Saudi Arabia (KSA).

In May 2017, L&T Hydrocarbon Engineering bagged the prestigious contract for setting up this Greenfield Petrochemical Complex on a lumpsum turnkey basis. It is the first large scale Petrochemical Complex Project undertaken by the Company in KSA on EPCC basis.

The Complex is under progressive commissioning and start-up from Jul-Sep 2020.



industrial area had to be obtained. This included hot tapping from the 24" Saudi Aramco Sales Gas pipeline.

- Multiple licensor coordination was required during the engineering, erection and commissioning phases.
- In its last leg the Project had to contend with the COVID-19 pandemic. However, taking the necessary preventive measures construction and commissioning activity continued throughout the period albeit with relatively lower productivity levels.

# EXECUTION STRATEGIES

Being a fast-track project, the deadlines were very tight – 32 months for taking over (ready for start-up) and 36 months for commercial completion. Considering the complexity and size (1800 m x 430 m) of the project, it has been divided into four areas, each declared a sub-project. Dedicated teams have been assigned to each area to execute engineering, procurement, construction and project management. The project team is implementing the latest digitalisation tools to plan and monitor an integrated EPCC schedule and the interfaces with all stakeholders.

The project has achieved 31 million safe man-hours as of July 1, 2020.

### **Detailed Engineering**

L&T Chiyoda executed detailed engineering for this project in 18 months at its office at Vadodara in India. Farabi's Integrated Project Management Team (Farabi IPMT) was present during this phase, and expedited the process of engineering deliverables, engineering resolutions and faster approvals on the engineering documents.

The joint efforts of the LTHE and Farabi IPMT teams laid the strong foundation of the project with effective coordination with licensors and on-time completion of major engineering, including timely completion of approx. 25 special studies.

### **Global Sourcing**

One of the bigger challenges during the project was supplying approx. 1000 tagged equipment – reactors, compressors, air fin coolers, multi tube exchangers, towers, vessels, pumps and utility packages, such as waste water treatment package, boiler, cooling tower, DM plant, etc. Farabi also novated critical long-lead items, like heaters, 3.3 MW screw compressor and Packinox exchanger, to the Company.

Considering the quantity of equipment to be supplied, LTHE identified the items coming under the critical path and prioritized ordering accordingly. First-priority items (approx.110) included reactors, switchgear, utility packages and compressors, and were ordered within three months from the date of the award of the contract. Secondpriority items (approx. 160), included ICSS, telecom, multi-tube exchangers, columns, API and non-API Pumps, and were ordered within five months of the award of the contract. As the equipment were procured from different parts of the world – and at different times – efficient logistics management proved critical.

## Construction

Multiple sub-contractors as well as in-house resources were used during construction. Considering peak manpower of almost 7000 personnel at site, sub-contractor management became extremely critical to project success.

Piping fabrication was undertaken at LTHE's yard at Kattupalli. Materials Management was undertaken through IT tools such as e+ALPS (Activity Planning System) and spool management through AUTO Spool. A QR Code system was used for piping and structural material for efficient handling from fabrication and storage to erection.

For various services, the project utilized a wide variety of UG piping materials -HDPE, CPVC, GRE and CS+ FBE coating lines. All FBE-coated pipes (up to 82000 IM) were fabricated and FBE-coated by a KSA-based vendor, and then sent to the site for erection.

Up to 5800 MT of the structural steel required for the plant was fabricated in prefabricated shops and supplied from two agencies located in KSA. In order to reduce construction time, 21 shelters were considered as PEB (pre-engineered buildinas).

### Tank Farm

The tank farm contains 56 tanks with diameters varying from 6 m to 22 m. The tanks have different types of roofs, e.g. fixed-cone roof, floating roof and dome roof. The tank farm has state-of-the-art facilities like tank farm management system, fire-protection systems, etc.

## **Buildings**

The complex contains several buildings - Process Area (five sub-stations & main control room) as well as Non-process Area (Admin Building technical, canteen, laboratory, fire station, flare houses). The entire plant is controlled from the main control room. Precast roof slabs have been used for substations. To reduce construction time and provide the thermal protection required by KSA norms, all buildings are made of insulated bricks instead of conventional bricks.

## Commissioning

At the time of publication, the Project is in the final stages of commissioning. The entire Project has been divided in to 66 Units and 594 sub-systems for the purpose of Turnover using Total's ICAPS software.

# **MELAMINE PROJECT**

### The Largest Capacity Melamine Plant for India's Sole Melamine Producer

GUJARAT STATE FERTILIZERS & CHEMICALS LTD., INDIA

In March 2016, Gujarat State Fertilizers and Chemicals Ltd. (GSFC) awarded to L&T Hydrocarbon Engineering a project for installation of a 40,000 MTPA Melamine Plant on EPCC basis at GSFC-Vadodara, India. Casale SA is the technology licensor for this unique project, which involves an off-gas treatment section and a high-pressure Melamine Plant, both integrated, consequently optimizing energy and utility consumption. This is Casale's first plant as a licensor for Melamine using the high-pressure Borealis technology.



# <mark>税</mark> PROJECT CHALLENGES

- Space constraints neccessitated a compact, vertical design. (OGT unit: 26.25 m x 64 m, Melamine unit: 44.75 m x 64 m)
- Three sides of the site were locked due to facilities at this Brownfield Project. This restricted movement and positioning of cranes.
- Licensor-specific vendors were mandated, largely from Europe (18 suppliers), for critical packages, equipment and instruments. These included a molten salt heater from APACO, Switzerland, a flash dryer from GEA Denmark / India, a vacuum drum filter from Andritz, Germany, a pneumatic conveyer by

Geroldinger, Germany, a bagging plant from H&B Germany, level transmitters (Zirconium diaphragm type) from WIKA, Germany, high-pressure reciprocating pumps from Peroni, Italy, axial flow pumps from Egger Switzerland, jacketed control valves from Parcol, Italy.

- The project involved placing 930 purchase orders on over 360 vendors – many for the first time for LTHE.
- Special metallurgy was involved (alloy-59, 25.22.2, Urea grade) for which there are limited international vendors.
- Dedicated teams were required to expedite critical packages, equipment

and exotic materials to ensure timely deliveries in order to meet the challenging construction sequence.

- Vertical plant construction posed challenges in sequential construction.
   Eight vertical levels in the plant with different equipment and piping were to be sequentially erected.
- Peak manpower was 1540 personnel with over 140 staff.
- High pressure, high temperature and harmful fluids made precommissioning and commissioning a major challenge. Maintaining the highest HSE standards in the field was of utmost importance.



### UNIQUE VALUE-ADDITION THROUGH EXECUTION O STRATEGIES

- As the plant was blocked on three sides, it was a unique challenge to position the cranes required. The Company mobilized a 650 MT ringer crane for heavy lift erection at site, positioning it on the main road of the GSFC plant for eight months.
- Unconventional methods were used for installation of plant and machinery. A tower crane was used to ensure continuous feeding of structural and piping material for erection at higher elevations.
- Quick movement across different levels in the plant was facilitated by construction elevators.
- Bar-coding was implementated for piping-spool storage, identification and erection.
- Early start of electrical & instrumentation activities was facilitated by a continuous front-generation drive.
- Completion of substation building on priority resulted in early energization.
- An average of 8% construction progress for six months during peak time resulted from micro-planning and monitoring.

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- An early switchover was made from construction completion to system-based monitoring.
- Centenary Completion Management System (CCMS) expedited and monitored the system-based plant precommissioning and commissioning.
- Trouble-free start-up and reduced commissioning problems resulted from the implementation of the Flawless Project Delivery concept during installation in the areas of flange and valve management, cleanliness ('Build it clean'), preservation and interface management.

# JAMNAGAR EXPANSION PHASE 3 PROJECT (J-3)

RELIANCE INDUSTRIES LIMITED, JAMNAGAR INDIA

A Landmark Construction Project



## PLANT CAPACITY AND LICENSORS

Plant Name	Plant Capacity	Licensor
Ethylene Cryogenic Storage	25 KMT	-
Paraxylene (Unit 4)	2.2 MMTPA	CB&I Lummus
Refinery Off Gas Cracker	1.4 MMTPA	Technip
Monoethylene Glycol	733,000 MTPA	Dow
Low Density Polyethylene	400,000 MTPA	Lyondell Basell
Pet Coke Gasification (DTA)	9.2 MMSCMD	Phillips 66
Pet Coke Gasification (SEZ)	13.8 MMSCMD	Phillips 66

### SCOPE OF ACTIVITIES

Activity	UOM	Scope
Concreting	m <sup>3</sup>	925,000
Structure Fabrication	MT	42,000
Structure Erection	MT	185,000
Piping (AG + UG) Welding	ID	2,860,000
Piping (AG + UG) Erection	IM	13,075,000
E&I Cabling	km	12,575

# 8 PROJECT CHALLENGES

- Given the enormous scale of the project, managing human resources and workforce mobilisation, posed the biggest challenges. A total of 250,000 workmen from across the country – with a peak strength of 34,700 and an average of 30,000 maintained over a period of 8 months – were mobilized during the program lifecycle.
- The project necessitated L&T Hydrocarbon Engineering (LTHE) to expand its Project Management staff base while still maintaining the right functional expertise, proficiency levels, and team compositions. To ensure this, a dedicated Human Resource Cell was created. During the project lifespan, a total of 2,322 Project Management staff – of which 1,640 were new recruits – were mobilized.
- The project even meant partnering with several new agencies, which presented additional challenges, from selection and scrutiny to performance monitoring and evaluation. The most crucial

aspect, however remained bringing them on-board and getting them up to speed with our systems, operational practices and norms and retaining their enthusiasm for the job.

- Though the majority of procurement didn't fall under the purview of the Division of Responsibility, LTHE was accountable for the consumption and reconciliation of all material, worth approximately USD 1.5 billion. Inventory Management proved a daunting affair, made even more difficult by the geographical spread of the project site. Every single material transaction was carefully tracked and scrutinised to ensure fair and optimum use.
- The Plant & System design presented a work environment that offered limited access for P&M and a constrained floor space for working. These issues, coupled with multi-disciplinary and multi-agency tasks being executed within close vicinity of each other, necessitated a highly interfaced and collaborative approach while execution.

# CHANGE MANAGEMENT

Given the scale of work, coupled with the lack of any precedent, the project required multiple system modifications and related changes including:

### Aligning LTHE HSE systems to J-3

HSE systems: Maintaining workmen to HSE Supervisor Ratio (50:1), Critical Skill Assessment of HSE Staff and Workmen Skills (17 trades), New Employee Development (NED), Mandatory 8-hour training for all, Work Permit Systems in Greenfield Projects, specific requirement of Safety Task Assignment (STA), mandatory Scaffolders Competency training for obtaining Skill Assessment Card (Green Card), Fall Protection Plan, etc.

# Training and orientation on J-3 HSE platform for all Project Management

**staff:** At the peak of the construction activities, LTHE had roughly 2,200 Project Management staff on the project. More than 80% of these were new recruits. Considering the aggressive project schedule and deployment of huge workmen resources, training and orientation for all project staff on HSE systems and compliance requirement was a major challenge.

### Aligning business partners (sub-contractors) to J-3 HSE systems:

Considering the huge workmen resource requirements and high workmen attrition rates (continuous inflow of new workmen), nearly all subcontractors had to stretch their limits in terms of workmen mobilization. Additionally, LTHE had to induct quite a few new agencies. This resulted in challenges in terms of establishing a robust system for continuous skill validation, ensuring required proficiency levels for all skill types, maintaining a balanced skill composition, training individuals on various HSE aspects of the job, handholding of many workmen new to a construction work environment, etc.

### FOCUS ON HSE

The HSE function operated with a stated objective of 'Zero Incidents', backed by an increased level of involvement and commitment from the leadership team. Some of the most noteworthy HSE initiatives implemented during the project included: Weekly Apex HSE Committee meetings, Stop-job Authority for HSE engineers, enhanced individual accountability, behaviourbased HSE Leadership Workshops, comprehensive orientation and training for all stakeholder levels, and continuous communication with the workforce through real-time messaging, town-hall meetings, weekly mass toolbox and craft-wise meetings with targeted groups, etc.

LTHE has been awarded the prestigious Sapphire (KAVACH) Award by Reliance Project Management Group (RPMG) for being selected as 'Safe Contractor of the Year 2018'. This is the second consecutive year that LTHE has been awarded the KAVACH award by RPMG.



### A PROJECT OF MANY FIRSTS

- LTHE partnered with RIL for delivering the world's largest installation of Gasifiers to produce Syngas (23 MMSCMD) and the world's largest Refinery Off Gas Cracker.
- LTHE mobilized over 250,000 workmen and clocked 300 million man-hours – the time in which one could have built 15 Burj Khalifas.
- The project saw LTHE break several monthly records. For instance, at its height, LTHE executed 48,500 m<sup>3</sup> of concreting, 11,500 MT of structure erection,

150.000 Inch Meter (IM) of underground piping erection and 903 km of E&I cabling. In case of above ground piping, it delivered a monthly peak of 670,000 IM of erection, 1,000,000 IM of hydrostatic testing, and boxed-up a little above 1,300,000 IM.

• Then there were single day records such as hydrostatic testing of 114,000 IM and box-up of 200,000 IM, at the ROGC Project Site. LTHE even conducted pressure testing for high pressure piping in LDPE plant, at a rating of 2,920 Bar.

### UNIQUE VALUE ADDITION THROUGH EXECUTION STRATEGIES

- The J-3 project allowed LTHE to scale new heights in terms of developing its project execution capabilities. One of the key value additions was building project execution capabilities for Plant Electrical and Instrumentation works.
- LTHE successfully installed 201 units of transformers across 12 substations. A total of 2,000 instruments were installed across 4 process units, with about 9,700 instrument hook-ups (both process and pneumatic). Additionally, the project saw installation of 74,000 units of light fixtures, and delivery of 13 plant / process interface buildings.
- LTHE further enhanced its capabilities for mobilizing a huge quantum of various skilled resources through intensive networking and

skill development programmes at sites. By investing more than 2.5 million man-hours on various training and development programmes, it trained 2,500+ scaffolders and created an online database of 1,800 scaffolders, validated and trained in their work.

• The J-3 project also led to the development of functional capabilities, and transition of roles for LTHE's Project Management Staff, e.g., WBS Heads, Planning In-charges, Project Managers / RCMs. Besides, a high number of project constraints, challenging schedules, highest level of HSE, quality standards in line with industry benchmarks led LTHE to enhance its risk handling capabilities for delivering such mega construction projects.

# **RAS TANURA INTEGRATED PROJECT**

**Construction for Mega Petrochemical Complex in KSA** 

In March 2012, SADARA Chemical Company awarded a contract for three Polyethylene trains on Lump Sum Procure and Build (LSPB) basis. An L&T subsidiary Larsen & Toubro ATCO Saudi Company (now L&T Hydrocarbon Saudi Company) won the contract on the basis of L&T's huge resource base, excellent track record in executing mega projects and its unmatched standards of safety and quality.

ect Name	LSPB 1 - Polyethylene Trains 1, 2, 4
ect Location	Al Jubail, The Kingdom of Saudi Arabia
s and Plant acity	Train 1 – Solution Polyethylene and common facilit Train 2 – Solution Polyethylene Train 4 – Specialty Elastomer
	Trains 1 and 2 have a combined capacity of 750,00
nt	SADARA Chemical Company (JV of Saudi Aramco 8
nsor	Dow Engineering Company (DEC)
ect Scope	Lump Sum Procure and Build (LSPB)





SADARA's mega complex was an integrated facility comprising 26 manufacturing units. These included a mixed-feed cracker and an aromatics plant as key upstream manufacturing units, three onsite third-party process units and supporting infrastructure. The project scope included:

Engineering: Detailed engineering for nine field-erected tanks and structural steel as well as field engineering

**Procurement**: Civil bulks including complete building material and HVAC, structural steel, piping below 2 inches and bulks, electrical and instrumentation, cables and bulk material

Construction: Piling, civil, structural, building, mechanical, piping, electrical and instrumentation works

Pre-commissioning & Commissioning Assistance: Flushing, drying, reinstatement, motor solo runs, equipment final alignment and box up, instrument loop check, substation energizing and manpower / equipment assistance for commissioning



# 🖏 PROJECT CHALLENGES

The polyethylene asset housed in the mega complex was not only SADARA's prime asset manufacturing its most profitable products but also the first asset commissioned there. The feedstock ethylene for the polyethylene plant was supplied by the mixed feed cracker unit within SADARA.

The project posed a number of challenges including:

- The project was the first of the SADARA program to be commissioned

   first product out from SADARA
- A new territory for LTHE and largest construction project executed in the international market at the time of award
- Extremely tight project schedule
- Huge mobilisation of manpower over 5100 people of various nationalities at the height of visa restrictions
- Compliance with localisation and Saudization requirements
- Various permits and Royal Commission approvals
- Acute shortage of local resources due to massive requirement for SADARA program

# O EXECUTION STRATEGIES

### **Project Planning**

Each train was treated as a separate project and an integrated Level-3 schedule was prepared, logically linking engineering, procurement, construction and pre-commissioning activities between various disciplines, phases, and units. Resource-loaded, the schedule served as a live model of the project, identifying its critical path, bottlenecks, milestones, and all activities necessary for the project completion. Schedules, prepared in Primavera Project Planner P6 (V8.2) were updated each week to reflect the project's progress.

### **Rapid Plant Construction**

State-of-the-art temporary facilities and a fabrication shop were set up to support the main plant construction works. This included office facilities such as site offices for the client and the project management team. Two dedicated piping fabrication shops – featuring EOT and automatic cutting and bevelling machines and automatic welding machines – with a total production total capacity of 35,000 DI/ month were also set up. A 500,000 m<sup>2</sup> laydown yard for material storage was also set up and supplemented by fullycovered warehouses (AC & Non-AC).

The main plant construction works were split train-wise with each train in turn being broken down into process units. While the civil work for Train 1 and the common facilities were carried out in-house, Trains 2 and 4 were sub-contracted to a reputed local civil sub-contractor, Dywidag Arabia. During the project, the single largest pour was 1800 m<sup>3</sup> of concrete, which, fed simultaneously from five batching plants, lasted for close to ten hours! In total, the project poured over 73,000 m<sup>3</sup> of concrete.

The entire structural detailing, material procurement, fabrication and galvanizing was sub-contracted locally to Zamil Steel while erection was carried out in-house by LTHE. On the piping front, the entire pre-fabrication was done in-house at our own fabrication shop. Erection was executed in-house with support from local contractors. Radiography and Phased Array Ultrasonic Testing ensured the integrity of critical lines and test packages. LTHE executed nine tanks on an EPC basis. Five tanks were designed to API 650 Code while the other four to API 620. The plant's 8-cell FRP cooling tower was manufactured by Spig SpA, Italy, and was erected in a record time of six months.

## **Electrical & Instrumentation**

The scope of work included complete construction and pre-commissioning works for four MCC buildings, three operator buildings, process units, underground cabling, heat tracing, motor solo runs and plant lighting works.

The instrumentation works entailed construction and pre-commissioning works of DCS and process interfaces in MCC buildings, works in process units, and tie-ins to the Central Operator Building. The plant extensively relies on Foundation Field Bus communication architecture – the first of its kind. A total of 1,350 km of E&I cables were laid.

All systems and equipment for each unit were pre-commissioned and handed over in sequence. Once handed over, LTHE continued to support the commissioning and start-up activities on a manpower time unit rate basis.

### Intense Resource Mobilization, Commitment to Safety & Quality

An optimum mix of in-house execution and sub-contracting ensured timely completion of the project. The sub-contractor selection was based on a number of criteria including stringent HSE and quality parameters. With over 5100 workmen from different nationalities and more than 50 cranes mobilised at its peak, the project stands out as a case study in resource management.

LTHE committed itself to the highest standards of HSE leading to 30 million safe man-hours. The team displayed a proactive approach, anticipating job hazards and assessing risks in advance. LTHE's efforts were rewarded on multiple occasions – including safety awards from SADARA and numerous other international agencies such as RoSPA, BSC, ASSE. The site was hailed as a role model for other contractors.

The Company also put in place systems to ensure a close check on quality as demanded by the client. The client had implemented the process of measuring the project's quality performance (index) (PQI) by way of compiling every quarter – LBE (log book entry), NCRs, weld rejection rate, RFI acceptance, guality document submissions, guality personnel mobilization, etc., against the project specifications. LTHE maintained a PQI of above 92% throughout the project and its weld rejection rate stood at 0.13% on a linear basis - the lowest among all the assets in the SADARA Complex.



# **MANGALORE AROMATICS COMPLEX**

India's Largest Single-Train Paraxylene Complex – One of the World's Largest

ONGC-MANGALORE PETROCHEMICALS LIMITED, INDIA

In March 2010, L&T won the prestigious contract to execute the Mangalore Aromatic Complex Project (MARC) of ONGC Mangalore Petrochemicals Limited (OMPL) – a company promoted by ONGC and MRPL.

L&T was given the responsibility of executing all the nine process units of this project, viz. Naphtha Hydrotreating Unit, Continuous Catalytic Regeneration Unit, Platforming Unit, Parex Unit, Isomar Unit, Xylene Fractionation Unit, Shell Sulpholane Unit, Tatoray Unit and Benzene & Toluene Fractionation Unit.



PROJECT CHALLENGES

The project involved many criticalities and large work volumes which had to be executed in a stringent time schedule. The project's multiple complexities included a large number of rotating machinery with various types of compressors and high capacity pumps, modularization of a CCRG structure exceeding 80 m height, large capacity furnaces including the platforming heater built to UOP proprietary design and other high-capacity fired heaters, various ODC columns and the complex adsorbent chamber circuit.

In addition to the huge quantum of work involved in the project, Mangalore's local conditions, including heavy rains and infrastructure constraints, added to the challenge. Various innovative measures were adopted to minimize the effect of rainfall on the progress and to limit any loss in productivity. As the project site is in rocky terrain, there were also several challenges in civil construction, design and execution because of slushy soil (during the monsoon), the discovery of rocks at unpredictable depths, etc.

The project involved the shipment of Over-Dimensional Consignment (ODC) from eight countries. Infrastructure challenges at the Mangalore port and the non-availability of proper facilities (roads, railway crossings, etc.) posed a major challenge during execution.

# O EXECUTION STRATEGIES

L&T is one among the few companies worldwide that has in-house capabilities to execute a project of this magnitude in an integrated manner.

L&T's internal strengths were leveraged by the project management team, using the platform of SAP's integrated network, multi-locational working, integrated 3D modeling and reviews, constructability studies and integrated EPC execution.

L&T's project management philosophy, which revolves around the key concept of becoming a Centre of Excellence, enables the Company to maximize productivity and efficiency and allows for maximum integration. This, in turn, results in adherence to safety, quality, and timeliness standards along with the budgetary constraints.

The magnitude and complexity of the project can be gauged from the followina:

- Engineering: >1 Million man-hours
- A workforce (6554 at peak) had to be mobilized
- Lack of access and infrastructure facilities and delay in availability of ODC route
- Unprecedented and extended monsoon
- Complex piping system with various metallurgies and high volumes
- Synchronized sequence of highly interconnected 9 process units

The challenges were managed through various project management philosophies and approaches such as:

- 'First Time Right' approach
- Dedicated expeditors at vendor shops to ensure timely delivery of equipment
- Effective Logistics Management
- Automation of construction activities
- Work-pack approach to planning and a construction-driven approach
- Management of workloads through use of various off-site fabrication facilities
- Smooth turnover of systems after mechanical completion to start-up and commissioning

The project was executed in the following broad phases:

The first phase included basic planning and conceptualization and substantial completion of civil work and technological structures to make the plant ready for equipment and piping integration, with 85 to 90% engineering completion.

The second phase involved integration of equipment to the project and connecting them by way of piping and cabling, followed by testing.

The third and final phase included loop completion, pre-commissioning and commissioning activities. This is the phase where the construction work moves to process systems.

# PANIPAT NAPHTHA CRACKER PROJECT

A World-Class Naphtha Cracker Project for IOCL

INDIAN OIL Corporation limited Panipat, India

In May 2006, a consortium of L&T and Toyo Engineering Corporation (Japan) won a Lump Sum Turn Key (LSTK) contract from Indian Oil Corporation Limited (IOCL) for setting up a Naphtha Cracker Complex and Downstream Polymer units in Panipat, India. Keeping in mind IOCL's long-term vision to turn its existing Panipat Refinery into a world-class Integrated Refinery and Petrochemical Complex and the central hub of its operations, the project was strategically significant to the Company. L&T's scope of work included Short Residence Time (SRT) Cracker Furnaces and associated units viz., C4 Hydrogenation, Pyrolysis Gasoline Hydrogenation (PGH), Benzene Extraction Unit, PSA Unit and substations on an EPCC basis. Once commissioned, the Naphtha Cracker was to be one of the largest capacity plants of its kind in the world.



Project Location	n Pa	nipat, India					
Plant Capacity							
Naphtha Cra	icker	800,000 MTPA Ethylene / 550,000 l	MTPA Propy	lene			
C4 Hydrogen	nation	142,000 MTPA					
Pyrolysis Gas Hydrogenati	soline on	540,000 MTPA					
Benzene Exti	raction	116,000 MTPA					
Client	Inc	dian Oil Corporation Limited	1.5	0			
icensor	CB	& Lummus					
Project scope	En &	gineering, Procurement, Construction Commissioning (EPCC)	n				
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## <mark>ᄗ</mark> PROJECT CHALLENGES

One of the key challenges faced by the consortium partners early in the project was arriving at a common set of objectives. A consortium alignment meeting ensured articulation of common design methodologies, project procedures, and sharing of resources and experience. Timely availability of the gas of desired purity and quantity hindered welding operations and threatened to slow down the overall pace of execution. To overcome the challenge, the project team set up a gas storage facility on-site, instead of depending on the supply of cylinders. Since qualified welders were in short supply, L&T set up a Welder Training Institute on-site. Having an army of fully-trained, top quality welders not only brought in added agility to the site operations, it also ensured little to no re-work on welding jobs.



### O EXECUTION STRATEGIES

The key factor in the successful execution of any project is proper planning, the ability to forecast future work fronts and flexibility in mobilization and allocation of resources.

Adopting a 'One Team One Goal' approach, multiple team-building sessions were organised. Fortnightly review meetings were held for cross-functional resolution of issues and setting weekly targets for resolution of issues proved crucial to successful and timely execution of the project.

Furnace Schedule: The seven SRT furnaces executed as part of the job were central to the success of the project. To ensure seamless execution, the project team garnered the support of CB&I Lummus, the Process Licensor at an early stage. Multiple interface meetings were conducted with the consortium partner wherein experts from both sides shared their experiences and methodologies, to arrive at the furnace execution plan, which was a key to timely execution of furnaces. The establishment of an on-site fabrication facility and a manufacturing approach to fabrication ensured on-time execution and delivery of the furnaces.

**Engineering**: A Cold Eyes Review of the engineering work was carried out for all

disciplines. For the furnace portion, the Process Licensor executed the verification of critical deliverables, which also helped in completing the design on time. A Four-level Model Review, i.e., stringent reviews at the 30%, 60%, 90%, and 100% stage, enabled the team to identify potential clashes and mismatches and take timely corrective action.

Collaborative engineering through 'vendor partnering' from the earliest stage onwards helped ensure quicker resolution of issues. The same approach was adopted right through the project and proved especially useful for steam section, compressors, riser-downcomer, refractories and pumps for seal selection, resulting in minimum rework.

Efforts were made to optimize resources by creating parallel fronts. Key actions were taken at multiple locations for the structural engineering, modularized convection module and weldless spools for the riser downcomer.

### **Bulk Material Management**

**System**: An integrated Bulk Material Management System facilitated tracking of the material from engineering to construction completion.

**Construction**: The Process Licensor's experience was leveraged in order to set execute the furnace sequence in a

phased manner. Interface and resource related problems were significantly reduced by conducting constructability studies in a phased manner. Machine movement and approaches were analysed in a 3D model and equipment delivery was staggered to meet site requirements. Rigging and lifting plans were constantly updated and reviewed to resolve bottlenecks on-line.

Lean Project Management was introduced while conceiving and executing the furnaces. Three manufacturing bays were created where the job could move to the work centre rather than the work centre moving to the job site. This helped in ensuring bottleneck-free manufacturing of the furnace elements. The manufacturing bays constantly provided the work-front for execution and helped in completing the furnace erection ahead of schedule.

One of the more critical activities during furnace erection was insertion of the radiant coil. A novel scheme for erecting the radiant coil – where Coil Erection, Superstructure and TLE Erection were made a parallel activity – saved 2 months of execution time. The Modular Fabrication concept was used for the Handrails and Furnace Superstructure. Regular construction audits were carried out to minimize punch listing by Owner / PMC.

# **TEREPHTHALIC ACID PLANT**

### One of India's Largest Single-Stream Purified Terephthalic Acid Plants

INDIAN OIL Corporation limited Panipat, india

In January 2003, Indian Oil Corporation Limited (IOCL) awarded an order to Larsen & Toubro (L&T) for a Purified Terephthalic Acid (PTA) plant of world-scale size at its Refinery & Petrochemical Complex at Panipat. This is one of the largest single-stream PTA units in India. Technologically, this is one of the most advanced plants in the country, with the technology from DuPont, UK (now Invista). EIL was the Project Management Consultant (PMC).

This was L&T's first major EPC LSTK project in the petrochemical sector and single largest LSTK order at that point of time. L&T formed an experienced task force to execute this challenging project, which had a stiff delivery schedule for mechanical completion.



# <mark> 양</mark> PROJECT CHALLENGES

The project involved global procurement, with 44 critical mandatory equipment (including 15 critical package systems). Most of the sourcing was from Europe, the Far East and North America. A large warehouse (420 m x 105 m) with state-of-the-art storage and bagging facilities was also a part of the overall project scope.

The engineering required a deep understanding of all fluid phases including gas, liquid, slurry and solid handling, and highly corrosive services including high concentration acid lines (acetic acid, hydro bromic acid, etc.) A variety of exotic metallurgies including Titanium, Hastelloy and Duplex stainless steel were used, which required clean environment for welding and stringent quality control.







### **\*** EXECUTION STRATEGIES

The PTA Plant has two sections, viz. Crude Terephthalic Acid Section and Purified Terephthalic Acid Section, viz.

### **Crude Terephthalic Acid Section**

- Oxidation Reaction Section
- Crystallization Section
- Separation & Drying Section
- Off-gases Recovery Section
- Solvent Recovery Section
- Catalyst Recovery Section

### **Purified Terephthalic Acid Section**

- FEED Preparation Section
- Reactor Section
- Crystallization Section
- Separation & Drying Section
- PTA Storage & Warehouse

Being one of the approved design engineering contractors for Invista Technology, Aker Kvaerner (now Aker Solutions) undertook the residual process and detailed engineering for the project at their UK and Mumbai offices, under the supervision of L&T's Engineering Management Team.

L&T implemented the project using innovative engineering and construction techniques, with Zero Lost Time Accidents, earning IOCL's 'Best Safety Award' and 'Silver Award for Occupational Safety' from The Royal Society for the Prevention of Accidents (RoSPA), UK. The successful commissioning of the PTA plant in June 2006 affirmed L&T's capabilities in helping mega projects move from concept to reality through its internationally benchmarked capabilities in engineering, fabrication, procurement and construction.



Operating Centre of Onshore Business at L&T Knowledge City, Vadodara, India



L&T Institute of Project Management (IPM) at Vadodara – a registered educational provider of PMI, USA – develops project managers across EPC domains



Safety Innovation School at Hazira, Gujarat – part of multiple initiatives for the propagation of a safety culture company-wide





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