PRE FEASIBILITY REPORT OF J-18 PROJECT

FOR

CAPACITY EXPANSION FROM 13.7 TO 18.0 MMTPA WITH 100% BS-VI AUTO FUEL PRODUCTION FOR IOCL GUJARAT REFINERY

INDIAN OIL CORPORATION LIMITED GUJARAT REFINERY

August 2019

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1 Introduction

1.1 Existing Refinery introduction

Indian Oil is India's flagship National Oil Company, with business interests that straddle the entire hydrocarbon value chain - from refining, pipeline transportation and marketing of petroleum products to exploration & of light and middle Distillates to a level of 78% on crude oil processed production of crude oil & gas as well as marketing of natural gas and petrochemicals. It is the highest ranked Indian corporate in the prestigious Fortune 'Global 500' listing, ranked at the 137th position for the year 2018. Indian Oil and its subsidiaries have a dominant share of the petroleum products' market, national refining capacity and downstream sector pipelines capacity. With a strong workforce, Indian Oil has been helping to meet India's energy demands for over five decades now. Indian Oil and its subsidiaries own and operate 10 of India's refineries and its cross-country network of crude oil, product and gas pipelines is the largest in the country, meeting the vital energy needs of consumers in an efficient and environment friendly manner. The corporation has a crude oil processing capacity of 79.7 million tons per annum. The Refineries process both low Sulphur and high Sulphur crude oils.

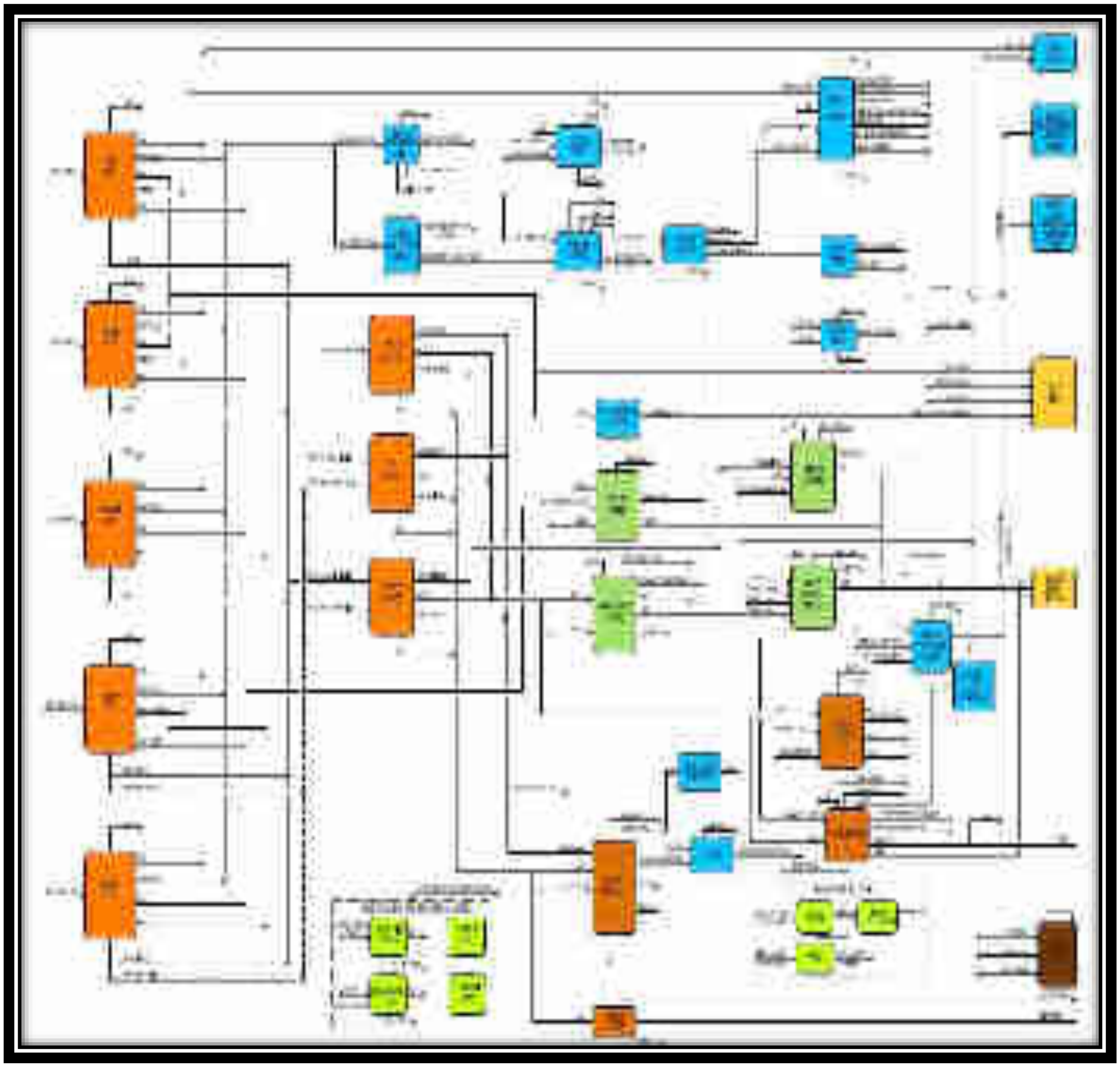
As a part of their expansion and product quality upgradation plan, Indian Oil Corporation Ltd (IOCL) intend to increase the capacity of its flag ship refinery located at Koyali in Gujrat known as Gujrat Refinery. Today it is the second largest refinery owned by IOCL after Panipat refinery

Gujrat refinery was commissioned in year 1965 with a crude processing capacity of 2 Million Metric Tons per year. Over the years, expansion in Gujrat Refinery has taken place in phases from 2 MMTPA of crude to present capacity of 13.7 MMTPA and is further gearing up for the expansion. The Refinery is designed to process crude basket comprising of 55% high Sulphur crude (7.6 MMTPA) and 45% low Sulphur indigenous crude (6.1 MMTPA).In addition to BS-III/BS-IV fuel products, the refinery also has the capability to produce a wide range of specialty products such as benzene, toluene, MTBE, MTO, Food Grade Hexane & LAB. Currently refinery is executing projects to upgrade the entire gasoline and diesel to BS-IV specification by revamp of existing DHDT, DHDS and VGO hydrotreater units. Further, with objective of meeting the guidelines established in Auto Fuel Policy 2025, wherein refinery would be required to manufacture 100% BS-VI fuels, IOCL is also executing BS VI project under which a new DHDT unit, a FCC Gasoline Desulphurization unit and a new HGU are envisaged.

Today, Gujrat Refinery is one of the most complex refinery in India and has around 40 operating units within the refinery complex. Over the course of five decades, the refinery has kept pace with the latest technological advancements which also includes ongoing project to upgrade the existing product slate to supply 100% BS VI fuels.

Process Block Diagram of Existing Refinery

The block diagram below presents the configuration of the existing refinery after BS VI expansion. (This block diagram is indicative and shows only the major process blocks)



1.2 Overall Refinery Capacity Expansion Details

IOCL is now considering increasing the processing capacity of the refinery from current 13.7 MMTPA to 18.0 MMTPA of crude oil. IOCL refers this project as “J18- Capacity Expansion Project”.

As a part of this J 18 -Capacity Expansion Project, IOCL has considered addition of following process facilities in its Gujarat Refinery to achieve its objective of capacity expansion. In addition to process facilities, this project also requires number of utilities which are also indicated here under.

Primary Processing Units: A new Atmospheric Vacuum Distillation Unit (AVU) of 15.0 MMTPA capacity has been considered after dismantling of AU-I, AU-II, AU-III, AU IV, FPU-I & VDU and by creating an additional capacity of 4.3 MMTPA. The dismantling of existing AUs, FPU I and VDU has been considered to replace old small units with a new higher capacity unit to increase the efficiency and ease of operation. Existing AU V (Design capacity: 3.0 MMTPA) and FPU II units have been retained.

AU-5 Revamp: In order to enable processing of low Sulphur and High TAN (TAN: 2.1) North Gujarat (NG) crude in AU-5 which is designed to process High Sulphur and low TAN: <0.5 crude, revamp of AU-5 has been envisaged under J-18. Some metallurgy change may be required in AU-5 for processing higher TAN crude. Further in order to take care of higher heavy residue yield in case of NG crude (RCO 68% vs 48%-50% in AU-5 design for HS), some revamp may be required for processing higher RCO yield crude.

SR LPG Treater unit: New straight run LPG Treater Unit of capacity 200 TMTPA has been considered to treat straight run LPG ex new Atmospheric Vacuum Distillation Unit.

INDMAX FCC: INDMAX FCC is a fluidized catalytic process for selectively cracking a variety of feed stocks to light olefins. INDMAX FCC is similar to conventional FCC in terms of basic process employed but the cracking's are higher in INDMAX unit. The objective of this process is maximization of LPG with higher selectivity towards propylene. LPG yield is typically 36-40 percent and propylene is typically 20 wt.%. Dry gas produced from this unit is rich in ethylene. New INDMAX FCC of capacity 2700 TMTPA with Propylene Recovery Unit of capacity 580 TMTPA has been considered for this project. Flue gas generated ex INDMAX FCC to be treated in Flue gas desulfurization unit to maintain SOx as per environmental norm before releasing to atmosphere.

CR LPG Treater unit: New Cracked LPG Treater Unit of capacity 1073 TMTPA has been considered to treat Cracked LPG from new INDMAX FCC Unit.

Kerosene Hydrodesulphurization Unit (KHDS): New KHDS unit of capacity 700 TMTPA has been considered to treat the excess kerosene stream from AVU to the unit to maintain Sulphur and other properties for ATF and also to make it suitable for feed to existing LAB unit.

Motor Spirit Production Block: New Catalytic Cracking Unit (CCRU) of capacity 1600 TMTPA and a new Isomerization Unit (ISOM) of capacity 925 TMTPA have been considered for maximum conversion of incremental Naphtha generated from the project to Motor Spirit (MS). A new Naphtha Splitter unit as well as Naphtha Hydro Treater Unit shall also be part of this MS production block.

Indmax Gasoline Hydro Desulphurization (IGHDS) Unit: The feed for this unit is gasoline produced in Indmax unit. The objective of this unit is to reduce the sulfur content of the feedstock whilst minimizing the octane number loss across the unit. New Indmax GHDS of capacity 650 TMTPA has been considered for this project.

Propylene Recovery Unit (PRU): A Polypropylene Recovery Unit of capacity 580 TMTPA has been considered to produce propylene from existing Coker LPG / FCC LPG and Indmax LPG. Propylene will go to new PPU and Butyl alcohol plant coming at Dumad.

Polypropylene Unit (PPU): A Polypropylene unit of capacity 420 TMTPA has been considered to polymerize propylene coming from PRU to improve the sales revenue.

Sulphur Recovery Unit (SRU): New SRU of capacity 400 TPD has been considered to process additional sour gas generation for processing high Sulphur crude under expansion project

Sour Water Stripper & Amine Recovery Unit – New Sour Water Stripper of 330 TPH and Amine Recovery Unit of 350 TPH shall be considered for generation of incremental acid gases from new units proposed under capacity expansion Project.

Utility Units – In order to meet the demand of utilities required by the new process units, new Utility facilities would be necessary, some important ones are listed below:

- Nitrogen Generation plant: 5000Nm3/hr including 500m3 Liquid N2 Storage
- Compressed air system: 3X7250 Nm3/hr (2W+1S).
- New Boiler: 450 TPH (3x150 TPH)
- DM water chain: 3X250 m3/hr (2W+1S) including ZLD
- Condensate Polishing unit : 2 x 250 m3/hr (1W + 1S)
- Circulating cooling water cells: CT-1 5 x 4000 m3 /hr (4W+1S) & CT2 – 9x 4000m3/hr (8W+1S).
- Flare: 1100 TPH New flare near BS IV flare after dismantling the existing flare.

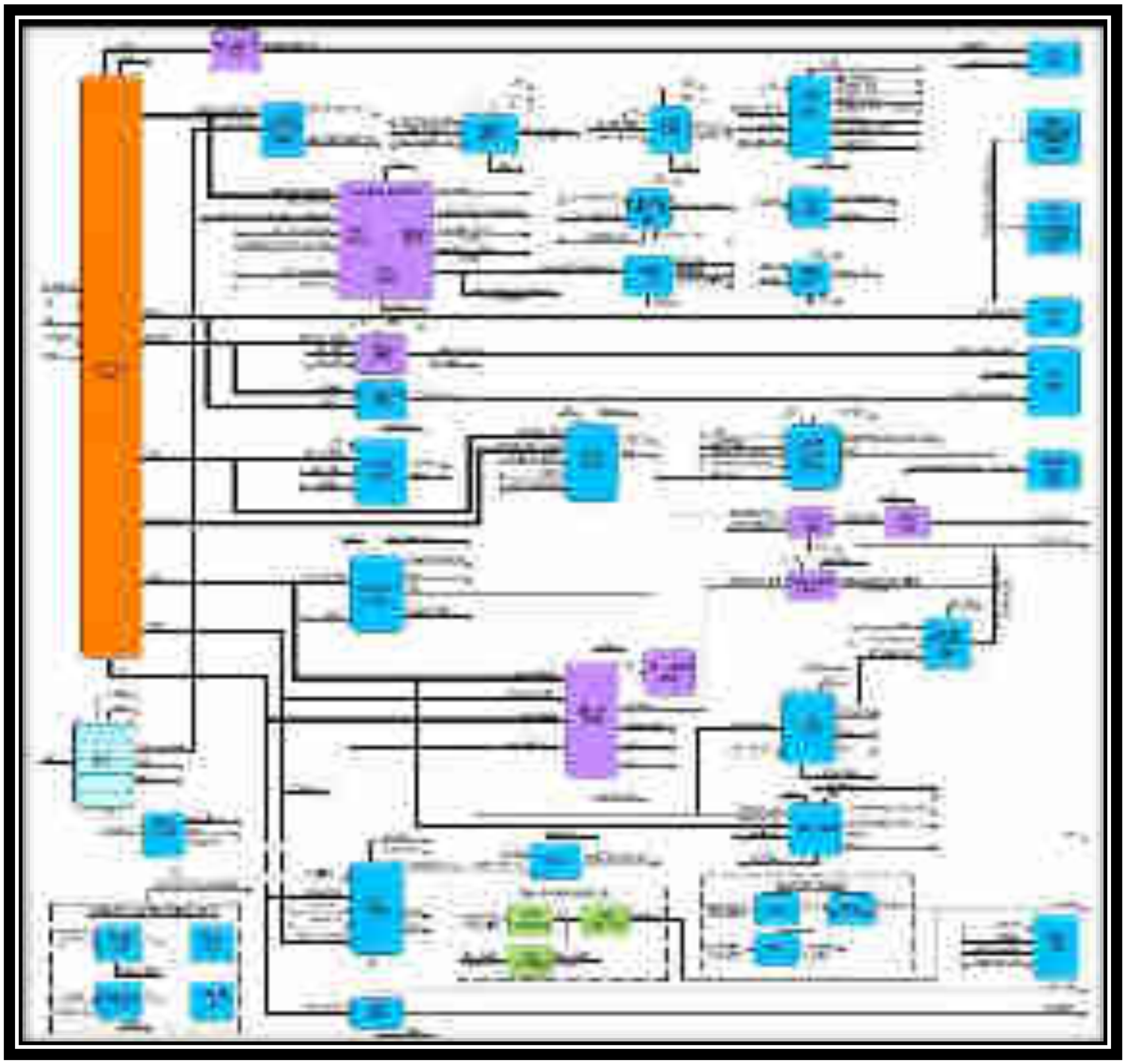
Offsite Facilities - The main offsite facilities shall include:

- NHT feed tank: 2 X 12000KL
- KHDS feed tank :2X 5000KL
- Propylene Bullets: 4X3500 KL
- MTO product storage tank: 1X5000KL
- LPG mounded bullets: 4X3000 KL at Dumad site (The location of LPG mounded bullets was changed from Gujarat Refinery site to Dumad as per IOCL request)
- New Effluent Treatment Plant (ETP): 385 m3/hr.
- Raw water system with bore well of 10 MGD (UK) capacity.

Other related equipment like pumps, valve, instrumentation, electricals etc. will also be part of J-18 Project

Process Block Diagram after J 18 Capacity expansion Project

The block diagram below presents the configuration of the Gujrat refinery after J 18- capacity expansion Project. (This block diagram is indicative and shows only the major process blocks)



1.3 Implementation Strategy

IOCL intends to implement the complete J-18 capacity expansion project in the following manner:

EPCC packages through LSTK	New AVU& SR LPG Treater, Indmax FCC& CR LPG Treater, MS Block (NHT & Isomerization and CCR), IGHDS & PRU, PPU, SRU
Conventional packages through EPCM	AU-5 Revamp, KHDS, SWS, ARU, utility systems, off-site storages and complete offsite integration

This requirement of IOCL has been considered while preparing this DFR.

The entire Project shall be implemented in two stages with the scope defined as under:

PMC-I	BDEP, FEED, DFR, EPCC tender and its recommendations for all EPCC packages and finalization of all utilities and offsites
PMC-II	Tender Award, Execution of EPCC contracts, Detailed Engineering, procurement and expediting of EPCM for conventional packages, construction management & supervision, assistance in start-up, commissioning and performance run.

For the implementation of its proposed J18 Capacity expansion project (From 13.7 to 18 MMTPA) of Gujarat Refinery in Vadodara, Gujarat, India, IOCL has awarded a Contract ref: KK/ RHQCC17071-1/AGT/201802019 dated 31st May 2018 to M/s. Technip India Limited (referred hence forth as PMC in this report) for providing Consultancy services for PMC-I. This document covers the DFR for whole execution of J18 Capacity expansion project.

The complete J18 is being implemented in a hybrid mode of project execution i.e. partly under PMC and partly under EPCM mode. The unit-wise mode of project execution along with their brief scope has been described as under;

Units under J18 project	**Mode of Project Execution**	**Brief Scope**	**Remark**
New AVU	PMC	• BDEP preparation and +/- 20% cost estimate. • FEED preparation and DFR with +/- 10% cost estimate • Issue of Tender and Recommendation for LSTK Bid Packages • Tender Award, Execution of EPC contract, construction management & supervision, assistance in start-up, commissioning and performance run	Open art Unit / Engineering, Procurement Construction and Commissioning (EPCC) Mode
INDMAX FCC, INDMAX GHDS, PPU and MS Block (NHT/NSU, CCRU &ISOM)	PMC	Review and endorsement of licensor BDEP packages and +/- 20% cost estimate. FEED preparation and DFR with +/- 10% cost estimate • Issue of Tender and Recommendation for LSTK Bid Packages • Tender Award, Execution of EPC	Engineering, Procurement Construction and Commissioning(EPCC) Mode

SRU and CRLPG	PMC	contract, construction management & supervision, assistance in start-up, commissioning and performance run	Licensor Selection, Engineering, Procurement Construction and Commissioning (LEPC) Mode (The execution revised by IOCL from EPC to LEPC mode)
PRU	PMC	BDEP preparation and +/- 20% cost estimate. FEED preparation and DFR with +/- 10% cost estimate • Issue of Tender and Recommendation for LSTK Bid Packages Tender Award, Execution of EPC contract, construction management & supervision, assistance in start-up, commissioning and performance run	Open Art Unit/ Engineering, Procurement Construction and Commissioning (EPCC) Mode
KHDS	EPCM	Review and endorsement of licensor BDEP packages and +/- 20% cost estimate. FEED preparation and DFR with +/- 10% cost estimate Complete project execution including Detailed Engineering, Procurement & Expediting services, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for units executed under EPCM mode.	conventional package
SWS, ARU and AU-5 Revamp,	EPCM	BDEP preparation and +/- 20% cost estimate. FEED preparation and DFR with +/- 10% cost estimate Complete project execution including Detailed Engineering, Procurement & Expediting services, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for units executed under EPCM mode.	Open Art units conventional package
Utilities and Offsites	EPCM		conventional package

DFR (this document) has been prepared based on PMC's own in-house process expertise, Licensor's information, best available software tools and the experience of PMC in executing similar projects in the past.

2 Scope of Detailed Feasibility Report (DFR)

2.1 Purpose

The purpose of this Detail Feasibility Report (DFR) is to study the benefits accrued by IOCL by enhancing the refining capacity of Gujarat Refinery from 13.7 MMTPA to 18.0 MMTPA by installing new primary & secondary processing units and required Utilities & Off-sites to produce 100% BS-IV fuels and other value added products including Polypropylene. The Refinery units have been designed to ensure maintaining environmental pollution within the limits of environmental norms.

The New Primary & Secondary processing Facilities and Utilities / Off-sites Covered under this DFR are given in 'Table 1 below;

Table 1 - New Processing Facilities / Utilities & off-sites Covered under the DFR

Unit		Unit number	Capacity as per design basis	Licensor
PROCESS UNITS				
New Atmospheric Vacuum Distillation unit(AVU)		1801	15 MMTPA	FEED package of M/s Amec FW for Paradip Refinery provided by IOCL is customized by PMC & BDEP prepared by PMC
SR LPG Treater unit		1802	200TMTPA	UOP
AU-5 Revamp		05	3.0 MMTPA (Revamped to process high TAN NG crude. No capacity change)	BDEP prepared by PMC
INDMAX FCC		1803	2700 TMTPA	BDEP prepared by Lummus Technology
INDMAX Gasoline Hydro Desulphurization Unit (IGHDS)		1804	650 TMTPA	BDEP by Axens
CR LPG Treater unit		1805	1073 TMTPA	Licensor selection by FCC LSTK contractor
Propylene Recovery Unit		1806	580 TMTPA	BDEP prepared by PMC
Polypropylene Unit (PP)		1807	420 TMTPA	BDEP by Novolen Technology
MS Block	NHT/NSU	1808	2400 TMTPA	BDEP prepared by UOP
	CCRU	1809	1600 TMTPA	BDEP prepared by UOP

	ISOM	1810	925 TMTPA	BDEP prepared by UOP
Kerosene Hydrodesulphurization Unit (KHDS)		1811	700 TMTPA	BDEP by EIL
Sulphur Recovery Unit (SRU)		1812	400 MTPD	Licensor selection by SRU LSTK contractor
Sour Water System (SWS)		1813	330 TPH	BDEP prepared by PMC
Amine Regeneration Unit(ARU)		1814	350 TPH	BDEP prepared by PMC
UTILITY SYSTEM				
Circulating Cooling Water System CT-1 for New AVU		1815	5 x 4000 m3/hr (4W + 1S Cells)	BDEP prepared by Technip India Limited
Circulating cooling water System CT-2 (For INDMAX IGHDS, PPU & MS Block)		1816	9 x 4000 m3/hr (8W + 1S Cells).	BDEP prepared by PMC
DM water chain		1817	3x 250 m3/hr (2W+1S)	BDEP prepared by PMC
Steam System (New Boiler) (Including BFW De-aerator System – 750 m3/hr)		1818	3 x 150 TPH	BDEP prepared by PMC
Condensate Polishing Unit		1819	2x 250 m3/hr (1W +1S)	BDEP prepared by PMC
Nitrogen generation plant (Including Liquid Nitrogen storage)		1821	5000 Nm3/hr Liquid Storage: 500 m3	BDEP prepared by PMC
Compressed Air System		1820	3 x 7250 Nm3/h (2W + 1S Compressor)	BDEP prepared by Technip India Limited
Flare (New flare near BS IV flare after dismantling the existing flare).		1822	1100 TPH	BDEP prepared by PMC
Raw water system with radial bore well		1823	10 MGD (UK)	BDEP prepared by PMC
New Effluent Treatment Plant (ETP)		1824	385 m3/hr	BDEP prepared by PMC
STORAGES AND OFFSITE FACILITIES				
NHT feed tank		1826	2 x 12000KL	BDEP prepared by PMC
KHDS feed tank		1826	2 x 5000KL	BDEP prepared by PMC
Propylene Bullets		1826	4 x 3500 KL	BDEP prepared by PMC

MTO product storage tank	1826	1 x 5000KL	BDEP prepared by PMC
LPG mounded bullets (The location of LPG mounded bullets was changed from Gujarat Refinery site to Dumad as per IOCL request)	1826	4 x 3000 KL at Dumad site	BDEP prepared by PMC
New Fire Fighting / Protection System	-	Foam Shed and Aux Fire Station	Design prepared by PMC
Power Import Facility		122 MW (104 MW from 220 KV grid import facility and 18 MW from existing CGP)	Design prepared by PMC
TECHNICAL BUILDINGS			
Control Room	-	4 New control rooms (New AVU/ Indmax FCC/ PPU/MS Block) + 2 Local Control rooms (ETP & Nitrogen plant)	Design prepared by PMC
Substation	-	7 New Substations (New AVU/ Indmax FCC/ PPU/MS Block/ Sulphur block/Cooling Towers/ ETP) + 1 Switch room for compressed Air package	Design prepared by PMC

2.2 Preparation of DFR

The scope of DFR for the whole J18 Refinery Capacity Expansion project includes process, engineering and project deliverables for the facilities mentioned above in Table -1 and the related enabling facilities which broadly cover the followings activities:

1. Formulate the project plan for the facilities defined in Table -1 above and their implementation philosophy. As per the tender specifications and subsequent instructions from IOCL on execution philosophy, J18 Project shall be implemented as per following modes of execution described in Table-2:

Table 2 – Mode of Execution for J18 Project

Mode of Execution		Name of Unit
Project Management Consultant (PMC)	Engineering, Procurement, Construction, commissioning (EPCC)	New AVU, SR LPG, PRU, PP Units, MS Block (NHT/NSU, CCRU, ISOM), INDMAX FCC, IGHDS.
	Licensor Selection, Engineering, Procurement, Construction, commissioning (LEPCC)	SRU, CR LPG TU
Engineering, Procurement, Construction Management (EPCM)		KHDS, ARU, SWS, Utility and off-sites

2. For the units which are implemented in EPCC mode of execution, Prepare the Complete BDEP for 15MMTPA capacity AVU only. (As per tender requirements Amec FW FEED available from the Paradip refinery was used as the basic reference document for preparing the FEED). For the units which are implemented in EPCM mode of execution (except KHDS), the scope includes preparation of the Complete BDEP which include process simulations (where necessary), PFD, Heat and Mass balance, P&IDs and other related documents. FEED is performed based on the BDEP documents.
   For the licensed units, the scope shall include review and residual engineering of BDEP prepared by licensors and complete the FEED.

3. The scope includes identification of site fabricated equipment and considering facilities for their movement and fabrication. Accordingly, 24 site fabricated ODC equipment have been identified namely Crude column, vacuum column, Crude flash drum, Reactor, Regenerator, Main Fractionator, Debutanizer, Deethaniser Stripper, Equilibrium Catalyst Hopper, Spent Catalyst Hopper, Main Fractionator Reflux Drum, Wet Gas Scrubber, Hot Feed Surge Drum, High Pressure Separator and Fractionator overhead distillate drum for Indmax FCC unit, Purge Silo, Pellet Blending Silo and Pellet Bagging Silo for Polypropylene unit, C3 Splitter Columns, Debutanizer, Deethanizer and Heat Pump K O Drum cum Overhead Receiver for Propylene Recovery Unit, De-Isohexanizer Column for MS block Isomerisation Unit and Atm Distill Column for AU-V Revamp. Special TCF requirements have been identified and considered in this DFR.

4. Identify the information required from IOCL and collect the required As-Built documents as necessary. The information which is not readily available in the documents but required for the completion of the project, the same to be generated by site visit and interacting with the corresponding experts.

5. Preparation of the process as well as Engineering design basis document for the facilities described under J18 project in the tender and as listed above in Table-1.

6. Carry out the Preliminary HAZOP study for the units for which BDEP was performed by Technip India Ltd (i.e. New AVU, PRU, SWS and ARU). HAZOP recommendation as applicable are considered while preparing the DFR.

7. Carryout the preliminary adequacy check for utilities, offsites and power availability based on the requirements worked out for the entire J18 project, taking into consideration of available spare capacities provided by IOCL JR

8. Identify the interface requirement and finalize all Tie-in's with the existing refinery for J18 project facilities. The interface and tie-in points have been coordinated with IOCL and their impact has been considered in the DFR.

9. Carryout Site visits to study constructability of all facilities of J18 project. The impact of constructability study for the J18 project facilities has been considered in the DFR.
10. Prepare electrical single line diagram based on load list, electrical area classification, main electrical cable routing, conceptual sub-station layout and identify load centers/substations for distributing load to different units.

11. Work out the requirement of HV/LV switchgear panels for the computed electrical loads and considered the same for DFR purpose.

12. Work out Safety requirements during construction in running refinery and considered them while preparing DFR.

13. Estimation of the Erection work and their impact on the schedule has been considered as part of DFR. Shutdown activities along with the expected time of completing the required work has also been identified. The same has been considered while considering hook-ups with the existing utility lines/feed lines etc.

14. Finalization of Master schedule, Project procedures & Project execution plan has been considered as part of DFR.

15. The utility and feed costing has been indicated based on the inputs provided by IOCL. The price of all utilities/Feed is in INR per unit

16. Estimation of operating cost (by IOCL) has been considered as part of DFR.

17. Estimation of Project costing within an accuracy of +/- 10% shall be part of DFR.

3.0 BASIS OF STUDY

3.1 Project Objective

At present, Gujarat Refinery has capacity to process 13.7 MMTPA of crude oil, with crude basket comprising of 55% high Sulphur crude (7.6 MMTPA) and 45%low Sulphur indigenous crude (6.1 MMTPA). In addition to BS-III / BS-IV fuel products, the refinery also has the capability to produce a wide range of specialty products such as Benzene, Toluene, MTBE, MTO, Food Grade Hexane & LAB.

IOCL has now undertaken, J18- Gujarat Refinery Capacity expansion project. As a part a part of capacity expansion project, Gujarat refinery is now increasing the processing capacity of the refinery from current 13.7 MMTPA to 18.0 MMTPA. Objective of this project is to:

- Increase overall efficiency of the refinery by dismantling smaller Atmospheric and Vacuum Units by considering one single, efficient unit of higher capacity (15 MMTPA)

- Increasing the overall processing capacity of the refinery and improve profitability of the refinery by installing multiple secondary processing units as listed below.

    - INDMAX FCCU including CR LPG Treater Unit
    - Propylene Recovery Unit
    - Naphtha Hydro Treater Unit / Naphtha Splitter Unit
    - Isomerisation Unit
    - Continuous Catalytic Reforming Unit
    - Kerosene Hydro Desulphurization Unit
    - Indmax Gasoline Hydro Desulphurization Unit
    - Polypropylene Unit
    - Sulphur Recovery Unit
    - Amine Regeneration Unit
    - Sour Water Stripper Unit
    - Associated Offsites and Utilities

This project execution is considered in two parts.

- PMC-1: Design phase (BDEP/ FEED preparation, ±10% cost estimate, DFR, Tendering, Evaluation and recommendation for Tendering activities
- PMC-2: Execution phase (Detailed engineering, Procurement, Construction, Commissioning)

3.2 Basic Design Parameters

Study to be done by TPIL : DFR

Execution Methodology for Project : Hybrid (Process units - LSTK, U&O- EPCM)

Project Duration Required in Months (PMC 2) : 44 months (38 for MC + 3 for Commissioning + 3 for Contract closure)

The design capacities of different units of J18 are as indicated in the following table

Execution Mode (PMC 2 stage)	**Unit**	**Unit No.**	**Capacity**	**On stream factor (hours / year)**
LSTK mode	New AVU	1801	15 MMTPA	8320
	SR LPGTU	1802	0.20 MMTPA	8320
LSTK mode	Indmax FCC	1803	2700 TMTPA	8000
	INDMAX Gasoline Hydro Desulphurization Unit (IGHDS)	1804	650 TMTPA	8000
	Propylene Recovery Unit	1806	580 TMTPA	8000
	Polypropylene Unit (PP)	1807	420 TMTPA	8000
	NHT/NSU	1808	2400 TMTPA	8000
	CCRU	1809	1600 TMTPA	8000
	ISOM	1810	925 TMTPA	8000
LEPC Mode	CR LPG Treater unit	1805	1073 TMTPA	8000
	Sulphur Recovery Unit (SRU)	1812	400 MTPD	8000
EPCM Mode	AU-V Revamp	05	3 MMTPA	8000
	Kerosene Hydrodesulphurization Unit (KHDS)	1811	700 TMTPA	8000
	Sour Water System (SWS)	1813	330 TPH	8000
	Amine Regeneration Unit(ARU)	1814	350 TPH	8000
	Offsites & Utilities	As per individual units	As Required	8000

3.3 Other Studies & Document for Reference

Sr. No	Document Details	Source of Origin
1.	Market survey/study report (Demand and supply analysis)	NA
2.	Environmental impact study	EIA and EMP study and data collection excluded from present scope.
3.	Site evaluation/selection	Most of the units are within the existing refinery premises on the south-west and north-east sides except the following which are located in the area adjoining and contiguous to the existing refinery complex: • Indmax FCC, CR LPG TU, IGHDS on the south-west side of Refinery (Koyali) • PRU, PPU, ETP and CT-2 on the south-east side of Refinery (Bajwa) New AVU, SR LPGTU, MS Block, KHDS, ARU, SWS. SRU and utilities are within the existing refinery premises. Refer overall plot plan 077154C-000-DW-0051-001 Rev F
4.	Evaluation/Selection of licensors	• New AVU: Open art unit, by TPIL (with Paradip FEED package as basis) • PRU, ARU, SWS – Open art unit with process design by PMC • SRLPGTU, KHDS, Indmax FCC, IGHDS, MS Block (NHT/ISOM/CCR), PPU - Licensor evaluation/ selection by IOCL • SRU and CR LPG TU shall be executed by LEPC mode.
5.	Constructability Study	FEED Phase by PMC & Detail Engineering Phase by Respective EPC Contractor
6.	Quantitative risk assessment(QRA)	By PMC, after the licensor process package is made available for all units
7.	Soil investigation	Preliminary Soil investigation carried out by IOCL at the identified new locations. (Detailed soil investigation shall be by EPCC)
8.	Route survey (for transport of ODC materials from various Likely ports / industrial areas of the country.)	Existing report of ongoing BS VI project is referred. Ref: Route Survey by M/s ACCI against the IOCL Fax of Acceptance (FOA) IOCL/CONT/RC/A882-000-TT-TN-7100/1004/FOA-4001 dated 19th July,2016)
9.	Marine Survey-effluent dispersion	Land-Lock Refinery. Therefore, not applicable

	study	
10.	Downtime assessment report (For Revamp)	Down time report for revamp of existing AU-V -By PMC. Most of the tie-ins are envisaged either by hot tap or tapping taken during the shutdown of the plant. All other units are New Units. Therefore, Not applicable for other units.

3.4 Plant Location

- State / Country : GUJARAT / INDIA
- Nearest Railway Station : VADODARA
- Nearest Town / City : VADODARA
- Nearest Airport : VADODARA
- Nearest National Highway : NH-8
- Nearest Port : DAHEJ

3.5 Land Availability Details

<table>
<tr><th>Parameter</th><th colspan="2">Information Description</th><th>Reference information</th></tr>
<tr><td>Plot Area</td><td colspan="2">As per Overall plot plan</td><td>Refer Plot Plan</td></tr>
<tr><td>Land availability</td><td colspan="2">Available within the existing refinery for all units other than the ones mentioned below.
Indmax FCC, CR LPG TU, IGHDS, PRU, PPU and ETP are located in the adjoining plot to the existing refinery on the south-wast and south-east side, for which land is under advanced stage of acquisition.</td><td>Refer Plot Plan</td></tr>
<tr><td>Rerouting Requirement</td><td colspan="2">No rerouting required as per site assessment</td><td>NA</td></tr>
<tr><td>Soil investigation data</td><td colspan="2">Preliminary data available from IOCL</td><td></td></tr>
<tr><td>Total Power requirement for Expansion</td><td colspan="2">122 MW
(@100% Normal Flow rate)</td><td></td></tr>
<tr><td rowspan="3">Grid power
(Through 220kV GIS Expansion)</td><td colspan="2">86 MW
(@100% Normal Flow rate)</td><td rowspan="3">2 Nos. of additional bays to be extended from existing 220kV GIS</td></tr>
<tr><td>Nearest Location (District/place)</td><td>Existing 220kV GIS at Grid Power Import Substation</td></tr>
<tr><td>Level</td><td>220 kV</td></tr>
</table>

Grid power (Through BS-VI Project Power Source)	18 MW (@100% Normal Flow rate)		Redundant 33kV feeders from “33kV GIS for BS-VI Project at Grid power import SS” is envisaged to feed the NEW AVU unit & Compressed Air Package loads.
	Nearest Location (District/place)	33kV GIS for BS-VI Project at Grid Power Import Substation	
	Level	33 kV	
Captive Power (CGP) (Through Existing Substations)	18 MW (@100% Normal Flow rate)		Redundant feeders from existing substations at 33kV, 6.6kV & 0.415kV Level
	Nearest Location (District/place)	Existing Substations	
	Level	33kV, 6.6kV & 0.415kV	

3.6 Raw Material (Feed)

Refer Attachment- 4.1 that summarizes the Raw material, Product specifications, and basis of design for each process unit that forms part of J18.

3.7 Products

Refer Attachment-4.1 that summarizes the Raw material, Product specifications, and basis of design for each process unit that forms part of J18.

3.8 Plant Units

Refer Attachment-4.1 that summarizes the Raw material, Product specifications, and basis of design for each process unit that forms part of J18 Part-II scope.

3.9 Utility Requirement

The overall utility requirement for J-18 is covered in the document, ‘Overall Utility Balance-077154C-1825-NM-0003-001’. Refer Chapter-7, Attachment-7.1.

Post the successful commissioning of new AVU of 15 MMTPA capacity, IOCL intends to decommission the existing units such as AU-1, AU-2, AU-3, AU-4, VDU-1, FPU-1, CRU.

The utilities consumed by these units such as CW, Steam, DM water etc. will become spared. IOCL has requested PMC to utilize this spare capacity for J18 Part-II utilization. It may be noted that utilization of existing spare capacity helps to reduce the capacity of various utility systems such as cooling tower system, compressed air system, etc. and the capital investment.

The table below summarizes the total requirement, capacity and source of all major utilities required for J18.

Utility System	**UOM**	**J-18 Total Design Requirement**	**Source**
Cooling water	m3/hr	48,000	Supplied from CT-1 of 16,000 m3/hr + CT-2 of 32,000 m3/hr capacity.
Instrument Air	Nm3/hr	14,500	Catered from New Compressed Air system – 3 x 7250 (2W+1S)
Plant Air	Nm3/hr		
Gaseous N2	Nm3/hr	5000	Catered from New Nitrogen Generation Plant
Liquid N2 Storage	m3	500	
HP Steam	TPH	450	3 x 150 TPH Utility Package Boiler
BFW	m3/hr	750	3 x 250 m3/hr Deaerator & BFW pumps
DM Water	m3/hr	500	3 (2W+1S) New DM Trains of 250 m3/hr each;
Condensate Polishing Unit	m3/hr	250	2 trains of CPU (1W + 1S)
Raw water	MGD (UK)	10	New Radial wells at banks of Mahi river.
Flare	TPH	1100	New J18 Flare
Effluent Treatment Facility	m3/hr	385	New ETP for J-18.

AU-5

Table below summarizes the utility requirement for AU-5 revamp of the J18 capacity expansion project.

Utility Name	**Requirement**	**Unit**	**Tap off from**
Lean Amine	5	m^3/h	Existing facility
HP Steam	Note 1	T/h	Existing facility
MP Steam	8.4	T/h	Existing facility
LP Steam	0.6	T/h	Existing facility
Cooling water	2565	m^3/h	Existing facility
Power	1500 (Note 2)	KW	Existing facility

Stripped Sour Water	35	m^3/h	Existing facility
DM Water	Note 3	m^3/h	Existing facility
Boiler Feed Water	0.6	m^3/h	Existing facility
Fuel Gas *	2.75	T/h	Existing facility
Fuel Oil *	3.0	T/h	Existing facility
Instrument Air	Note 1	Nm^3/h	Existing facility
Plant Air	Note 3	Nm^3/h	Existing facility
Drinking Water	10 Note 3	m^3/h	Existing facility
Sour Water to ETP	8.98	m^3/h	Existing ETP facility
Desalter Water	34.17	m^3/h	Existing facility
Steam Condensate	2.85	T/h	Existing facility
Flare	84**	T/h	Existing facility

*Value specified is considering 100% Fuel oil or Fuel gas firing respectively.
**Total Power Failure case

Note 1: As existing
Note 2: BKW excluding desalter and furnace package
Note 3: Intermittent

3.10 Offsite, Raw Material/ Product and Other Storages

Raw material

Existing crude storage facilities will be used for crude storage and no new facilities are envisaged.

Intermediates & Products

In line with scope of J18 project, the following storage facilities are envisaged at Offsite facilities.

a) KHDS Feed Tank

Two new KHDS feed storage tanks each of 5000 KL capacity to be installed along with transfer pumps of 135 m^3/h capacity (1W+1S). These tanks act as intermediate feed storage for KHDS unit and are intended to receive Kerosene from New AVU, VGOHT Kero & AU-5 Kero.

b) NHT Feed Storage Tank

New NHT feed storage tanks will receive cold Naphtha produced from new AVU unit and existing secondary processing unit. The stored Naphtha will be pumped to New J18 Naphtha Hydrotreating Unit that forms part of J18 MS Block for further processing.

Two new NHT feed storage tanks each of 12000 KL capacity will be installed along with transfer pumps of 300 m^3/h capacity each (2W+1S).

c) MTO Storage Tank

MTO is a new product envisaged in post J18 scenario. A new MTO Storage tank of 5000 KL capacity will be installed along with 350 m^3/h capacity transfer pumps (1W+1S) to cater to the storage requirement of this new product.

d) Propylene Bullet

Four new Propylene bullets each of 3500 KL capacity to be installed along with transfer pumps of 72 m^3/h capacity (2W+1S).

These propylene bullets act as intermediate storage for High Purity Propylene produced from PRU and provides feed holdup for downstream Polypropylene unit.

e) LPG Bullets

Four new LPG bullets each of 3000 KL capacity to be installed along with transfer pumps of 300 m^3/h capacity (1W+1S) in DUMAD area to handle the incremental LPG produced as part of J-18. LPG from Refinery shall be transferred to DUMAD area through the existing pipeline. No new pipeline is envisaged.

All other intermediates and products that are in J18 scope will be utilizing existing storage facilities available in Gujarat Refinery.

3.11 Product Handling

The dispatch modes of various products that are impacted by J18 project are summarized in the table below.

S No	Product	Post J18 Requirement, TMTPA	Pipeline	Road	Rail
1	MTO	120	0	100%	0
2	ATF	650	100%	0	0
3	MS	4727	100%	0	0

4	HSD	8012	100%	0	0
5	Sulfur	200	0	100%	0
6	Fuel Oil	250	0	0	100%
7	PP	420	0	100%	0
8	LPG	1045	100%	0	0

For all the above products except PP, existing dispatch facilities will be utilized. For PP new facilities will be provided.

3.12 Utilities

Utility conditions at units' battery limit:

Sl. No.	Parameter	Minimum	Normal	Maximum	Mech Design
1	**HIGH PRESSURE (HP) STEAM**				
	Pressure, kg/cm^2g	29	33	37	48 / FV
	Temperature, °C	410	425	455	485
2	**MEDIUM PRESSURE (MP) STEAM**				
	Pressure, kg/cm^2g	8	12.5	14.0	19 / FV
	Temperature, °C	235	280	300	380
3	**LOW PRESSURE (LP) STEAM**				
	Pressure, kg/cm^2g	3	3.5	5.1	8 / FV
	Temperature, °C	145	160	170	220
4	**CONDENSATE RETURN**				
	Pressure, kg/cm^2g	-	5.0	-	15 (Hold)
	Temperature, °C		90	100	150
5	**RAW / SERVICE WATER**				
	Pressure,kg/cm^2g	-	3	-	7
	Temperature, °C	-	40	-	65
6	**COOLING WATER (Note A)**				
	Supply Pressure,kg/cm^2g	4	4.5	5	7
	Return Pressure, kg/cm^2g	-	2.5	-	7

Sl. No.	Parameter	Minimum	Normal	Maximum	Mech Design
	Supply Temperature, °C		33	35	65
	Return Temperature, °C		42	45	65
7	**POTABLE WATER**				
	Pressure, kg/cm^2g	2	4	6	10
	Temperature, °C	-	40	-	65
8	**DM WATER**				
	Pressure, kg/cm^2g	4	7.5	8	12
	Temperature, °C	-	40	-	65
9	**BOILER FEED WATER**				
	Pressure, kg/cm^2g	56	56	56.5	79
	Temperature, °C	110	110	115	150
10	**FIRE WATER**				
	Pressure, kg/cm^2g	-	7	10.5	15
	Temperature, °C	-	40	-	65
11	**PLANT AIR (Note B)**				
	Pressure, kg/cm^2g	3	4.5	8.0	10
	Temperature, °C	35	40	55	65
12	**INSTRUMENT AIR**				
	Pressure, kg/cm^2g	3.5	5.2	7	10
	Temperature, °C	35	40		65
13	**NITROGEN (Note C)**				
	Pressure, kg/cm^2g	4	5	7	10.5
	Temperature, °C		15		65
14	**HYDROGEN (EXPORT FROM HGU)**				
	Pressure, kg/cm^2g		19		22.5
	Temperature, °C		45		150
15	**FUEL GAS**				

Sl. No.	Parameter	Minimum	Normal	Maximum	Mech Design
A)	**REFINERY FUEL GAS (START-UP FUEL)** **There are four fuel gas headers in the refinery. Pressure conditions vary according to tie-in point, that will be decided for each unit and cannot be same for all units.** **1. RUP header is at 4.8 barg** **2. GHC header is at 4.3 barg** **3. GRE header is at 4.2 barg** **4. GR header is at 1.8 barg**				
	Pressure, kg/cm^{2}g	1.6	1.8	4.5	7
	Temperature, °C	35	40	65	65
B)	**Refinery Fuel Gas (Post J18)**				
	Pressure, kg/cm^{2}g	3.5	4	4.5	7
	Temperature, °C	35	40	-	65
	***RLNG supply pressure is 39-40 kg/cm2.g at JR Battery Limit (Received at ~38-39 kg/cm2.g at CGP-I). RLNG from CGP-I is given to following locations:** **1. Same is fed to HGU-III, wherein it is controlled by PIC at 29-30 barg** **2. To CGP-II, where it is let down to ~20 kg/cm2.g for GTs.** **3. To CGP-I, where it is let down to ~20 kg/cm2 g for GTs.)** **4. To SRU-III FG mixing station, where it is let down to 4.5-4.8 barg) for RUP and other process units.** **5. Pressure to existing fired Heater varies in range of 2-4 barg** **6. Pressure at fuel gas generation unit is 5 kg/cm2g.**				
16	**FUEL OIL**				
	Supply Pressure, kg/cm^{2}g	8	10	12	15
	Return Pressure, kg/cm^{2}g	-	3	-	15
	Supply Temperature, °C	-	120	160	200
	Return Temperature, °C	-		-	200
17	**LEAN AMINE (from New J18 ARU – Unit 1814) @ ARU B.L**				

Sl. No.	Parameter	Minimum	Normal	Maximum	Mech Design
	Pressure, kg/cm^2g		9		17 (Hold)
	Temperature, °C		40		70 (Hold)
18	**RICH AMINE @ ARU B.L**				
	Pressure, kg/cm^2g		4.5		16 (Hold)
	Temperature, °C		51 - 75		120 (Hold)
19	**SOUR WATER @ SWS B.L**				
	Pressure, kg/cm^2g	5	5.5	9	16.2(Hold)
	Temperature, °C		51 - 55		85 (Hold)
20	**STRIPPED SOUR WATER**				
	Pressure, kg/cm^2g		6		15.3(Hold)
	Temperature, °C		40 - 65		100 (Hold)
21	**FRESH CAUSTIC (46wt%)**				
	Pressure, kg/cm^2g		4		14
	Temperature, °C		40		65
22	**SPENT CAUSTIC**				
	Pressure, kg/cm^2g		6		13
	Temperature, °C		38		65
23	**FLUSHING OIL**				
	Pressure, kg/cm^2g	3			10
	Temperature, °C	40			60
24	**CLEAN CONDENSATE SUPPLY**				
	Pressure, kg/cm^2g	-	5	-	10
	Temperature, °C	-	65	100	150

Electric Power

Source of Power	Grid / Existing substations	
Volts At design Stage	Refer below for individual substation	
Frequency At design Stage	50 Hz	
Rate Rs./kWH	To be provided by IOCL	
Distance in km from the power supply Available point to unit	Substation for New AVU Unit (ESS-041)	1250 m (Approx.) (From 33kV GIS for BS-VI Project at Grid power import SS)
	Substation for Cooling Water Package (ESS-042)	1800 m (Approx.) (From Existing SS (CGP-2) at 33kV level) (See Note-1)
	Switch room for Compressed Air Package (ESS-043)	1500 m (Approx.) (From New AVU SS (ESS-041) at 6.6kV level (See Note-1)
	Substation for INDMAX FCC, CR LPG & IGHDS Units (ESS-044)	2500 m (Approx.) (From 33kV GIS for J18 Project at Grid power import SS)
	Substation for MS Block, KHDS & Utility Units (ESS-045) (See Note-2)	3000 m (Approx.) (From 33kV GIS for J18 Project at Grid power import SS) (See Note-1)
	Substation for PPU & PRU units. (ESS-046)	1100 m (Approx.) (From 33kV GIS for J18 Project at Grid power import SS)
	Substation for ETP Package. (ESS-047)	200 m (Approx.) (From PPU/PRU Unit Substation (ESS-046) at 33kV level
	Substation for Sulphur Block (SRU/SWS/ARU) unit & Flare Package. (ESS-048)	1100 m (Approx.) (From 33kV GIS at Existing Substation (ESS-038))
	NHT & MTO	To be fed from nearby existing

<table>
<tr><td></td><td>Tanks / Raw Water System / LPG Bullets</td><td>substations at 6.6kV & 0.415kV levels, which need to be identified.</td></tr>
<tr><td rowspan="8">Emergency Power for Process & Utility Units</td><td colspan="2">From Existing Substation (CGP-1) at 11Kv level for New AVU & Compressed Air System Package.(1250 m (Approx.)</td></tr>
<tr><td colspan="2">315 kVA DG Set at 0.415kV level for Cooling Tower Package (CT-1 & CT-2). (Near ESS-042)</td></tr>
<tr><td colspan="2">2250 kVA DG Set at 6.6kV level for INDMAX FCC, CR LPG & IGHDS Units (Near ESS-044)</td></tr>
<tr><td colspan="2">2000 kVA DG Set at 0.415kV level for MS Block and KHDS Units. (Near ESS-045)</td></tr>
<tr><td colspan="2">2 x 2750 kVA DG Set at 6.6kV level for Utility Block Units. (Near ESS-045) – See Note -2</td></tr>
<tr><td colspan="2">2000 kVA DG Set at 0.415kV level for PPU & PRU units. (Near ESS-046)</td></tr>
<tr><td colspan="2">2000 kVA DG Set at 0.415kV level for ETP Package. (Near ESS-047)</td></tr>
<tr><td colspan="2">800 kVA DG Set at 0.415kV level for Sulphur Block (SRU/SWS/ARU) unit. (Near ESS-048)</td></tr>
</table>

Note 1:

- The Cooling Water Circulation pumps are fed from ESS-042 (Captive Power Source) & ESS-046 (Grid Power Source)
- The Compressor Air system motors are fed from Existing SS, ESS-033 (Captive Power Source) & New AVU substation, ESS-041 (Grid Power Source)
- The N2 Compressor motors are fed from Existing SS, ESS-033 (Captive Power Source) & Utility Block Unit Substation, ESS-045 (Grid Power Source)

Note 2: The Utility Block Unit includes DM Plant+ZLD+CPU, Boilers-1, 2 & 3, N2 Package & Propylene Bullets

Note 3: Refer Attachment 4.3 – Electrical Power Distribution Philosophy for J-18 Project

Raw Water

Additional RAW water requirement of New facilities are met by new radial well of 10 MGD (UK) capacity as part of J18 Project.

The intake system consists of a radial well of 5.8 meters' diameter located at banks of Mahi river, raw water pump house (including the vertical intake pumps 6 nos), near the well head, booster pump house (including 3 booster pumps) at the refinery battery limit, interconnecting piping between the pump houses of 700 mm dia x 17 Km long, electrical buildings near both the pump houses and other required systems.

PARAMETER	RAW WATER
pH	7 - 8.1
Turbidity	< 2
Total dissolved solids, ppm wt.	340 - 740 ppm wt
Suspended solids, ppm wt.	5 - 15 ppm wt
M alkalinity, ppm wt.	270 - 372 ppm wt
Ca hardness as $CaCO_3$, ppm wt.	80 - 124 ppm wt
Total hardness as $CaCO_3$, ppm wt.	200 - 372 ppm wt
Silica as SiO_2, ppm wt.	25 - 62 ppm wt
Chloride as NaCl, ppm wt.	90 - 165 ppm wt
Sulphate as $CaCO_3$, ppm wt.	25 - 45 ppm wt
Iron as Fe, ppm wt.	Trace

Cooling water

After due consideration of spare CW due to dismantling of existing AVU's one new 5 x 4000 m^3/hr (4W+1S) Cooling Tower has been considered for supplying cooling Water system to Primary processing units (AVU and SR LPG Treater units).

And a new 9 x 4000 m^3/hr (8W+1S) Cooling Tower has been considered for supplying cooling Water system to various secondary processing units.

Circulating cooling water quality is considered as below-

Quality	Normal / Design
pH	7 - 8.2
Total hardness as $CaCO_3$	800 ppm wt
Calcium as $CaCO_3$	350 ppm wt

Quality	Normal / Design
Magnesium as $CaCO_3$	400 ppm wt
TDS as $CaCO_3$	3000 ppm wt
MO Total Alkalinity as $CaCO_3$	220 ppm wt
Chloride as Cl	600 ppm wt
Turbidity in NTU	40
Iron as Fe	0.7 ppm wt

DM Water

New DM water plant of 3 x 250m3/hr (2W + 1S) envisaged for J-18 expansion project is RO based DM plant to meet the normal and peak demand of DM water requirements of process units and utility systems.

Quality	Design
pH	7-8
Total dissolved solids	< 1 MicroS/cm
Total hardness as $CaCO_3$	< 0.1 ppmw
Total Silica as SiO_2	< 0.02 ppmw
Total Chloride as Cl	-
Total Sulphur as S	-
Total iron as Fe	< 0.5 ppmw
Total Copper, as Cu	-
Oil Content	-
Conductivity at 20	< 0.2 Micro Mho/cm

Steam system

The various process units in J-18 scope require all levels of Steam namely, HP Steam, MP steam and LP Steam. Some of the process units such as Indmax FCC, MS Block have steam generation facilities. In addition to this, to meet the overall net requirement of 450 TPH for J18, 3 new Steam boilers of 150 TPH each is envisaged. The package boilers are dual fired boiler to meet the normal and peak steam requirement for new process units and utilities. The overall package consists of High Pressure Boiler and associated facilities like Deaerator, BFW pumps, Boiler Blow-down Drums and dosing system etc.

Condensate system

New Condensate Polishing Unit of 2 x 250 m3/hr (1W + 1S) is envisaged to treat suspect condensate from various process units for J-18 expansion project. Clean condensate collected from various units is directly sent to BFW preparation.

POLISHED CONDENSATES QUALITY

PARAMETER	VALUE
Turbidity, NTU	NIL
pH	7 - 8
Total dissolved solids, µS/cm	< 1 ppm
Total hardness as CaCO3, ppm	< 0.1 ppm
Total Silica as SiO2, ppm	< 0.1 ppm
Total Chloride as Cl, ppm	Nil
Total Sulphur as S, ppm	Nil
Total Iron as Fe, ppm	< 0.5
Total Copper, as Cu, ppm	Nil
Oil Content, ppm	Nil
Conductivity at 20, Micro Mho/cm	< 0.2

Nitrogen system

A new nitrogen generation system of capacity 5000 Nm3/hr gaseous nitrogen and liquid nitrogen of 500m3 Storage capacity along with vaporizer of 8000 nm3/hr capacity shall be installed to meet the peak nitrogen requirement for new process units / utilities in the J18 Capacity Expansion Project. The product specification of nitrogen required is as given below:

Quality	Design
Nitrogen Purity	99.99 vol% minimum
O_2 Content	5 ppmv maximum
CO_2 Content	1 ppmv maximum
CO Content	Traces
Quality	Dry & Oil free
Dew point	-100 °C
Oil Content	Nil

Air system

New Compressed Air system of 3 (2+1) X 7250 Nm^3/hr consisting of air compressors and air driers is considered. This system will be suitable to cater the requirement of total J18 Project.

Plant Air Quality	Design
Dew Point (Ambient)	Saturated
Oil Content	Nil

Instrument Air Quality	Design
Dew Point (Ambient)	-40°C at atmospheric pressure
Oil Content	Nil

Fuel

Fired heaters in J18 New AVU & Utility Boilers are designed for operation on Fuel oil as well as Fuel gas. During the normal operation, these heaters are expected to operate most of the time on Fuel gas. All other fired heaters are designed only for Gas Firing. Following fuel composition is considered in heater design

Fuel gas specification: Typical fuel gas composition remains as mentioned below in Case-I, however in case of operational exigency, some parameter like H2S in fuel gas may be on higher side (approx. 250 ppm). Accordingly, acid dew point corrosion aspect to be taken care of in Case-2 parameters)

Case	Case-1	Case-2
Composition	mole%	mole%
H_2O	0.0	0.0
O_2	0.2	0.0
N_2	2.72	0.0
CO	0.02	0.0
CO_2	0.20	0.0
H_2	37.14	69.68
C1	33.48	6.05
C2	10.17	5.55
C3	8.82	14.0
C4	6.04	4.72
C5	0.34	0.0
C5+	0.87	0.0
Total	**100**	**100**
H_2S	50 ppm	250 ppm
Total Heating Value, Kcal/kg	11500 NCV	13043.8 NCV
Average MW	18.5	12.9

Fuel Oil Specification

Fuel Oil Properties	Specifications
Sp. Gravity at 15 C	0.95-1.04
Kinematic Viscosity at 70 C	275 cSt
Kinematic Viscosity at 100 C	160 cSt
Pour Point	< 51 Deg C
Sulphur	0.5 % wt max
Vanadium	100 ppmw max.
Nickel	150 ppmw max
Iron	100 ppmw max
Sodium	50 ppmw max
Total Metal	400 ppmw max.
Nitrogen	1300 ppm wt max
Ash	0.1% wt (max)
Water Content	1 % vol (max)
Total Sediments	0.25 wt% (max)
Kinematic Viscosity at 170 C -175 C	18 cSt -24 Cst
Flash Point	>66 Deg C
Net Heating Value	10000 / 9800Kcal/kg

RLNG Fuel Specification

Composition	Measured Value (Guaranteed)
Methane	85.0 mole%, min.
Ethane	9.2 mole%, max.
Propane	3.0 mole%, max.
Butanes & heaviers	2.0 mole%, max.
Pentanes & heaviers	0.25 mole%, max.
Nitrogen	1.25 mole%, max.
Oxygen	0.5 mole%, max.
Total Non-Hydrocarbons	2.0 mole%, max.
Total S including H2S	10 ppmw*, max.
Water Content	112 Kg per mmscm, max.
Impurities	Gas shall be reasonably free from dust (5-micron size, max.), gum forming constituents and other deleterious solid and/or liquid matter which will cause damage to or interfere with operations of transporter facilities.

*Expected H2S content is 4 ppmv, max.

Flare

Based on the existing flare system details provided by IOCL and subsequent study done by PMC, flare from New AVU, SR LPGT, MS Block & KHDS units these units will be connected to BS-VI flare.

Scenario	Load	Unit
Total Power Failure	1092	T/h

A new flare system is provided to cater to the relief requirement from rest of the J18 process units. This new flare will be built in the current location of New GR flare stack and will operate along with the BS-IV flare (being executed by others) in post J18 scenario

Scenario	Load	Unit
Total Power Failure	1100	T/h

Effluent Treatment

The new ETP system of 385 m3/hr capacity will be designed to treat the effluent generated from various Process units and Utility systems of J-18 expansion project as given below:

INFLUENT CHARACTERISTIC

Sr. no	Parameters	Unit	Design	
			Average	Maximum
1	pH	(mg/l)	6.0- 7.5	8.5
2	Oil Content (Total)	(mg/l)	2000 (2)	20000 (2)
3	BOD	(mg/l)	200	300
4	COD	(mg/l)	600	1200
5	Sulfide	(mg/l)	10	70
6	Phenol	(mg/l)	6	20
7	Total S. S	(mg/l)	500	2000
8	Cyanide	(mg/l)	0.5	2
9	NH3-N	(mg/l)	50	60
10	TDS	(mg/l)	1500	2000
11	TKN	(mg/l)	33	40
12	P	(mg/l)	2.42	3
13	Cr (Hexavalent)	(mg/l)	Nil	Nil
14	Cr (Total)	(mg/l)	0.03	1
15	Lead as Pb	(mg/l)	0.09	0.1
16	Mercury as Hg	(mg/l)	0	0

17	Zinc as ZN	(mg/l)	0.4	1
18	Nickel as Ni	(mg/l)	1.29	1.5
19	Copper as Cu	(mg/l)	0.052	0.08
20	Vanadium as Vd	(mg/l)	Nil	Nil
21	Benzene	(mg/l)	0.3	0.3
22	Benzo (a)-Pyrene	(mg/l)	Nil	Nil
23	Colour	(mg/l)	500	600
24	Fluoride as F	(mg/l)	1.2	1.5
25	Arsenic as AZ	(mg/l)	Nil	Nil
26	Cadmium as Cd	(mg/l)	0.04	0.05
27	Chloride as CI	(mg/l)	250	350
28	Sulphate as SO_4	(mg/l)	133	200 - 400
29	Insecticide / Pesticides (Std. D.D.T., Malathion, Aldrin)	(mg/l)	Nil	Nil

Notes:

1. The inlet effluent characteristics indicated are based on existing refinery data. This will be confirmed later based on actual effluent data from various J-18 process units.
2. Inlet to TPI will have 70% of free oil and 30% in emulsified form.

TREATED EFFLUENT CHARACTERISTICS

Sr.no	Parameters	Unit	Design
1	pH	(mg/l)	6.0- 8.0
2	Oil Content (Total)	(mg/l)	< 2
3	BOD	(mg/l)	< 5
4	COD	(mg/l)	< 40
5	Sulfide	(mg/l)	< 0.1
6	Phenol	(mg/l)	< 0.1
7	Total S.S	(mg/l)	5
8	Cyanide	(mg/l)	< 0.005
9	NH3-N	(mg/l)	< 15
10	TDS	(mg/l)	2000
11	TKN	(mg/l)	5 -10
12	P	(mg/l)	<1
13	Cr (Hexavalent)	(mg/l)	Nil
14	Cr (Total)	(mg/l)	<0.04
15	Lead as Pb	(mg/l)	<0.04
16	Mercury as Hg	(mg/l)	Nil
17	Zinc as ZN	(mg/l)	< 0.5

18	Nickel as Ni	(mg/l)	<0.2
19	Copper as Cu	(mg/l)	< 0.05
20	Vanadium as Vd	(mg/l)	Nil
21	Benzene	(mg/l)	Nil
22	Benzo (a)-Pyrene	(mg/l)	Nil
23	Colour	(mg/l)	< 20
24	Fluoride as F	(mg/l)	<1
25	Arsenic as AZ	(mg/l)	Nil
26	Cadmium as Cd	(mg/l)	< 0.03
27	Chloride as Cl	(mg/l)	< 200
28	Sulphate as SO_4	(mg/l)	100 – 350
29	Insecticide / Pesticides (Std. D.D.T., Melathion, Aldrin)	(mg/l)	Nil

Interconnection

The overall interconnection drawing covering all new process and utility lines is covered in the **Attachment-4.2**.

3.13 Construction Facilities

3.13.1 Construction Power

Construction power Availability	Available	From Existing CGP-2/TPS.
Volts	33 kV	
Rate (Rs./KWH)	IOCL to confirm	
Contract Demand Charges	IOCL to confirm	
Energy Charges.	IOCL to confirm	
Minimum energy charges (as % of Contract Demand)	IOCL to confirm	

Area	Units / Facilities	Power Source	Power in MW	Voltage Level	Distance of source Location from site Plot (in M)
Area 1	New AVU Unit	TPS	2	6.6kV	500
Area 2	PPU, PRU, CT-1 & CT-2 & ETP	New AVU SS (ESS-041) (or) CGP-2	7.5	33kV	900
Area 3	FCCU, IGHDS, Sulphur Block	ESS-38	7	33kV	800
Area 4	MS Block, KHDS & Utility Units	BSVI SS	6	33kV	1075

Area 5	NHT & MTO Tanks	ESS-16	1	33kV	900
Total Power			**23.5**		

3.13.2 Construction Water

For Primary Processing Unit (AVU & SR LPGTU)

Construction Water Availability	For inside refinery new bore well.
Distance of source Location from site Plot (in Km.)	Within the unit

For Secondary Processing Units

ESTIMATE OF CONSTRUCTION WATER REQUIREMENT					
1	Mechanical & Piping Testing Requirements	Site fabricated Equipment	35,000	KL	**Total Project Duration**
		Piping	35,000	KL	
		Flushing	15,000	KL	
		Tanks	34,000	KL	
		Bullets	35,000	KL	
2	Civil Work	Concreting & Curing	1,825	KL	
3	Drinking Water	Worker & Staff	31,200	KL	
4	Others	Offices, Offsite & Utilities	5,000	KL	
		Total	**192,025**	**KL**	

3.13.3 Construction Site Facilities and Fabrication Yard

For AVU and SRLPGTU

Fabrication area Location	Outside the Refinery complex area
Minimum Area requirement for fabrication yard.	20 Acres
Area requirement for Office and projects stores	2250 sq. m
Lease/Hiring of Land cost	IOCL to provide

Area availability for the following construction facilities for other Units are provided below.

- Offices
- Warehouse / Stores
- Canteen
- Safety / First Aid
- Fabrication
- Sand blasting / Painting
- Parking

Zone	Units	Area Available in SQ.M
BAJWA	FCCU, IGHDS, PRU and CT2	83,900
CALICO	MS Block, KHDS Propylene Bullets & Utilities	22,800
KOYALI	PPU, PPU Warehouse & IETP	17,900

Area for Batching plant is not considered inside the Refinery premises as there is no adequate space available and the same to be manged by respective EPCC contractor.

For EPCM, space for batching plant to be provided by IOCL.

For LSTK/LEPC contractors the contractors have to consider construction site facilities and fabrication yard outside the refinery boundary. Only ODC equipment fabrication area will be provided inside the refinery boundary limit.

Lease/Hiring cost of land for storage and fabrication outside refinery boundary limit is taken care by LSTK / EPCC contractors.

3.14 Environmental Requirement

3.14.1 Emission

As per state / central pollution control board or min online analyzer to be installed for O2 at arch and NOx, SOx, CO & SPM at stack whichever is more stringent.

Default permissible emission (as per MOEF & CC notification) is:

S. No.	Parameter	Maximum Emission Limit Existing Plants (mg/Nm^3)	Maximum Emission Limit New Plants (mg/Nm^3)
1	NOx Oil firing	450	350
2	NOx Gas firing	350	250
3	CO Oil firing	200	150
4	CO Gas firing	150	100
5	SOx Oil firing	1700	850
6	SOx Gas firing	50	50
7	Particulate Matter - Oil firing	100	50
8	Particulate Matter - Gas firing	10	5

3.14.2 Effluent Specifications:

Liquid effluents from plant:

The liquid effluents from various process & utility units of J18 are treated in the new Effluent Treatment plant to make it fit for discharge.

Re-use of treated effluent will be maximized to the extent possible and the remaining effluent will be discharged to Vadodara Enviro Channel Ltd (VECL) which is finally discharged into Gulf of Khambat.

Treatment facilities are being provided to meet the "MINAS" standards for the final effluent from the refinery. The key specifications for treated effluent as per MINAS standards are provided below

Parameters	Unit	Value
PH		6.0 - 8.5
Sulphide	mg/lit	0.5
Oil	mg/lit	5
TSS	mg/lit	20
Phenol	mg/lit	0.35

BOD	mg/lit	15
COD	mg/lit	125

Solid effluents from plant:

The basis of disposal for various Solid effluents generated from J18 is as follows:

Oily Sludge generated from ETP will be stored in the existing lagoon and processed for recovery of Oil. The residual sludge is bio-remediated.

Spent Catalyst: Spent catalyst is also generated from refinery processes due to its aging after prolonged use. This catalyst is kept in sealed drums and disposed to MoEF&CC approved vendors for recycling or else sent to secured landfill.

Discarded Drum/containers are decontaminated and sold to authorized vendors.
Spent Carbon/resin: It is also sent to incineration or secured land fill.
Insulation Material/cotton waste: It is sent to secured land fill area.

3.14.3 Green Belt Requirement

As advised in Environment Clearance by MOEF&CC.

3.14.4 Quantitative Risk Analysis

Rapid Risk Analysis: QRA shall be carried out as part of J18 PMC-2 stage.

3.15 Buildings

Administrative Building	Not envisaged
Warehouse (Chemical, Spares, Product, Cement)	As required
Workshop	Not envisaged
Canteen	Not considered
Central Laboratory	Not envisaged
Control rooms for Plant Operation Refer Attachment-4.4	There are 4 new control rooms, 2 Local control rooms and 2 Satellite Rack Rooms (SRR): 1. CR for AVU+SR LPG+CT-1 2. CR for FCC+CR LPG+IGHDS+ SRU Block+ Flare with SRR for SRU+ARU+SWS 3. CR for MS Block+ KHDS+ Utilities with SRR for KHDS

	4. CR for PPU+ PRU +CT-2 5. Local Control Room for N2 generation and storage 6. Local Control Room for ETP There are 4 existing control rooms as follows: 1. GR-1 (AU-V) Control Room: a. Remote DCS, ESD, FDS I/O cabinets required for interfacing signals associated to Amine & sour water storage tanks shall be installed in this existing control room, which shall be controlled and monitored from the control room for Indmax FCC (control room number 2, above). b. For AU-V revamp, existing spares of existing control & safety system in this control room shall be used for interfacing signals associated to AU-V Revamp and controlled and monitored from the existing GR-1 (AU-V) control room. 2. North Block Control Room: a. Existing spares of existing control & safety system in this control room shall be used for interfacing signals associated to new NHT storage tanks and control & monitoring from this existing North Block control room. b. Remote DCS, ESD, FDS I/O cabinets required for interfacing signals associated to new MTO storage tanks shall be installed in this existing North Block control room, which shall be controlled and monitored from the existing OM&S Control room. 3. OM&S Control Room: Existing spares of existing control, safety system & Tank Farm Management System

	(TFMS) in this existing control room shall be used for interfacing signals associated to new MTO storage Tanks and Propylene mounded bullets including tank gauging instruments. Control and monitoring of these tanks shall be from this existing OM&S Control room. 4. Existing Control Room at Dumad Existing spare of existing control & safety system in this control room shall be used for interfacing signals associated to new LPG bullets.
Satellite Rack room (SRR)	One SRR for SRU+SWS+ARU and another SRR for KHDS are envisaged
conference rooms	Considered within control room building
Training Center	Not Required
Substations Refer Attachment-4.3	There are 7 new substations & 1 Switch Room to feed J18 Project units: 1. SS for New AVU Unit (ESS-041) 2. SS for Cooling Tower Package (ESS-042) 3. Switch Room for Compressed Air Package (ESS-043) 4. SS for FCC+IGHDS units (ESS-044) 5. SS for MS Blcok+KHDS+Utility Units (ESS-045) 6. SS for PPU+ PRU Units (ESS-046) 7. SS for ETP Package (ESS-047) 8. SS for Sulphur Block Unit & Flare Package (ESS-048) Electrical system for Raw Water package, LPG Bullets and NHT & MTO Tank area are to be fed from nearby existing substations, which need to be identified.
Fire Station	Not considered
PP Ware House	Considered for 17 days of Inventory

3.16 Construction Aids

Construction AIDS By IOCL	None (None of the construction equipment to be provided by IOCL)	
Heavy crane to be purchased by owner (If yes, then specify capacity of range proposed and hiring charges)	No	
	Capacity range	-
	Hiring charges	-
Hydra and medium size crane by Owner	No	

Respective Contractor to mobilize the construction and Equipment / Aids.

3.17 Owner Expenses during Project Implementation

Expenditure Heads	**Requirement To be considered**
Expenses Towards Public Issue	Yes
Salaries	Yes
Perks and Facilities	
To People Employed on this project/plant	To Be Provided By IOCL
Communication	Yes
Travel	Yes
Training	Yes
Legal Expenses	Yes
PMC Fees	Yes
Contingency	Yes
Any Other (for ESR)	……% of Project Cost (To be Loaded by IOCL)
Total Amount for All the Above Heads	Refer Chapter 9

4 Process Configurations

4.1 Introduction

Process configuration for the capacity configuration of existing Gujarat Refinery was carried out by Engineers India Limited and was adopted by IOCL for the implementation of the J18 project. Enhancement of the crude processing capacity has brought the major configuration change in the secondary processing units with the addition of following units.

a) Licensed process units – Units which have licensed process technologies such as Indmax FCCU, CR LPG TU, IGHDS, PPU, KHDS, NSU, NHT, ISOM, CCRU and SRU with related TGTU.
b) Open-art Process units - Process Units which don't require licensed technologies and for

which the process design has been carried out by TPIL such as New AVU, SWS, ARU, and PRU

c) Process units Revamp - Revamp of exiting 3 MMTPA atmospheric vacuum distillation unit AU-V.

d) Associated offsites and Utilities – The scope also includes the Utility units offsite storages and their interconnection with new and existing units/Refinery, for which process package shall be prepared by TPIL.

4.2 Technology Options

The Process configuration of the refinery expansion under J18 has been carried out by IOCL and was provided to PMC for further design detailing/Residual engineering and detailed engineering. Process unit configuration details are provided as under.

4.2.1 Licensed Process Units

IOCL has opted the licensors' technology for the following new process units. The licensors shall provide Basic Engineering Design Package to PMC for performing FEED and cost estimate.

<table>
<tr><th colspan="2">Unit</th><th>Unit number</th><th>Capacity as per Design Basis</th><th>Licensor</th></tr>
<tr><td colspan="2">SR LPG</td><td>1802</td><td>200 TMTPA</td><td>UOP</td></tr>
<tr><td colspan="2">INDMAX FCC</td><td>1803</td><td>2700 TMTPA</td><td>Lummus Technology</td></tr>
<tr><td colspan="2">Indmax Gasoline Hydro Desulphurization Unit (IGHDS)</td><td>1804</td><td>650 TMTPA</td><td>Axens</td></tr>
<tr><td colspan="2">CR LPG Treater unit*</td><td>1805</td><td>1073 TMTPA</td><td>To be confirmed</td></tr>
<tr><td colspan="2">Polypropylene Unit (PP)</td><td>1807</td><td>420 TMTPA</td><td>Novolen Technology</td></tr>
<tr><td rowspan="3">MS Block</td><td>NHT/NSU</td><td>1808</td><td>2400 TMTPA</td><td rowspan="3">UOP</td></tr>
<tr><td>CCRU</td><td>1809</td><td>1600 TMTPA</td></tr>
<tr><td>ISOM</td><td>1810</td><td>925 TMTPA</td></tr>
<tr><td colspan="2">Kerosene Hydrodesulphurization Unit (KHDS)</td><td>1811</td><td>700 TMTPA</td><td>EIL</td></tr>
<tr><td colspan="2">Sulphur Recovery Unit (SRU)</td><td>1812</td><td>400 MTPD</td><td>By LEPC contractor</td></tr>
</table>

*- For CR LPG Treatment Unit, the Licensor selection and execution in LEPC mode are by Indmax FCCU LSTK contractor

4.2.2 Open-art Process Units

IOCL has nominated TPIL to provide Basic Engineering Design Package for the following process units and utility packages for performing FEED / cost estimate.

Unit	Unit number	Capacity as per Design Basis	Licensor
New Atmospheric and Vacuum Unit (New AVU)	1801	15000 TMTPA	BDEP prepared by PMC
Propylene Recovery Unit (PRU)	1806	580 TMTPA	BDEP prepared by PMC
Sour Water System (SWS)	1813	330 TPH	BDEP prepared by PMC
Amine Regeneration Unit(ARU)	1814	350 TPH	BDEP prepared by PMC

4.2.3 Revamp Process Units

In addition to the above open-art units, TPIL shall also perform the BDEP for FEED and cost estimate for the below mentioned revamp units.

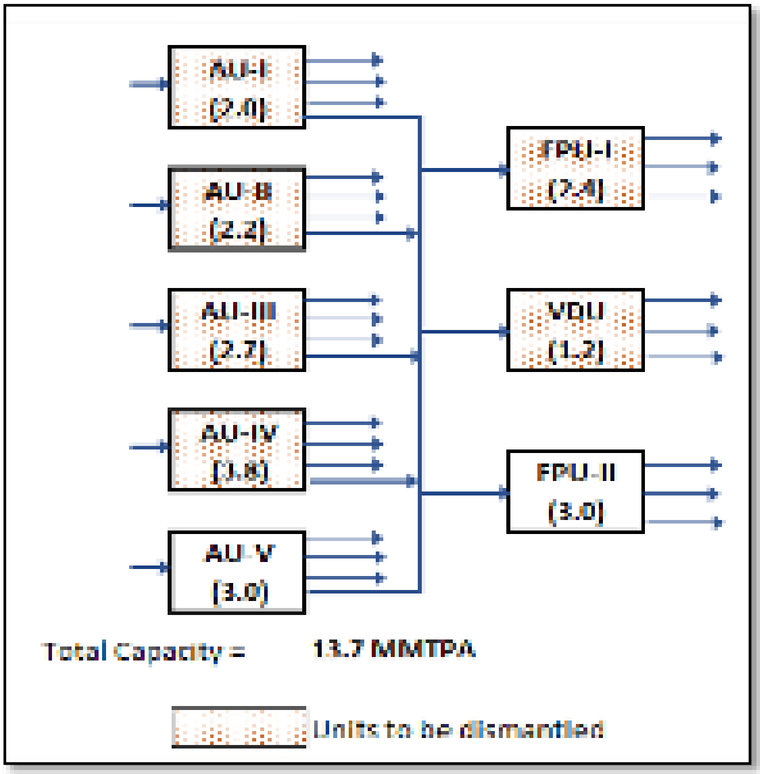
Unit	Unit number	Capacity as per Design Basis	Licensor
AU-5 Revamp	05	3 MMTPA	BDEP prepared by PMC

4.3 Process Configuration of Gujarat Refinery

4.3.1 Existing AVU configuration

Existing Gujarat Refinery has five Atmospheric Distillation units, two FPU and one vacuum distillation unit. The configuration of these processing units with their capacities has been indicated in Figure 5.1 below. The combined crude processing capacity of these units is 13.7 MMTPA.

Figure 5.1 Existing Crude processing unit configuration



4.3.2 New AVU Refinery configuration

4.3.2.1 AVU Process Configuration

The existing Gujarat refinery configuration was relooked and a new configuration was evolved with the objective to enhance the Refinery capacity and to improve the Gross Refinery Margins (GRM).

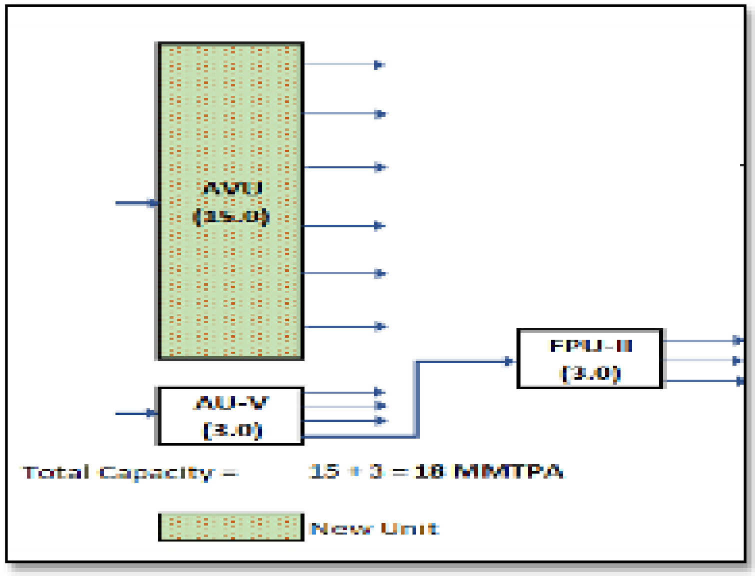
The individual capacity of each of the existing crude units AU-I to AU-V are relatively of low capacity. (as comparative to present day crude distillation units) and are operating at relatively lower efficiency. Moreover, these units are also aging and require upgradation or replacement.

Therefore, for the Gujarat refinery following configuration has been selected:

a) One New AVU unit of 15 MMTPA shall be installed replacing four old AUs namely AU I to AU IV which constitute a total capacity of 10.7 MMTPA
b) The existing AU V with a capacity of 3 MMTPA shall be revamped to process High TAN crude.
c) Existing VDU and FPU I shall not be required and shall be dismantled.

With this new configuration, the crude processing capability of Gujarat Refinery shall become 18 MMTPA. The new Gujarat Re finery crude distillation is presented in the Figure 5.2 below:

Figure 5.2 Existing Crude processing unit configuration

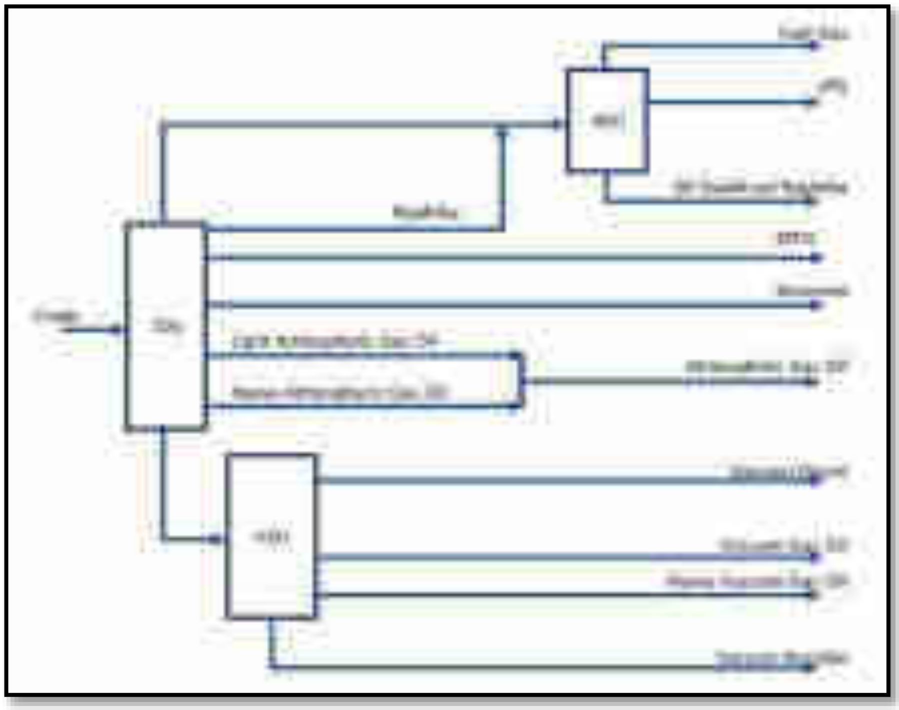


4.3.2.2 New AVU Configuration

The unit will act as mother unit for the refinery and provides a primary separation of crude oils to produce straight run blend stock or distillate products (as suitable to treating processes) and feedstocks for other downstream secondary process units like DHDT, DHDS, INDMAX, FCC, HCU, CCR, VGO-HDT and DCU.

The main operational Blocks in New AVU unit are shown in the Figure 5.3 below:

Figure 5.3 – configuration of New AVU



Function of each of these operational blocks is as under:

a) **Crude distillation section (CDU)** -The crude from the storage is heated and fed to the crude column where fractionation takes place at nearly atmospheric pressure. The crude column operates at a pressure 1.2 kg/cm^{2}g and temp. 116 °C at the top. The crude is fractionated with five side stream yields namely Side Cut Naphtha, Kerosene, MTO, LAGO, HAGO. An off-gas compressor is provided at the downstream of overhead receiver for achieving maximum LPG recovery.

b) **Vacuum Distillation section (VDU) -** The heavy residue from crude column bottom is further processed in Vacuum column. The distillation takes place at vacuum column top pressure of 17 mm Hg absolute. Atmospheric column residue(AR) is fractionated into four side stream yields namely Vacuum Diesel oil, VGO, HVGO, Recycle oil. The remaining Vacuum Gas oil (VGO) further cooled and routed to HCU/New INDMAX at 149 °C which are covered under J18 project.

c) **Naphtha Stabilization section (NSU)** – Naphtha cut from atmospheric column although drawn after distilling propane and butane but this stream is generally not stable because of presence lighter hydrocarbons. This stream is fed to NSU column which removes lighter components of C_3 -C_5 to stabilize the Naphtha to a desired RVP. The stabilized Naphtha so received from NSU can be stored and transported or used as a feed stock in the reformer or crackers.

4.3.2.3 New AVU Crude Assay

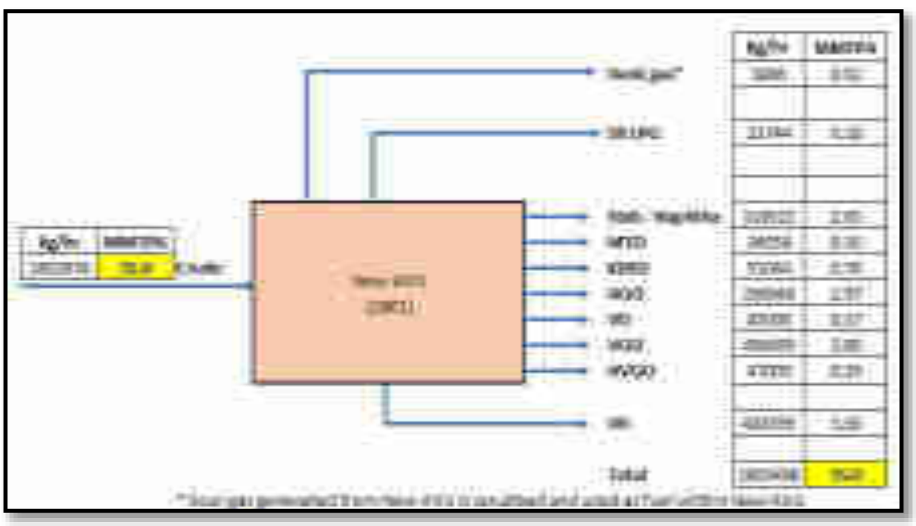
The unit is designed to process crude blend as indicated below:

Crude Blend	Design Crude (Flow in MMTPA)	Wt%
Basrah Light	4.3	28.7%
North Gujarat	0.7	4.7%
South Gujarat	1.7	11.3%
Mangala	0.8	5.3%
Kuwait	7.5	50%
Total	**15**	**100%**

4.3.2.4 New AVU material balance:

The material balance includes only hydrocarbon feed and product streams from New AVU as indicated in Figure 5.4 below.

Figure 5.4 – New AVU Material Balance



Refer to the, "Basis of Design – New AVU" for detailed information of Feed and Products quality.

4.3.3 SR LPG Treater Unit

4.3.3.3 SRLPG Treater Process Configuration

LPG from crude source contains sulfur as mercaptans (- SH). The Sulphur compounds in LPG are to be extracted to meet the specifications for its industrial and domestic application. Although

the refined products from AVU are treated in downstream process units, however the Straight run LPG from the AVU is treated in a LPG treater for the removal of H_2S and Mercaptan to feed to the refinery LPG product pool.
The design capacity of this unit is 0.2 MMPTA.

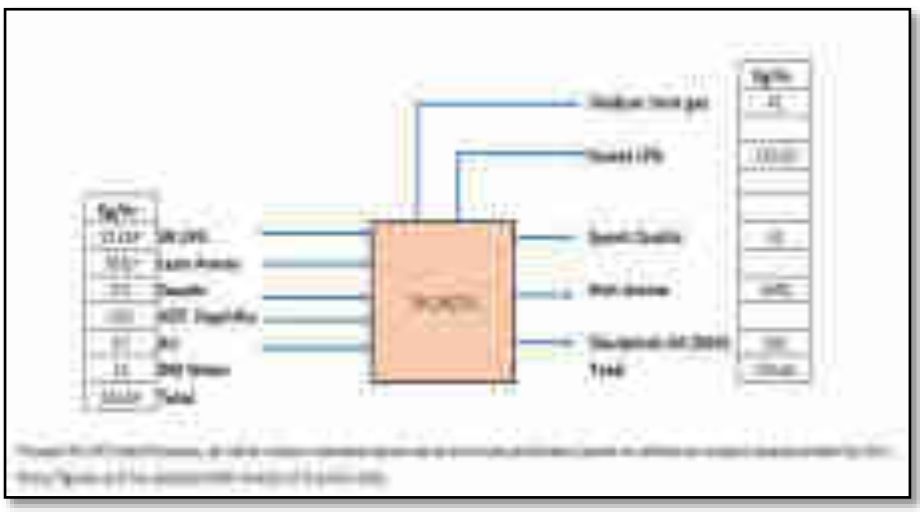
SR LPG Treater unit has the following main sections: -

- Amine treating section
- Pre-wash section
- Extraction section
- Caustic re-generation section
- Wash oil system

4.3.4 SR-LPGTU Material Balance

The material balance of SR-LPGTU is shown below in figure 5.5.

Figure 5.5 – SR LPG Treater Material Balance



4.3.5 Indmax FCCU

4.3.5.3 Function of the unit

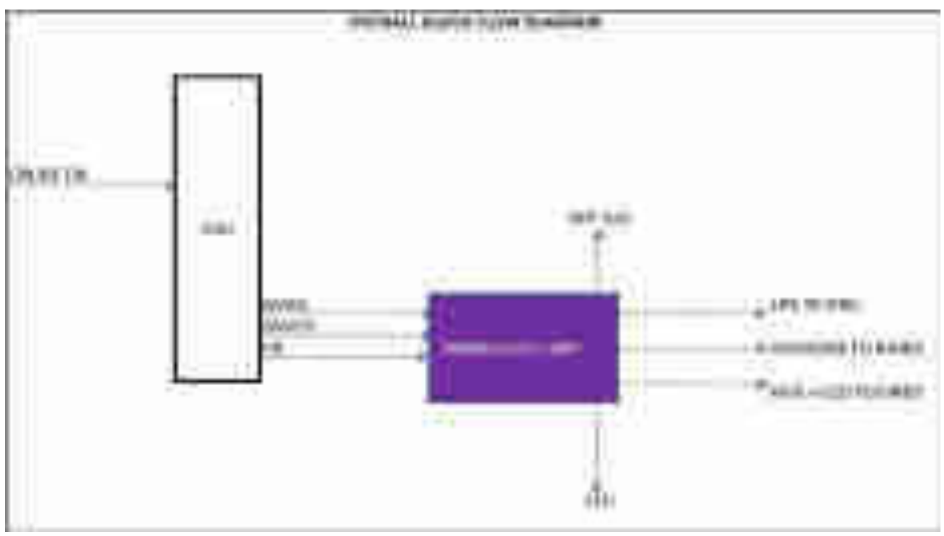
Indmax Fluid catalytic cracking (FCC) is one of the most important unit in the J18 project which converts the high-boiling, high-molecular weight hydrocarbon fractions of gas oil and vacuum residue from upstream AVU into more valuable gasoline, olefinic gases, and other products. The design capacity of this unit is 2700 TMTPA and includes Flue gas desulphurization unit.

The technology for Indmax FCC is licensed jointly by Indian oil and Lummus. Indmax FCC technology is similar to any other conventional FCC which breaks large hydrocarbon molecules into smaller molecules by contacting them with powdered catalyst at a high temperature and moderate pressure which first vaporizes the hydrocarbons and then breaks them. The cracking reactions occur in the vapor phase and start immediately when the feedstock is vaporized. However, the cracking is higher in the Indmax FCC in comparison to other available technologies. The objective of this process is maximization of LPG with higher selectivity towards Propylene, with LPG yield typically 30 – 40 wt% and Propylene 20% by weight. The dry gas produced by this unit is rich in Ethylene.

4.3.5.4 Process Configuration

Heavy residues produced from AVU are processed in a new INDMAX FCC unit under J18 project. Ref figure-1 for INDMAX FCC overall unit configuration.

Figure 1 – INDMAX FCC overall unit configuration



Various products from INDMAX FCC units are sent to downstream processing units for further treatment.

4.3.5.5 Unit Description

Indmax FCC unit consists of following major process blocks.

- Reactor & Regenerator section
    - Reactor
    - Regenerator
    - Main air Blower
    - Flue gas desulfurization
    - Catalyst handling

- Vapor recovery section
    - Main Fractionator
    - Wet Gas Compression
    - Primary and Secondary Absorber
    - Deethaniser Stripper and Debutanizer
    - LPG & Off gas treatment

Reactor & Regenerator section

Indmax FCC, fluidized catalytic cracking is an endothermic reaction. The preheated feed is injected into the riser/reactor and dispersed using steam. The regenerated catalyst flows from regenerator into the riser. The cracking reactions take place in the Riser as the oil vapors and catalyst flow upward into the Reactor. Cracked products and catalyst are separated using cyclones. Cracked products are sent to main fractionator while the catalyst is stripped off hydrocarbons and sent to regenerator.

The coke-laden deactivated catalyst is restored to full activity in the Regenerator (1803-R-101) by burning off the coke with air from the blower. Regenerator operates at 1.9kg/cm2g & 714˚C. *The hot regenerated catalyst supplies the net heat demand required by the reaction system.*

Flue gas Cooling and Desulfurization

Flue gas from regenerator flows through regenerator primary and secondary cyclones where entrained catalyst is separated from the flue gas. Heat is recovered from flue gas in Waste heat boiler by generating HP and MP steam. Flue gas are finally treated in wet gas scrubber to limit the flue gas emissions within the regulation limit. The flue gas is scrubbed with caustic to remove catalyst particulates and Sox (NOx within emission level before letting into atmosphere).

Catalyst Handling

IFCC unit requires continuous addition and withdrawal of catalyst. Four large catalyst storage hoppers are provided for managing the addition and removal of catalyst to the unit. These consist of 1 Equilibrium catalyst (E-cat) hopper (1803-H-101), 1 Spent catalyst hopper (1803-H-102) and 2 Fresh Indmax FCC catalyst hoppers (1803-H-103 and 1803-H-104). E-cat or spent catalyst is withdrawn from regenerator using catalyst withdrawal system (X-104). Fresh catalyst is loaded from hopper to regenerator using auto loaders (X-101 & X-102). One additional hopper (1803-H-106) is provided for additives loading. This is required on intermittent basis when flue gas CO and NOx level rise above regulatory limits.

Vapor Recovery Section

Main fractionator

The hot vapor from riser reactor is fractionated in main fractionator to produce following products:

- Wet gas

- Overhead liquid
- Heavy Cracked Naphtha (HCN)
- Light Cycle Oil (LCO)
- Clarified Liquid Oil (CLO)

The three pump around circuit, MCB PA, HCO PA and LCO PA helps in heat integration.

Wet Gas Compression

Wet gas is compressed upto 16.8kg/cm2g in Wet gas compressor, air-cooled (AC-205) and separated in HP separator(V-205). Vapor from the HP Separator is sent to Primary Absorber and liquid is routed to the Deethanizer Stripper.

Primary and Secondary Absorber

Function of primary absorber is to recover C3+ components from the HP separator vapor. Liquid from the Main Fractionator Overhead Distillate Receiver and Naphtha recycle from the Debutanizer bottom are used as the absorbent in the Primary Absorber. Vapor from the Primary Absorber is fed to the Secondary Absorber (C-207) after cooling it with CW in E-224A/B. Liquid from the Primary Absorber is pumped to the High-Pressure Air Condenser (AC-205) inlet.

The function of the Secondary Absorber (C-207) is to recover C5+ components from the Primary Absorber off gas. Lean oil (LCO) is used as the absorbing medium in the Secondary Absorber. The off gas is sent to off gas scrubber while rich oil is sent back to main fractionator.

Deethaniser Stripper and Debutanizer

The function of Deethanizer Stripper (C-205) to strip off ethane and light ends from HP separator liquid. Stripped vapors are returned to AC-205 inlet.

The function of the Debutanizer (C-206) is to fractionate the Deethanizer bottoms to produce LPG and stabilized gasoline.

LPG & Off gas treatment

The LPG is sent to CR LPG treatment unit for removal of impurities like mercaptans, COS, total sulfur. Off gas is treated with MDEA to remove acid gases.

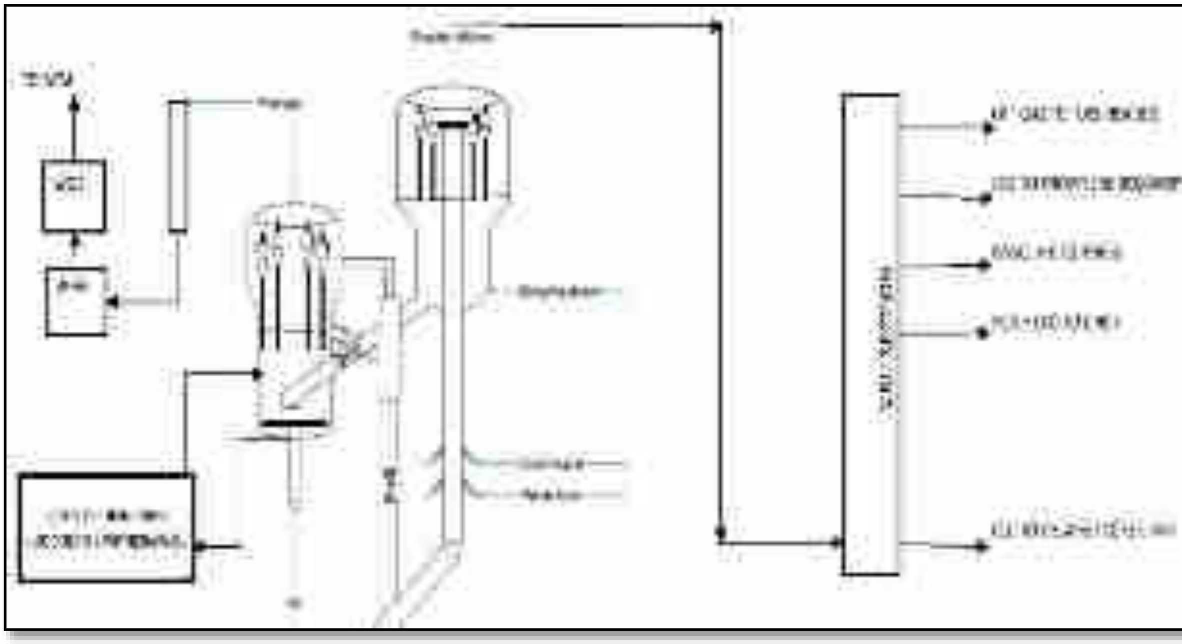


Figure -2 Major blocks in INDMAX FCC unit

4.3.5.6 Material Balance

Overall Material balance indicated for Design case 1 & 2 in the following table. Only hydrocarbon feed and product details are tabulated. Utilities such as Wash water is used in process for avoiding Ammonium chloride formation in air cooler & MP steam for stripping purposes are not listed. Fuel gas shall be use for firing in Air preheater.

Overall Material Balance

Case	Design Case 1	Design Case 2	Notes
	MT/hr	MT/hr	
Inputs to Indmax FCC			
Feed	337.5	337.5	
Air	[illegible]	[illegible]	1
Steam	[illegible]	[illegible]	
Light Aromatics	[illegible]	[illegible]	
Purge Offgas	0.4	0.4	
TOTALS	[illegible]	[illegible]	
Outputs of Indmax FCC			
Flue Gas	[illegible]	[illegible]	1
Treated Dry Gas	[illegible]	[illegible]	2
C_3/C_4 LPG	[illegible]	[illegible]	
Indmax Gasoline	[illegible]	[illegible]	
HCN/LCO	[illegible]	[illegible]	
CLO	[illegible]	[illegible]	
Heavy Aromatics	[illegible]	[illegible]	
Sour Water	[illegible]	[illegible]	
TOTALS	[illegible]	[illegible]	

NOTES:

1. Wet Basis
2. Includes [illegible]

4.3.6 CR LPG Treater Unit

4.3.6.1 Function of the unit

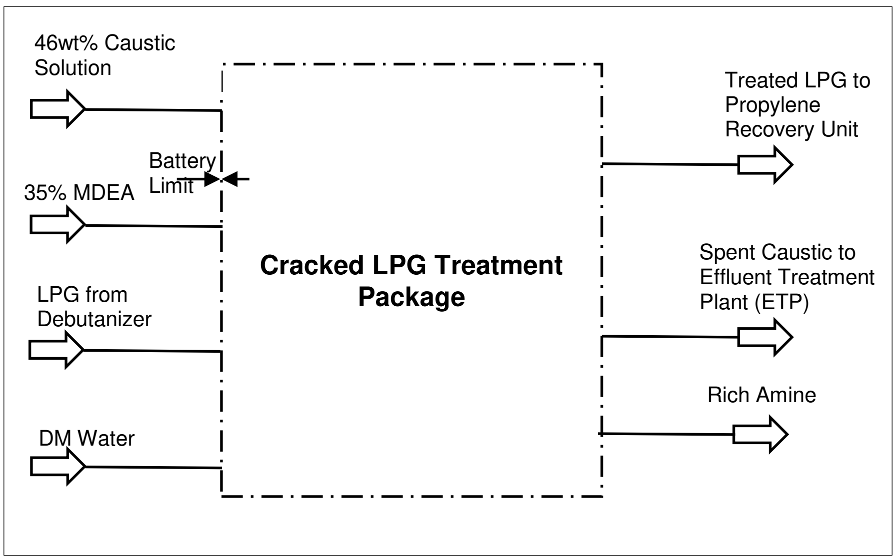
CR LPG treater unit function is to remove H2S, Mercaptans and any other extractable Sulphur components from high propylene LPG from Indmax FCC unit, to meet the desired LPG specification as a feed for Propylene Recovery Unit (PRU).

4.3.6.2 Process configuration

LPG from Indmax FCCU is treated in CR LPG treatment unit to remove H2S, mercaptans (- SH), COS, and any other extractable sulfur. The treated LPG is then routed to Propylene Recovery Unit (PRU).

LPG from existing DCU is also routed to new CR LPG Treater unit to remove the COS content

Figure3 – CR LPG Treater Unit



4.3.6.3 Unit Description

LPG from Debutanizer is pretreated with dilute caustic solution to remove SO2. LPG is then sent to LPG Amine contactor to remove H2S. LPG is then sent to caustic treatment section, wherein LPG is treated with caustic to remove residual H_2S and mercaptans. LPG enters first, second and third stage caustic contactor column wherein LPG contacts with caustic solution in film/ packed contactor counter currently. Treated LPG is sent to Propylene recovery unit. The unit includes caustic regeneration facility.

The process shall be confirmed based on selected Licensor during detailed engineering.

4.3.6.4 Material Balance

Overall Material balance indicated for Design case 1 & 2 in the following table.

	Design Case-1	Design Case-2
	MT/h	MT/h
Input to CR LPG		
LPG from FCC	117.8	123.5
Make up Caustic	(Note 1)	(Note 1)
Lean Amine	(Note 1)	(Note 1)
Output from CR LPG		
Treated LPG	115.6	121.4
Rich Amine	(Note 1)	(Note 1)
Spent Caustic	(Note 1)	(Note 1)
Disulfide Oil	(Note 1)	(Note 1)

Note 1: Based on selected Licensor input.

4.3.7 Indmax Gasoline Hydro Desulphurisation (IGHDS)

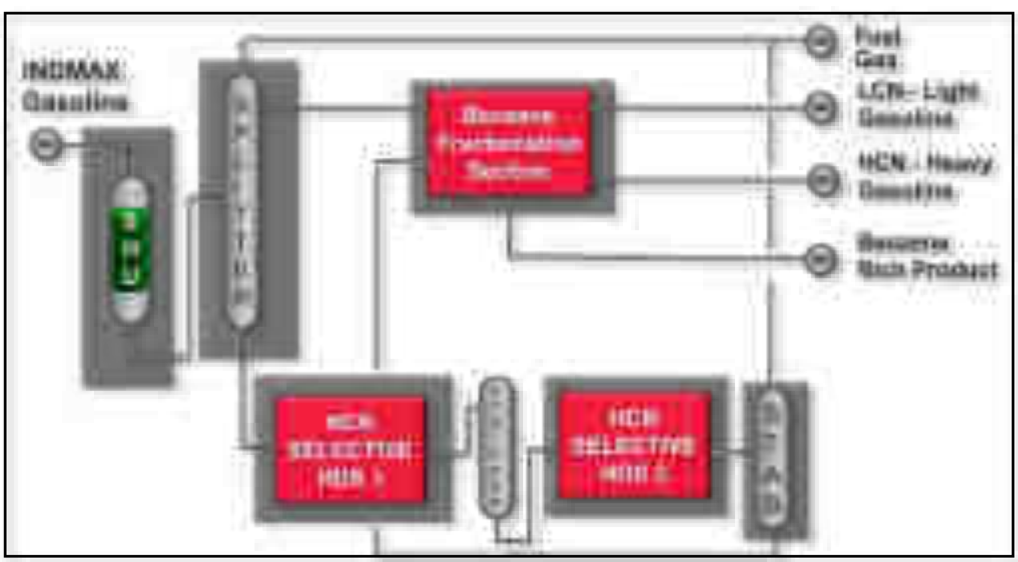
4.3.7.1 Function of the unit

The main function of Gasoline Hydro Desulphurization unit is desulphurization of full range FCC gasoline with high feed Sulphur content to low product Sulphur specification. The design capacity of this unit is 650 TMTPA. Technology for this unit is licensed by Axens. 2 stage HDS scheme is selected by licensor to allow processing high olefinic feeds keeping low Sulphur specification in the product while maximizing octane retention.

4.3.7.2 Process Configuration

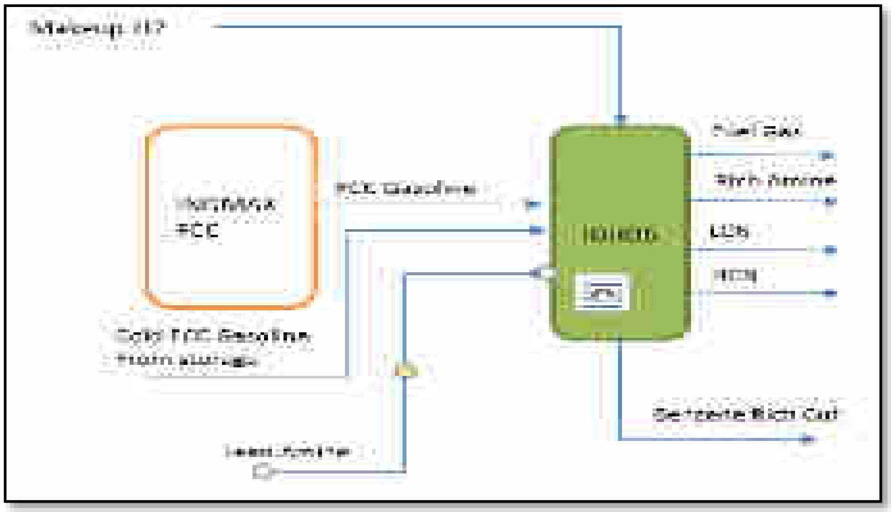
The simplified flow scheme of the unit with major input and output is as shown below:

Figure 4 – IGHDS overall unit configuration



4.3.7.3 Unit Description

Figure 5 - Major blocks in IGHDS unit



Main function of each section is summarized below

a) **SHU section:** Two SHU reactors operating mainly in liquid phase with slight excess hydrogen. perform conversion of diolefins into olefins which is required to reach long cycle length in downstream hydrodesulphurization section. Also, light Sulphur compounds are converted to heavier ones to facilitate production of ultra-low Sulphur light gasoline. A slight octane boost is also expected due to isomerization of external olefin into internal olefins.

b) **Splitter section:** Splitter at downstream of SHU section produces two cuts, namely, a mercaptan free, desulphurization light cut as a side draw in the top section of the column and a heavy cut that is sent to HDS section. Light olefins are recovered through the LCN thereby minimizing the quantity of olefins sent to HDS section where there is chance for octane loss during desulphurization reaction.

c) **HDS section:** Main desulphurization reactions occur in the two stage HDS scheme (2 main HDS reactors and 1 finishing reactors). H2S stripping is carried out between two stages to improve selectivity. Compared with conventional catalyst, Axens' HDS catalyst provides lower olefin saturation rate for the same hydrodesulphurization rate. The 2-stage scheme results in the required sulphur removal with maximizing octane retention and lower hydrogen consumption compared to 1 stage HDS scheme.

d) **Benzene fractionation section:** To meet benzene specifications of FCC gasoline, a dedicated benzene removal section is proposed. This section has the flexibility to be bypassed during cases when benzene specification is not a constraint.

4.3.7.4 Material Balance

Estimated overall material balance	Design feed case (SOR)
Feeds, kg/h	
FCC gasoline Make up hydrogen	81250 237
Total	81487
Products, kg/h	
LCN gasoline HCN gasoline Benzene rich cut H2S Fuel gas	23495 54476 3000 244 272
Total	81487

4.3.8 Polypropylene Unit (PPU)

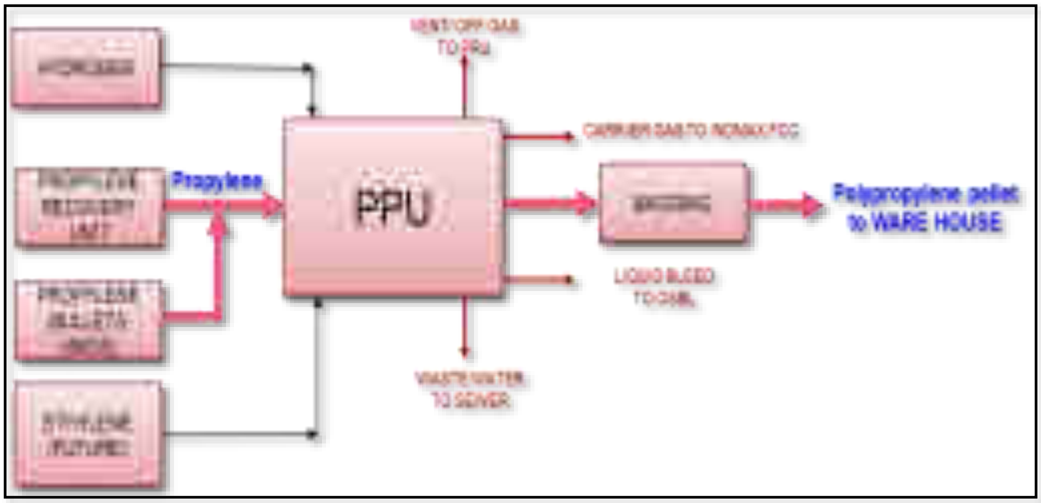
4.3.8.1 Function of the unit

The objective is to install a grass root Polypropylene unit of 420 KTPA capacity of Homopolymers in one production line and provisions to produce binary Random-Copolymer and Impact-Copolymer in the future upon availability of Co-monomer ethylene. The production line will use two polymerization reactors in parallel operation and a double screw extruder.

4.3.8.2 Process Configuration

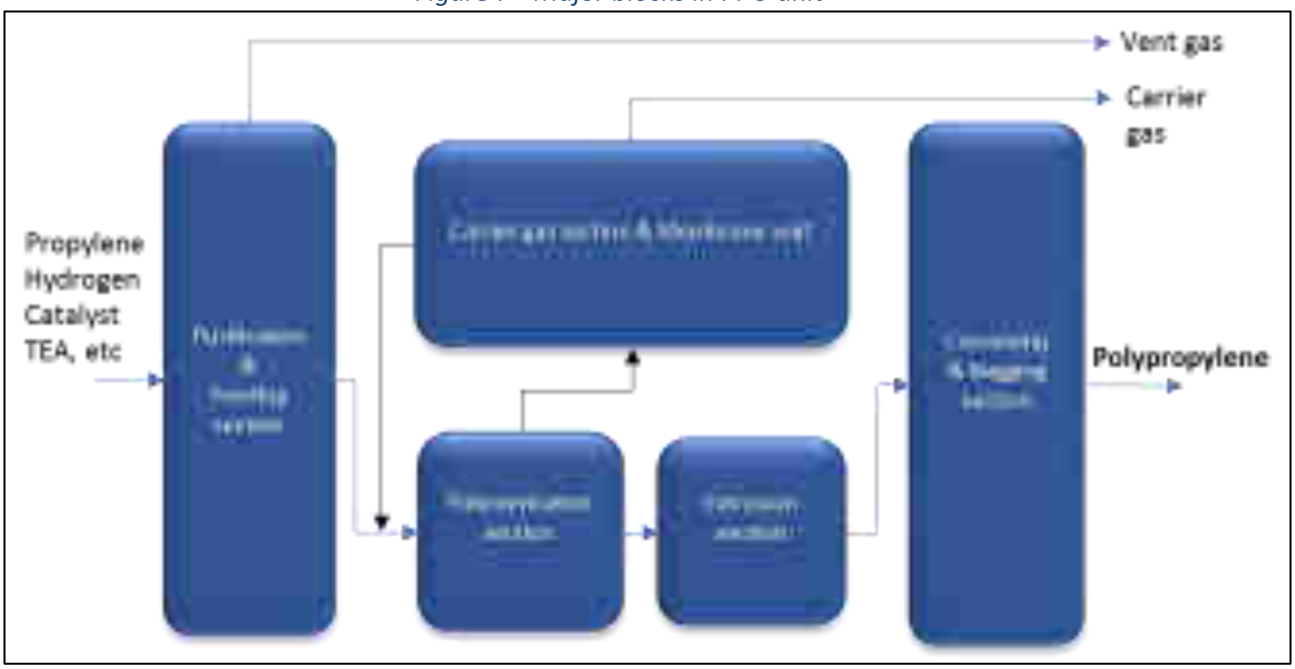
Polypropylene unit receives propylene feed from Propylene recovery unit (PRU) and optionally from Propylene bullets. Hydrogen will be received form refinery plant header and ethylene sourcing will be identified in future by IOCL. Novolen provided process configuration for producing various polypropylene grades such as Homopolymer, Random Co-polymer (future) and Impact co-polymer (future).

Figure 6 – PPU overall unit configuration



4.3.8.3 Unit Description

Figure 7 - Major blocks in PPU unit



Purification section: Fresh propylene from OSBL is fed through a propylene purification unit (stripper, treater and dryer) to the reactors along with the required catalyst, co-catalyst, hydrogen and stereo-modifier. If impact copolymer is produced, ethylene vapor and isopropanol are also fed to the second reactor (cascade operation). For Random copolymer ethylene is fed to both reactors (parallel operation).

Reaction section: Polymerization itself is carried out in a gas phase stirred reaction. Heat removal is managed by evaporative cooling. Liquid propylene entering the reactor vaporizes and thereby removes the exothermic reaction energy. Reaction gas is continuously removed from the top of the reactor and filtered. Reactor overhead vapor ("Recycle Gas") is condensed and pumped back to the reactor as coolant. Non-condensable gases (mainly H2 and N2) in the recycle gas are compressed and returned to the reactor. The polypropylene product powder is blown out (discharged) of the reactor under reactor operation pressure.

Carrier gas section & Membrane unit: From the reactors, the carrier gas and powder pass into the discharge cyclone and subsequently the degassing vessel where powder and gas are separated. The carrier gas is routed through a cyclone and filter to remove residual powder and is routed to the compression.
Powder from the degassing vessel is routed via rotary feeder to the purge silo. Nitrogen is used to purge the powder off residual monomers. Demineralized water is vaporized and mixed with the nitrogen for powder deactivation (TEA deactivation). The overhead gas from the purge silo is sent to the membrane unit for monomer/nitrogen recovery. The recovered nitrogen is sent back to the purge silo and is used as make up. The condensed monomers from the purge gas are mixed with propylene make up stream and used as refrigerant within the membrane unit. The recovered monomer and carrier gas are compressed and sent back directly to the reactors or remainder is sent to the OSBL. In the cases of homopolymer and random copolymer production, normal 60% (max. 70%) of the carrier gas is returned directly to the reactors.

Extrusion section: The PP powder from the purge silo is fed to the extruder where polymer powder and additives are mixed, melted, homogenized and extruded through a die plate, which is heated by hot oil. The extruding section is steam heated.
Pelletizing of the final product is carried out in an underwater pelletizer where the extruded polymers - after passing the die plate - are cut by a set of rotating knives. The polymer/water slurry is transported to a pellet rotary dryer where polymer and water are separated. Water is recycled to a pellet water tank, for which demineralized water is used as make-up.

Conveying & bagging section: The cooled pellets (~60°C) are pneumatically conveyed to the pellet blending silos by an air conveying system. After homogenization in the blending silos the pellets are conveyed to the bagging and palletizing system. Prior to the bagging unit, a PP fines separation (elutriator system) is may be required to separate the fines from the pellets, generated during conveying. Conveying vendor needs to consider an elutriator system based on the selected conveying type and conveying distance.

4.3.8.4 Material Balance

Material balance indicated for Design grade 1102 K in the following table. Only major feed and product details are tabulated. Additives (solid & meltable), Chemicals such as Silane, Peroxide, and Isopropanol are not included in the overall material balance. Utilities such as Pellet water (demin water) for pellet removal from Extruder is not considered. Instrument air shall be used for catalyst bed oxidation, LP nitrogen for regeneration, HP nitrogen for flushing and pressurization of equipment's, plant air for drum pumps.

Feed		Product	
	kg/h		kg/h
Propylene	58027	Polypropylene	52500
Hydrogen	2	Offgas to PRU	120
White oil+TEA+Catalyst	28	Carrier gas to FCC	5437
Total	58057		58057

4.3.9 MS Block

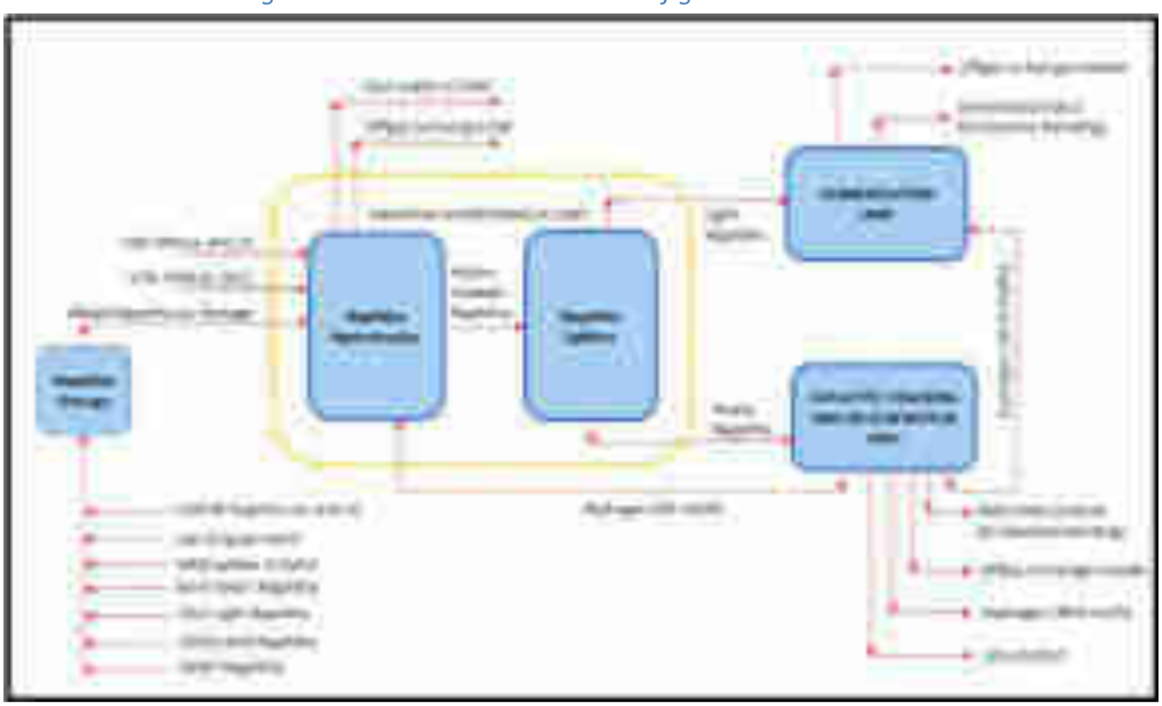
4.3.9.1 Function of the unit

The new MS Block of J18 project consisting of a Naphtha Hydrotreater & Splitter Unit (NHT/NSU), an Isomerization unit (ISOM) and a Catalytic cracking & Regeneration Unit (CCRU) is licensed by M/s. Honeywell UOP. The MS block units convert naphtha from AVU and other secondary processing units such as DHDT, DHDS to valuable Motor Spirit with high octane number.

4.3.9.2 Overall Process Configuration

The configuration for MS Block is as given below:

Figure 8 – MS Block overall unit configuration



4.3.9.3 Overall Material Balance

Material balance is displayed for Overall MS Block in the following table. Only hydrocarbon feed and product details are tabulated. Utilities such as Wash water is used in process for avoiding Ammonium chloride formation in air cooler & steam for stripping purposes are not included in below table.

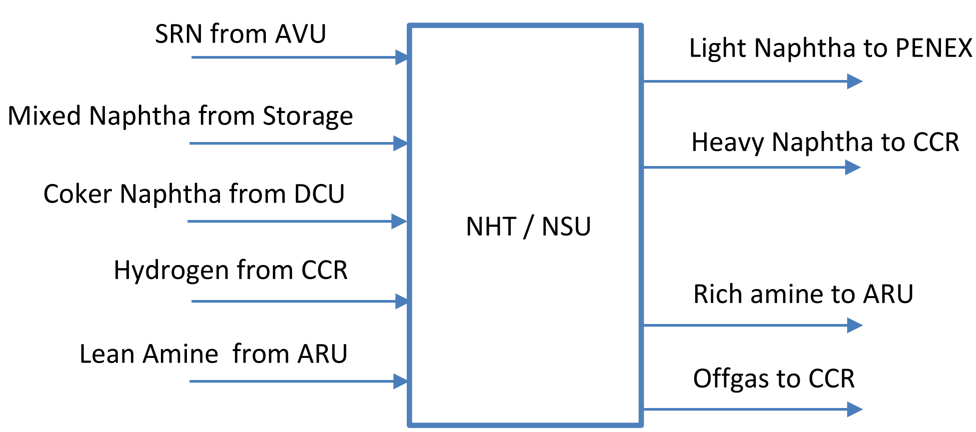
Feed		**Product**	
	TPH		TPH
Combined Naphtha Feed	300	Isomerate product	105
Other Feeds to ISOM	17	Reformate product	190
		Hydrogen (99.9mol%)	7.6
		Offgas	1.6
		LPG	12.5
		Rich amine (H2S only)	0.3
Total	317		317

4.3.9.4 Unit Description

NHT / NSU

a) Unit Description

Figure 9 - NHT/NSU unit scheme



The new J-18 NHT/NSU receives naphtha feedstock from AVU-6, DCU, DHDT, DHDS, BS-VI DHDT, LAB unit and MSQ Splitter. The naphtha feedstock is desulphurized and split into Light and Heavy naphtha feeds for new ISOM unit and CCR unit.

The main sections in NHT/NSU are,

- Feed pre-heating section
- Reaction section
- Reactor effluent cooling section
- Make-up gas and Recycle gas compression section
- Naphtha Stripper section
- Naphtha splitter section
- Steam generation section in combined fired heater convection section.

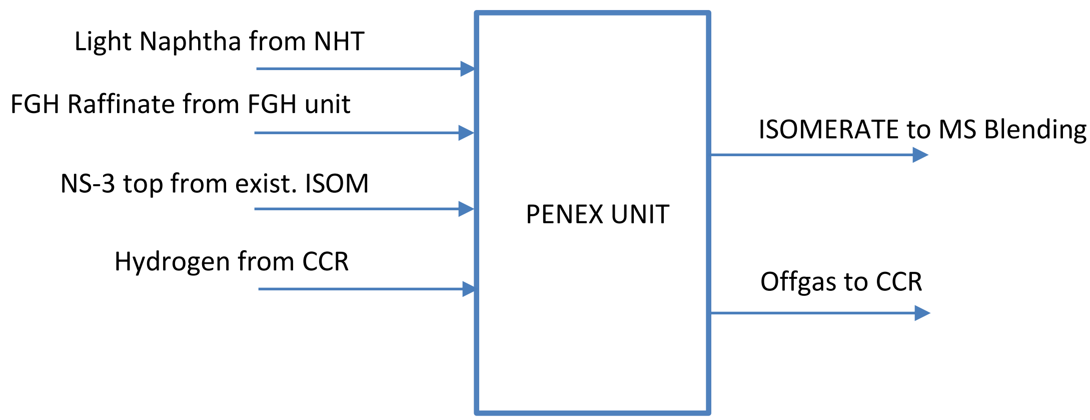
b) Material Balance for NHT

Feed		**Product**	
	TPH		TPH
Makeup H2	0.86	Off gas	2.70
Combined Naphtha	300	Hydrotreated Heavy Naphtha	200.20
		Hydrotreated Light Naphtha	97.67
		Rich amine (H2S only)	0.285
Total	300.86		300.86

Isomerization Unit

a) Unit Description

Figure 10 - PENEX unit scheme



The Penex Process Unit is a fixed bed catalytic isomerization unit for the conversion of C5/C6 hydrocarbons to their respective isomers. The Unit is designed for 925 KMTA of hydrotreated light naphtha from Naphtha Splitter overhead to achieve Isomerate product RON of 87.

ISOM unit consists of the following main sections,

- Feed Section
- Makeup Gas Section
- Reactor Section
- Stabilizer Column
- Scrubber Section
- DIH Column
- Drier Regeneration Section

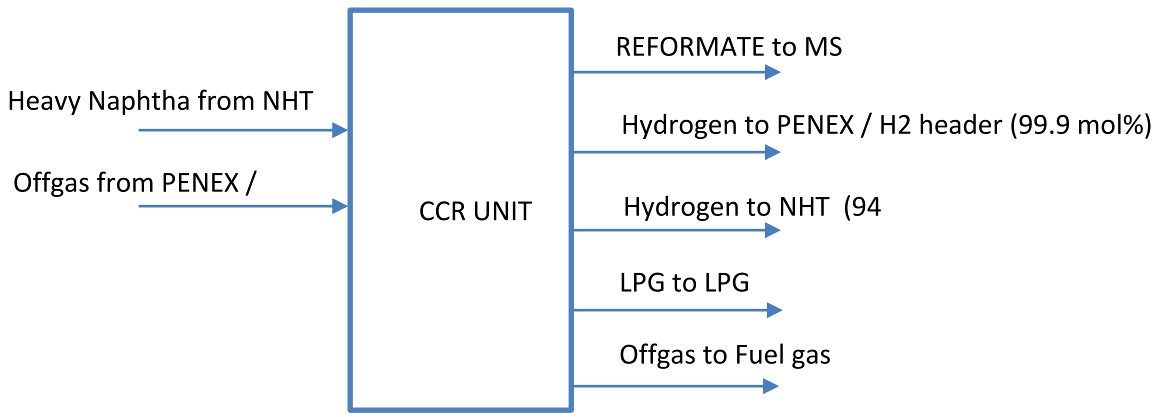
b) Material Balance of ISOM unit

Feed		**Product**	
	TPH		TPH
Makeup H2	0.80	Off gas	10.8
Light Naphtha	98.5	Isomerate	105.6
Other feeds	17.1		
Total	116.4		116.4

Catalytic Cracking and Regeneration (CCR) Unit

a) Unit Description

Figure11 - CCR unit Scheme



The new CCR unit will process Hydrotreated Heavy Naphtha from Naphtha Splitter bottoms and produce Reformate stream of RON 103 for Motor Spirit blending. The catalyst used in CCR reactors is under continuous pneumatic circulation between CCR reactors and Catalyst Regenerator. The catalyst regenerator regenerates CCR catalyst by burning and removing coke deposited on catalyst surface.

Since the unit's, Technology Supplier is UOP, UOP's trade name of "Platformer unit" is also used to refer to the CCR unit throughout this document.

The main sections in CCR/Regen unit are,

- Feed / Preheat Section
- Reactor Section
- Net Gas Section
- Hydrogen Recovery Section
- Absorber Section
- Debutanizer Section
- Catalyst handling and transport system
- Catalyst Regeneration system
- Steam generation in Platforming Heater Convection Section

b) Material Balance of CCR Platformer unit

Feed		**Product**	
	TPH		TPH
Heavy Naphtha	200	Off gas	2.7
Offgas from NHT/PENEX	14.1	Reformate	190.2
		LPG	12.7
		Hydrogen product	7.6
		Hydrogen to NHT	0.8
Total	214.1		214.1

4.3.10 Kerosene Hydrodesulphurization Unit (KHDS)

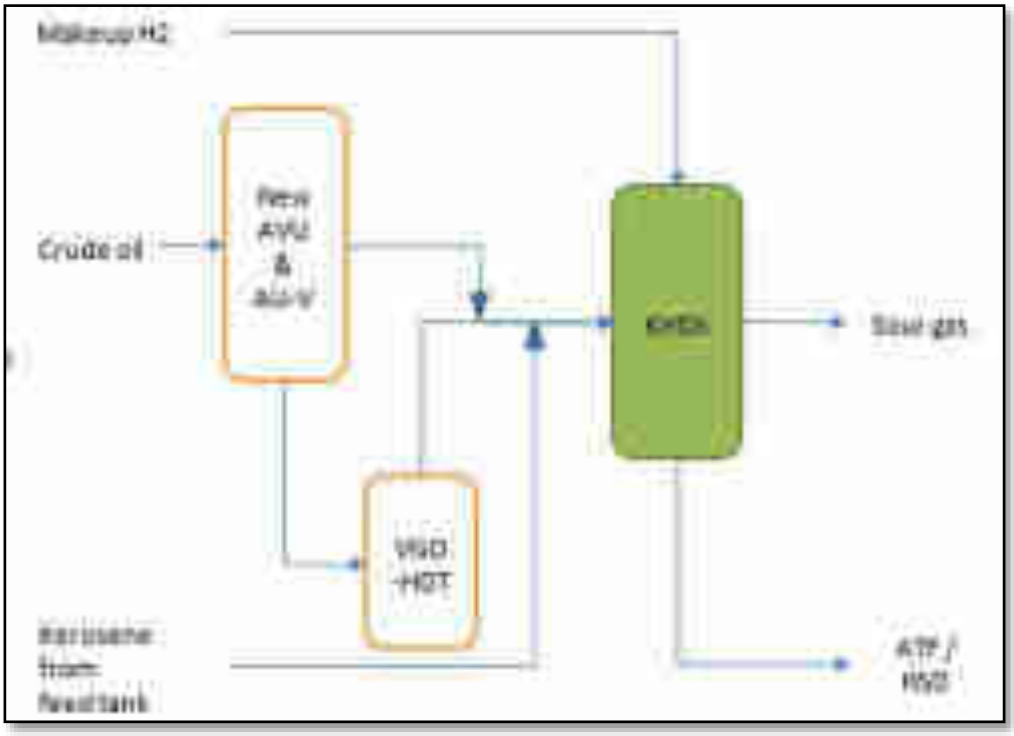
4.3.10.1 Function of the unit

The objective is to install a grass root Kero-HDS (indDSK) unit of 700KTPA capacity. Kerosene from New AVU, AU-V and VGO-HDT are treated in KHDS unit to remove Sulphur & mercaptans for blending in BS-VI grade HSD and ATF.

4.3.10.2 Process Configuration

A new KHDS unit to process additional kerosene produced from expansion while existing kero streams are being treated in DHDT/DHDS units. Desulphurization kerosene from new KHDS unit is sent to BS-VI grade HSD and / or ATF product storage tanks.

Figure 12-KHDS Overall Unit Configuration



4.3.10.3 Unit Description

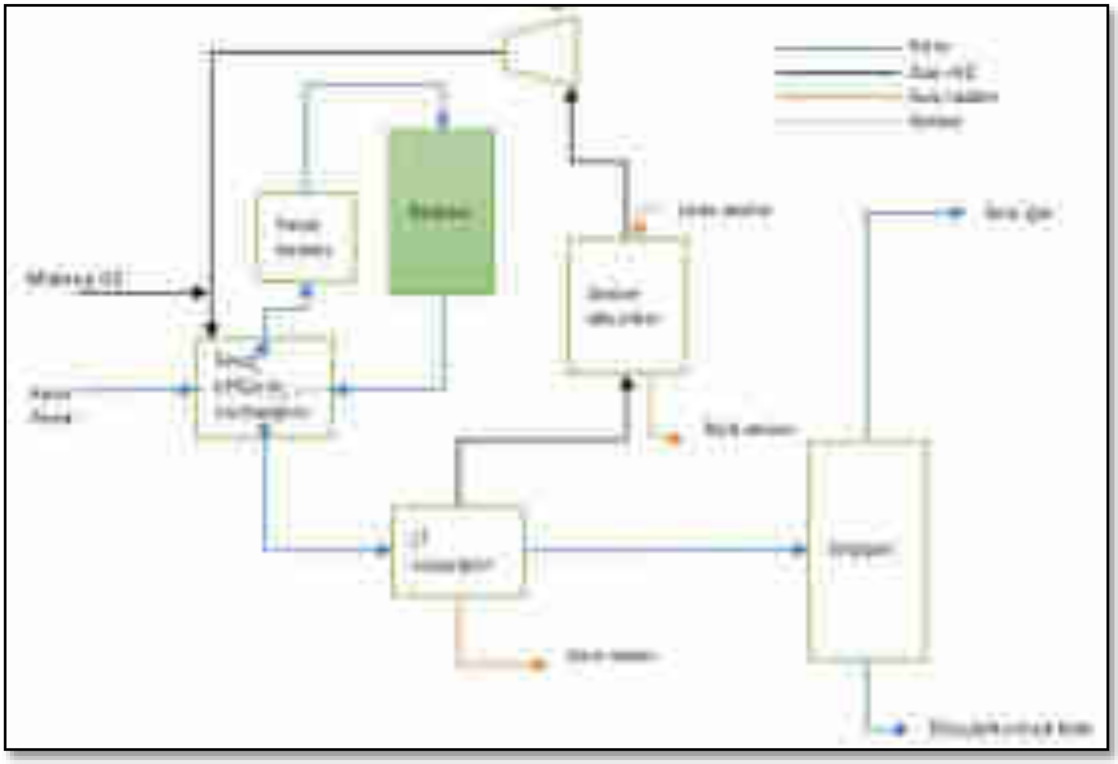
Feed & preheat section: Hot Kero feed & Cold Kero feed are filtered separately and combined at unit surge drum. Kerosene is pumped from unit surge drum and preheated through series of feed-effluent exchangers followed by feed heater before sending to Reactor. Recycle gas along with makeup H2 is injected into preheated kerosene line before entering in to feed heater.

Reaction section: The sulfur & sulfur containing compounds in kerosene reacts with Hydrogen in presence of catalyst to form H2S and other compounds. Reactor effluent is cooled in feed-effluent exchangers to recover heat and cooled in reactor effluent air cooler to bring it to lower temperature to separate gases / liquid in LP separator.

RG amine absorption section: Sour recycle gas from the LT separator is treated in amine absorber to remove H2S using lean amine. Sweet recycle gas from amine absorber is then compressed & recycled to kero preheat line (upstream of feed heater).

Stripper section: Liquid from LT separator is preheated in stripper feed-effluent exchangers & stripped with MP steam to remove H2S from kerosene. Stripped kerosene is cooled in stripper feed-effluent exchangers and cooled in product air cooler before sending it to storage.

Figure 13 - Major blocks in KHDS unit



4.3.10.4 Material Balance

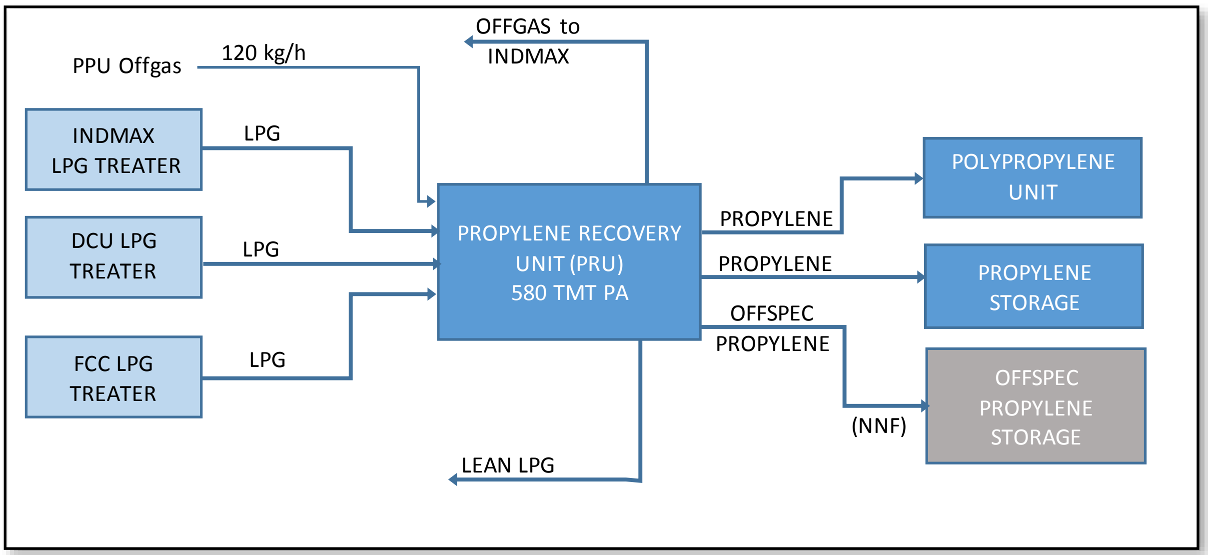
Material balance indicated for Design case 1 SOR in the following table. Only hydrocarbon feed and product details are tabulated. Utilities such as Wash water is used in process for avoiding Ammonium chloride formation in air cooler & MP steam for stripping purposes. Fuel gas shall be use for firing in feed heater.

Feed		**Product**	
	kg/h		kg/h
Makeup H2	197	Sour gas	200
Kerosone	87500	Desulphurized Kero	87360
		Rich amine (H2S only)	137
Total	87697		87697

4.3.11 Propylene Recovery Unit (PRU)

4.3.11.1 Process Configuration

The Primary objective of this unit is to recover the Propylene from LPG streams produced from INDMAX, FCC and DCU as a Polymer Grade Product, suitable for downstream processing (in Polypropylene Unit (PPU) and Butyl Alcohol Plant coming at Dumad).



4.3.11.2 Unit Description

The objective of the Propylene Recovery Unit (PRU) is to recover the Propylene from LPG and supply downstream users with polymer-grade propylene for petrochemical applications.

To meet polymer-grade specifications, the stream should be concentrated to 99.5 % propylene and be essentially free of all relevant contaminants / impurities.

With Propylene Recovery Configuration, feed would first be de-butanized then de-ethanized. Thereafter C3 splitter fractionates propane & propylene; propane is sent from bottoms of column along with C4+ to Storage while propylene is taken overhead and sent downstream for further processing.

Propylene is further processed to remove impurities. After drying, propylene stream is treated to remove trace amounts of COS, arsine, phosphine and other metals, if any.

The resulting product meets specification for polymer-grade propylene.

4.3.11.3 Material Balance

Feed		Product	
	kg/h		kg/h
INDMAX LPG	136923	PROPYLENE	72529
FCC LPG	28750	Deethanizer Offgas	1397
DCU LPG	10625	Lean LPG	102378
PPU Off gas	120		
Total	176418		176304

4.3.12 Sulphur Recovery Unit (SRU)

The function of (SRU) Sulphur Recovery unit is to convert hydrogen sulfide present in feed gas streams i.e. acid gas from Amine Regeneration unit and sour gas from Sour Water Stripper Unit and recover it as Sulphur product in order to minimize pollution from the refinery complex. Sulphur Recovery Units has been considered along with Tail Gas Treating Unit (TGT) facilities. Total Sulphur recovery is 99.9 wt %.

One train of Sulphur Recovery Unit with TGTU and incinerator shall be considered to achieve Sulphur recovery of 99.9 wt%. The capacity of SRU is 425 TPD. The TGTU unit shall be designed to enhance overall Sulphur recovery from guaranteed Sulphur recovery at EOR across Claus unit (96.4% wt) minus 1%wt. (95.4% wt) to 99.9% wt. (min.).

The technology selection and process configuration is by the LEPC contractor.

A Typical block flow diagram is shown below:

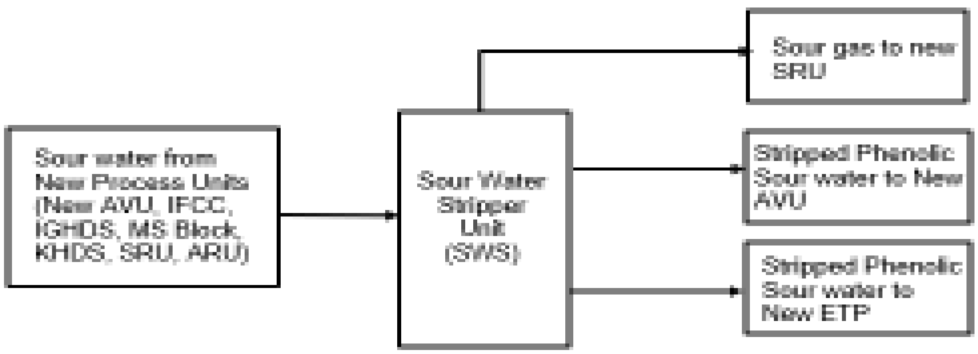
4.3.13 Sour Water System (SWS)

4.3.13.1 Function of the unit

The process objective of Sour Water Stripper Unit is to treat sour water streams generated in New AVU, Indmax FCC (IFCC including CR LPG Treater Unit), Indmax GHDS (IGHDS), MS Block, KHDS, SRU-TGTU and ARU, for removal of Hydrogen Sulphide and Ammonia to meet the emission norms.

4.3.13.2 Process Configuration

The configuration for SWS unit is as given below:



4.3.13.3 Unit Description

Sour water is introduced into a flash drum to remove hydrocarbons by flashing. The sour water from flash drum bottom is fed to Sour Water Stripper which strip off H2S and NH3 using heat generated by reboiler. The sour water stripper overhead temperature is maintained by pump around cooler and pumps. The acid gases are drawn from sour water stripper overhead. The stripped sour water from the SWS is then recycled partially to New AVU as wash water and remaining amount is sent to Effluent Treatment Plant for further treatment / disposal.

4.3.13.4 Material Balance

Description	Inputs, kg/h	Output, kg/h
Sour water from B/L	330,000	
Stripped water to AVU		172,000
Stripped water to ETP		156,269
Acid gas to SRU		1,731
Total	330,000	330,000

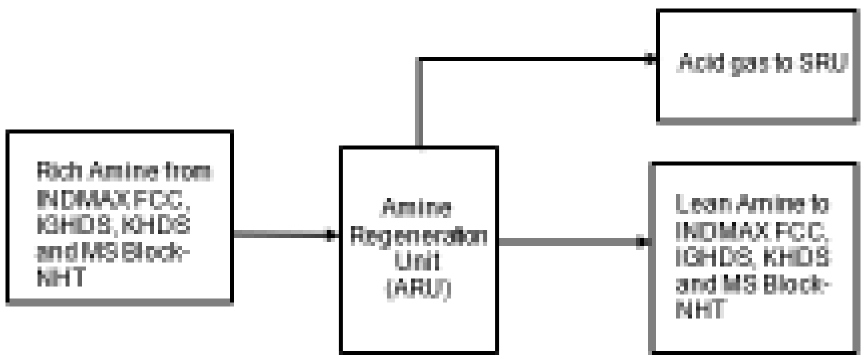
4.3.14 Amine Regeneration Unit (ARU)

4.3.14.1 Function of the unit

The Process objective of Amine Regeneration Unit is to regenerate Rich amine streams from the new process units (INDMAX FCC Unit, IGHDS Unit, KHDS Unit, and MS Block-NHT) and to circulate Regenerated Lean amine to these new Process units.

4.3.14.2 Process Configuration

The configuration for ARU is given below:



4.3.14.3 Unit Description

Rich amine is introduced into a flash drum to remove hydrocarbon by flashing. Rich amine from the flash drum bottom is fed to regenerator which strip off H_2S & CO_2 using heat generated in reboiler. Acid gases are drawn from the reflux drum top and routed to the Sulphur Recovery Unit (SRU). Regenerated (lean) amine solution is drawn from the column bottom and recycled to the amine absorber units.
MDEA (35 wt%) is the selected amine for the new Amine Regeneration unit.

4.3.14.4 Material Balance

Description	Inputs, kg/h	Output, kg/h
Rich Amine from B/L	350,000	
Lean Amine to B/L		337,847
Sour water to SWS		1,900
Acid gas to SRU		10,027
Off-gas to flare		226
Total	350,000	350,000

4.4 Process Configuration - Utility and Offsite

4.4.1 Utility and Offsite configuration

The capacity and configuration of utility packages have been finalized based on integration of new facilities with existing facilities. The spare capacities available in existing facilities as provided by IOCL have been considered for finalizing the capacity of various utilities.
The following section summarizes the major configuration features of various utility & offsite systems that forms part of J18 project.

4.4.2 Cooling Tower – 1

4.4.2.1 Cooling Tower Configuration

Cooling Tower 1 (CT-1) is designed largely to meet the cooling water requirement of Primary processing units such as New AVU and SRLPGTU. The design capacity of CT-1 is 16,000 m3/hr.

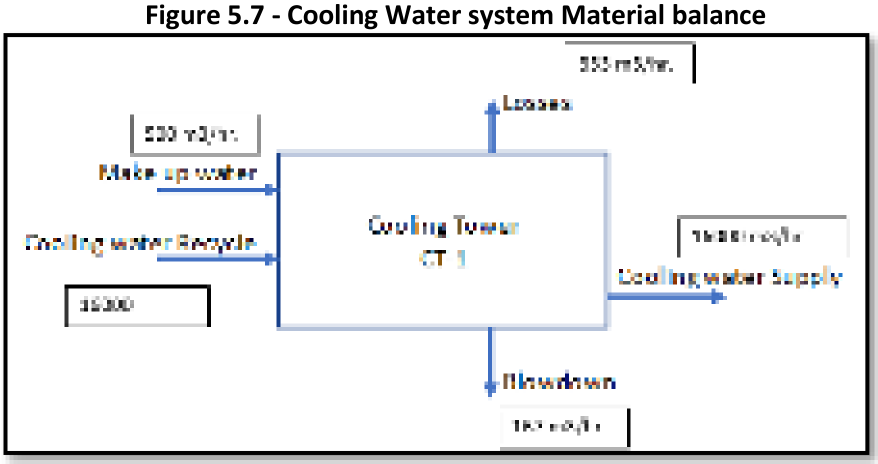
CT-1 is provided with 5 cells of 4,000 m3/hr capacity each (4 operating + 1 standby). The cooling towers will be of counter flow, induced draft type and the fan motors are provided with VFD drives. Cooling tower is being designed to cool water from maximum return temperature of 45°C to design cooling water supply temperature of 33°C. CT-1 system is provided with 5 centrifugal pumps (3 Working + 2 standby), each of 6,000 m3/h capacity. Blow down from the cooling tower shall be routed to RO based DM Plant to minimize Effluent generation.

Raw water is used as makeup for the CT-1 system to compensate for the blowdown, drift and evaporation losses.

4.4.2.2 Cooling Tower Material balance

The cooling water system material balance is shown below in Figure 5.7 below

Figure 5.7 - Cooling Water system Material balance



Values indicated are preliminary. To be confirmed after receipt of vendor data

4.4.3 Cooling Tower – 2

A new circulating cooling water system, CT-2 of 32000 m3/hr design capacity is being installed to meet the cooling water requirement for new secondary processing units and utilities which are being added in J-18 expansion project.

Post the successful commissioning of new AVU of 15 MMTPA capacity, IOCL intends to decommission the existing units such as AU-1, AU-2, AU-3, AU-4, VDU-1, FPU-1, CRU. The utilities consumed by these units such as CW, Steam, DM water etc. will become spared. It may be noted that utilization of existing spare capacity helps to reduce the capacity of the cooling tower system & in turn Raw water system. The cooling tower capacities reported herein take into account the CW spared from shutdown of existing units as indicated above.

The normal and design cooling water capacities are as follows:

(A). COOLING TOWER CT-2

Cooling tower design capacity	=	32,000 m^3/h
Design capacity of One Cooling Tower Cell	=	4,000 m^3/h
Number of Cooling Tower Cells Required	=	9 (8 Working + 1 Spare Cell)

CT-2 system will be provided with 7 pumps (5 Working + 2 standby) of capacity 7,400 m^3/h each.

The type of cooling towers will be counter flow, induced draft type. Cooling tower shall be specified to cool water from 45°C to 33°C. Cooling tower shall be with filmy fill. The basin of each cell will have provision to isolate for maintenance. Blow down from the cooling tower shall be routed to RO based DM Plant to minimize Effluent generation.

4.4.4 Compressed Air System (IA / PA)

4.4.4.1 Air System Configuration

The Compressed Air system is designed to meet the total Instrument Air and Plant Air requirement for J-18 expansion project.

Available spare capacity in Instrument air & Plant air has been considered as provided by IOCL in finalizing the design capacity of new compressed air system.

Compressed Air System mainly comprises of Air Compressors, Air Receivers and Instrument Air Dryers. Dedicated instrument air and plant air distribution headers with suitable control systems are provided to accord priority to instrument air supply.

The design capacity of the compressed air system is 14,500 Nm3/h. To meet this demand, a total of 3 compressors each with 7250 Nm3/hr capacity is being installed. (2 Operating + 1 Standby)

To meet the instrument air requirement, two nos. of fully automatic Instrument Air Dryer Package with a design capacity of 5,500 Nm3/h (2 x 100 % capacity) is provided.

4.4.4.2 Air System (Instrument Air / Plant Air system) Material balance

Air system material balance for J18 is shown in Figure 5.8 below:

Figure 5.8 - Air System Material Balance

Values indicated are preliminary. To be confirmed after receipt of licensor and vendor data.

4.4.4.3 DM Water Unit

New DM plants (3x 250 m^3/hr with 2W + 1S) will be installed to meet the DM water requirement for new process units / utilities which are being added in J-18 expansion project. The DM Water is RO based DM Plant to meet the normal and peak demand of DM water requirements of process units and utility systems.

RO based technology is selected for the DM plant based on the available raw water quality (high TDS). The RO technology results in a high reject flow rate which cannot be used or disposed off elsewhere. Hence, a Zero Liquid Discharge (ZLD) is also designed for appropriate capacity to maximize water recovery and concentrate the RO reject into a solid waste.

The DM water plant + ZLD package shall be a complete unit including all equipment, piping, instrumentation and controls, safety devices and associated structures. DM water will be mainly utilized for producing steam from steam boilers and to other process units for internal steam generation. The DM water generation and distribution system will be designed to meet the requirements of process units and utility systems of J-18 expansion project.

DM water Plant capacity shall be as per the following:

DM water plant design capacity : 500 m^3/h

Number of Trains (RO + Mixed Bed) : 3 x 250 m^3/h (2W + 1S)

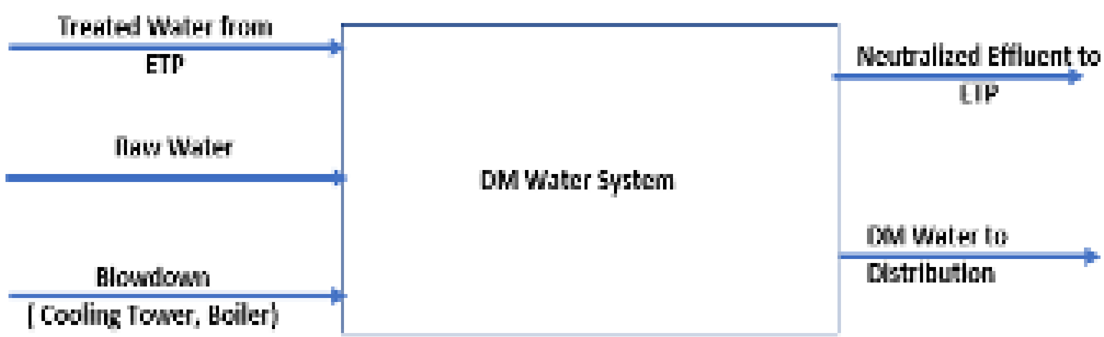
DM water plant will be provided with 3 pumps of capacity 125 m^3/hr for each 250 m^3/hr train with below configuration.

Type	:	Centrifugal
Rated Capacity	:	125 m^3/hr
Number of Pumps	:	3 (2 Operating + 1 Standby)
Discharge Pressure	:	10 kg /cm^2(g)
Driver	:	Electric Motor driven
Material of construction	:	SS304

DM water from the DM plant shall be stored in the atmospheric storage tank and distributed to other units. DM water tank shall be nitrogen blanketed. Normally, one tank shall be receiving DM water from the DM Water System and the second tank shall be supplying DM water to consumers with below specifications:

Type	:	Fixed Roof
Quantity	:	Two
Nominal capacity	:	6750 m^3 * (each)
MOC	:	CS with Epoxy coating

* Total working capacity of storage tanks is corresponding to 2 days storage requirement.



4.5.1 Condensate Polishing Unit

New Condensate Polishing Unit of 2 x 250 m^3/hr capacity (1W +1 S) is proposed to polish the suspect condensate generated from J-18 expansion project, IOCL – Gujarat Refinery. The Condensate system will be designed to meet the boiler feed water.

Condensate Polishing unit package is based on Ion-exchange type to polish the suspect condensate return from process units. Facilities like re-generation, neutralization and effluent management system shall be common for DM plant and CPU unit.

CPU will be provided with Feed pumps and Polished condensate pumps with below configuration.

CPU Feed Pumps:

Type	:	Centrifugal
Drive	:	Electric motor
No. of pumps	:	2 (1 operating + 1 standby)
Rated Capacity	:	250 m^3/h
MOC	:	SS304

Polished Condensate Pumps:

Type	:	Centrifugal
Drive	:	Electric motor
Quantity	:	2 (1 operating + 1 standby)
Rated Capacity	:	250 m^3/h
Discharge Pressure	:	10 kg/cm^2g
MOC	:	SS304

CPU will be provided with Feed Condensate Storage tank and Polished condensate storage tank with below configuration.

Feed Condensate storage tank:

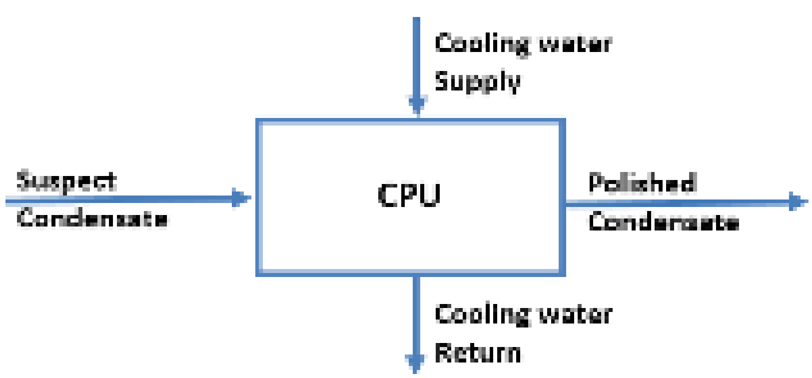
Type	:	Fixed Roof
Total Storage capacity	:	6000 m^3*
Quantity	:	Two
Capacity of each tank	:	3000 m^3
MOC	:	CS with Epoxy coating

(*) Total working capacity of storage tank corresponds to 1 day storage requirement.

Polished condensate storage tank:

Type	:	Fixed Roof
Total Storage capacity	:	6000 m^3*
Quantity	:	Two
Capacity of each tank	:	3000 m^3
MOC	:	CS with Epoxy coating

(*) Total working capacity of storage tank corresponds to 1 day storage requirement.



4.5.2 Nitrogen Generation Plant

A new nitrogen generation system is envisaged to produce 5000 Nm^3/hr of gaseous nitrogen and 500m^3 of liquid nitrogen for supplying 99.99% pure nitrogen in J18 Capacity Expansion Project, IOCL-Gujarat Refinery. Also HP gaseous nitrogen of 1700 Nm3/hr is envisaged in J18 project to meet the HP N2 requirement of MS Block unit. This is met by a dedicated booster compressor system.

The nitrogen generation system is a complete package unit including all equipment, piping, instrumentation & control, safety devices, insulation and associated structures, which is supplied by vendor as a package unit. The system is designed to produce the nitrogen required for normal operation of the units under J18 Capacity Expansion Project.

The Nitrogen generation package will be capable of producing both gaseous Nitrogen and Liquid Nitrogen. Continuous Liquid N2 production is not envisaged. Once Liquid N2 storage is met, the N2 plant needs to operate in fully GAN mode. LIN production + LIN vaporizers are required only on intermittent basis whenever there is a peak Nitrogen demand in the Refinery which cannot be met by GAN.
LP LIN storage capacity:

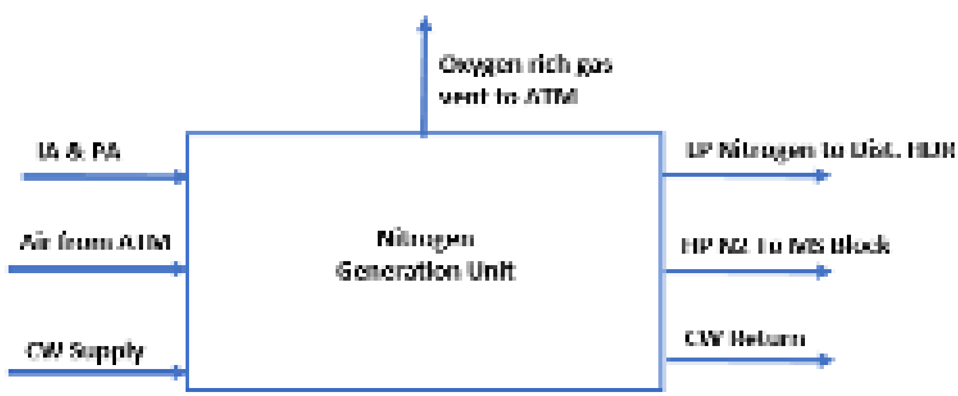
Total capacity of LIN Storage Tanks	: 500 m^3 (min)
No. of LIN Storage Tank	: 2 nos.
Capacity of each Storage Tank	: 250 m^3

LP LIN vaporizer capacity:

Capacity of each Vaporizer	: 4000 Nm^3/h
No. of LIN Vaporizer	: 4 nos. (2W+2S)

HP Booster compressor:

Capacity of each compressor	: 850 Nm3/hr
Number of compressors	: 2 nos



4.5.3 Raw Water

A new borewell for raw water system of 10 UK MGD (1894 m3/hr) capacity shall be installed to meet the raw water requirement for both process and utility units that are being added in J-18 expansion project.

The raw water distribution system is designed to meet the requirements of following units / systems of IOCL- Gujarat J-18 expansion project.

1. Cooling tower make-up
2. DM plant feed
3. Service water / Drinking water make up and
4. Fire water (intermittent requirement)

Borewell pump details:

Capacity : 520 m^3/hr.
Head : 125 m.
No. of pumps : 6 nos. (4W + 2S).

The operating pressure of Raw water header at Refinery battery limit is expected to be 1 – 1.5kg/cm2(g). Hence, booster pumps of below specification are envisaged to meet the raw water supply pressure inside the refinery.

Booster pump details (inside refinery):

Capacity : 900 m^3/hr.
Head : 60 m.
No. of pumps : 3 nos. (2W + 1S).

4.5.4 Effluent Treatment Plant

A new Effluent Treatment Plant (ETP) to treat the effluent generated from various process/ utility systems of 230 m^3/hr capacity and 160 m^3/hr of phenolic sour water from SWS unit is envisaged as part of J-18 expansion project. The new ETP system will be designed to treat the effluent generated from various Process units and Utility systems of J-18 expansion project as given below:

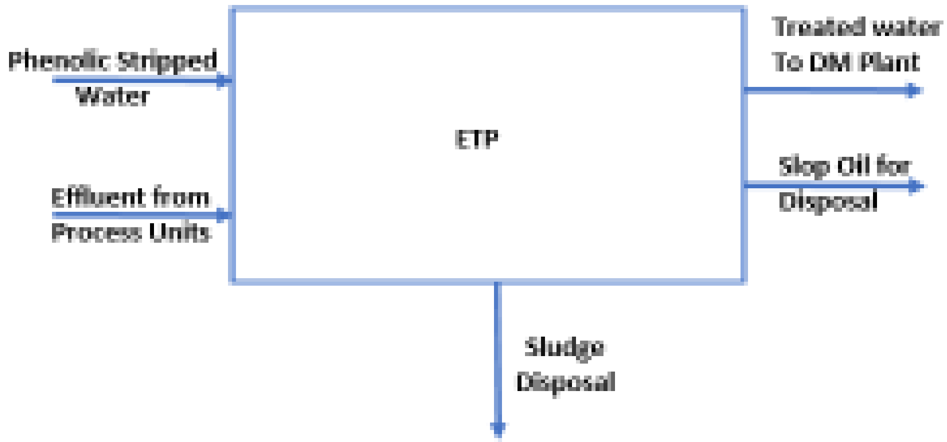
Process Units:

New AVU, SR LPG, INDMAX FCC, GHDS, CR LPG, MS-Block, KHDS, PRU, PPU, SWS, SRU & ARU.

Utility system:

DM Plant, condensate polishing unit, Boiler.

The phenolic Sour water is separately treated inside ETP before blending with other effluent coming from other units. The spent caustic from process units will be fed to caustic oxidation unit through spent caustic tank and oxidized caustic will be sent to ETP.

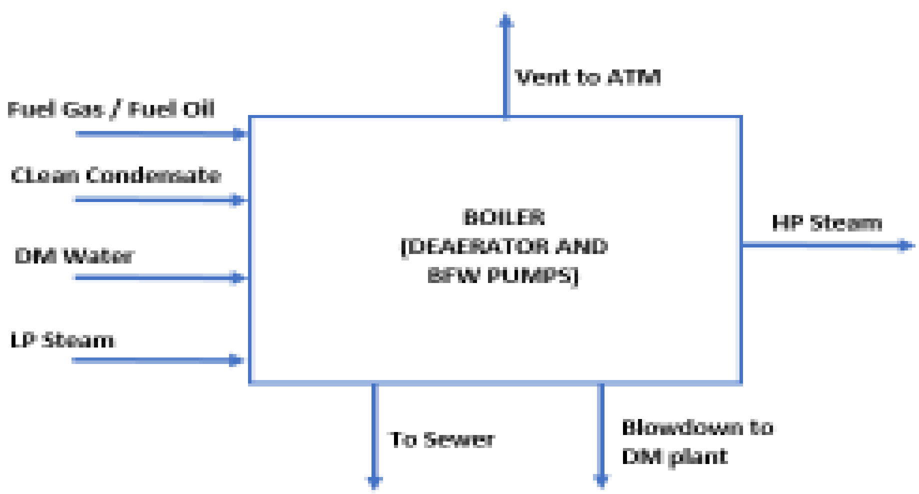


4.5.5 Boiler Package

The new steam boiler of 450 TPH (3 x 150TPH) capacity is envisaged for J-18 expansion project is dual fired boiler to meet the normal and peak steam requirement for new process units / utilities. The overall package consists of High Pressure Boiler and relevant facilities like Deaerator, BFW pumps, Boiler Blow-down Drums and dosing system etc. The boiler package is to be supplied complete with burners, forced draft fan motor driven, air pre-heaters, flue stack, air inlet screens silencers. The flue gases stack height to be based on CPCB norms.

Three Boilers of each 150 TPH along with three Deaerator each of capacity 250 m^3/hr capacity are to be installed to meet the total steam requirement of J-18.

The primary steam required in plant is 40 kg/cm^2g steam produced in the boilers. Steam is produced at 40 kg/cm^2g to guarantee at package BL.



4.5.6 Storage Tanks

KHDS Feed

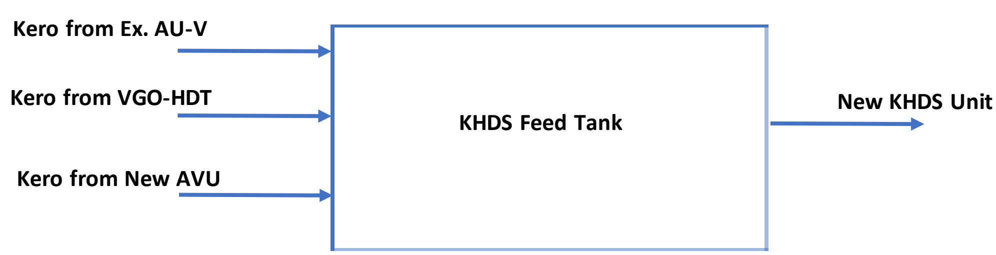
The new KHDS feed storage tanks will receive cold Kero produced from Existing AU-5, VGO-HDT and new AVU unit. The stored Kero will be pumped to KHDS unit for further processing. Cold Kero product containing Sulphur and Nitrogen is produced from existing AU-5, VGO - HDT and New AVU unit. Cold Kero produced from the above listed units are routed to KHDS feed storage tank using rundown (R/D) pump in Process unit before it is routed to KHDS for Hydrotreating. Kero from AU-5 and new AVU is routed to existing LAB unit and new KHDS unit, whereas Kero from VGO-HDT is routed to new KHDS unit alone.

The details of new KHDS feed storage tanks and pumps are provided below:

Tank	1826-T-004 / 005
Service	KHDS Feed Storage Tank
Nominal capacity	Each 5000 KL
Type	Internal Floating Roof
Diameter x Height	20 x 16 m (to be confirmed)

KHDS feed pumps:

Pump	1826-P-004 A/B
Service	KHDS feed pumps
Type	Centrifugal
Rated Capacity	135 m^3/h
Number	2 nos. (1W + 1S)
Differential Head	102 m (To be confirmed later)
Driver	Electric motor



MTO Product

New MTO storage tank is to store MTO produced from New AVU unit. MTO product is produced intermittently from New AVU unit. MTO produced from New AVU is routed to new MTO storage tank using rundown (R/D) pump in Process unit. MTO produced in excess of market demand can be routed to existing ATF Merox unit or to Kero header within New AVU unit. The maximum loading rate is 36 x 1.1 MT/h (51.4 m3/h).

The details of new MTO feed storage tanks and pumps are provided below:

Tank	1826-T-01
Service	MTO Storage Tank
Nominal capacity	5000 KL
Type	Internal Floating Roof
Diameter x Height	20 x 16 m (to be confirmed)

MTO Transfer pumps:

Pump	1826-P-001 A/B
Service	MTO transfer pump
Type	Centrifugal
Rated Capacity	350 m^3/h
Number	2 nos. (1W + 1S)
Differential Head	To be calculated
Driver	Electric motor

NHT Feed

The new NHT feed storage tanks will receive cold Naphtha produced from new AVU unit and existing secondary processing unit. The stored Naphtha will be pumped to Naphtha Hydrotreating Unit for further processing.

The maximum filling rate is considered as 2400 TMTPA (430 m^3/h).

The details of new NHT feed storage tanks and pumps are provided below:

Tank	1826-T-002 / 003 (2 X 100%)
Service	NHT Feed Storage Tank
Nominal capacity	Each 12000 KL
Type	Internal Floating Roof (IFR)
Diameter x Height	29 x 18 m (to be confirmed)

NHT feed pumps:

Pump	1826-P-002 A/B/C
Service	NHT feed pumps
Type	Centrifugal
Rated Capacity	300 m^3/h for Each Pump
Number	3 nos. (2W + 1S)
Differential Head	164 m (To be confirmed later)
Driver	Electric motor

Propylene Bullet

Propylene bullets is envisaged to store Propylene during unforeseen minor shutdown of either PRU or PPU. Based on PRU Propylene production rate of 72,525 kg/hr, the filling time per bullet is estimated to be about 21 hours. During normal operation, PP unit shall be fed directly from PRU. The bullet shall be mounded type. It shall be designed as per latest OISD STD 150. The bullet shall have hemispherical heads. Minimum two number of manholes shall be provided. The external surface of the vessels which is covered by mound should be suitably treated to protect it from corrosion.

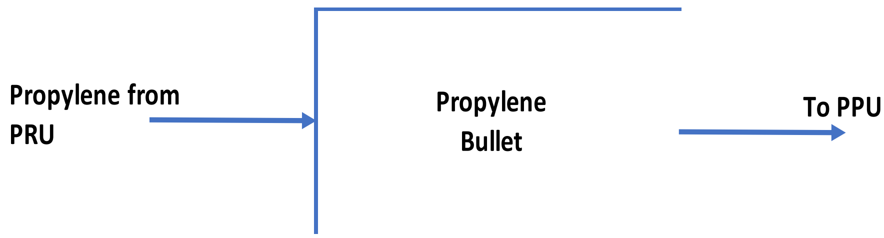
The details of new propylene bullets and pumps are provided below:

Bullet : 1826-T-012/013/014/015
Type : Mounded bullet
Quantity : Four
Nominal capacity : 3500 m^3 (each)
MOC : LTCS + 3 mm CA

The specifications of the propylene pumps are given below.

Pump : 1826-P-005 A/B/C
Type : Centrifugal (vertical barrel type)
Drive : Electric motor
No. of pumps : 3 (2 working + 1 standby)
Rated Capacity : 72 m3/h (*)

(*) Rated capacity is estimated considering 20% design margin on normal flow rate



LPG Product

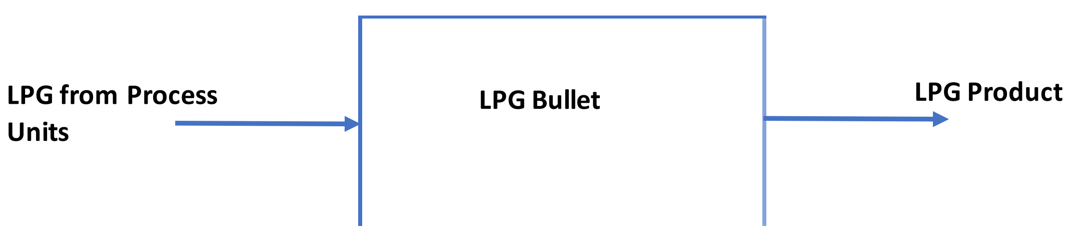
Four new LPG bullets each of 3000 KL capacity to be installed along with transfer pumps of 300 m^3/h capacity (1W+1S). The details of new LPG bullets and pumps are provided below:

LPG Bullet:

Bullet	:	1826-T-007/008/009/010
Type	:	Mounded bullet
Quantity	:	Four
Nominal capacity	:	3000 m^3 (each)
MOC	:	CS + 3 mm CA

The specifications of the LPG pumps are given below.

Pump	:	1826-P-004 A/B
Type	:	Centrifugal (vertical barrel type)
Drive	:	Electric motor
No. of pumps	:	2 (1 working + 1 standby)
Rated Capacity	:	300 m^3/h



LAB REVAMP FEASIBILITY REPORT

Introduction

Linear Alkyl Benzene Unit (LAB) was commissioned in Aug 2004 with an production capacity of 1,20, 000 MTPA of LAB. The LAB Complex includes Kerosene Prefractionation Unit, the Distillate Unionfining Unit, the Molex Process Unit (comprising the “Front End Units”), the Pacol Process Unit, the PEP Process Unit, the Detal Process Unit (comprising the “Back End Units”), and the Hot Oil System. In the Front End section n- paraffin is made from Kerosene and this n-paraffin is fed to PACOL unit in Back End Section. Linear Alkyl Benzene(LAB) is produced in Back End Section by reacting treated Pacolate (from PEP) and Benzene using heterogeneous non-corrosive catalyst to form LAB

Objective: Increasing the capacity of LAB complex to 135% of the original design capacity or 162,000 MTA of LAB product

Basis

This study identifies which major pieces of equipment will require modification or replacement to achieve the target capacity The basis of the study was a single feed case with a Low molecular weight (“LMW”) LAB product (having a molecular weight in the range of 235-239) and a high molecular weight (“HMW”) LAB product (having a molecular weight in the range of 239-243). As per the feasibility study Front End section of LAB Complex can be revamped for 35% capacity increase over the name plate capacity, while in the BE section of the LAB plant, the capacity increase can be by 40% over the name plate capacity. Hence, LAB production can be increased to 162 KTA with 135 % revamp

Kerosene Prefractionation unit

The primary purpose of the Kerosene Prefractionation Unit is to prepare a kerosene heart cut (nominally C10-C13 range) that contains the n-paraffins that, after hydro processing and selective recovery, will meet the desired molecular weight and light/heavy tail requirements for the LAB product.

All equipment was evaluated for both the HMW Case and the LMW Case with a normal paraffin product capacity 130 KMTA. Preliminary evaluation indicates that the HMW Case will govern most of existing equipment sizing. The LMW Case operation will govern the Feed Surge Drum, Feed-Rerun Bottoms Exchanger, Rerun Column Net Bottoms Cooler, Feed Pumps and Rerun Column Bottoms Pumps. The Stripper Column and Rerun Column trays appear to be adequate. However the trays require a more detailed evaluation in the next phase. Rerun Column packing needs to be replaced with higher capacity packing. The Feed-Rerun Pump around Exchanger requires a identical shell in parallel for revamp requirement. The Stripper Column Condenser requires additional rows or bays to meet the revamp requirement. For the Feed–Rerun Bottoms Exchanger, the existing exchanger and one shell of the identical exchanger installed already to meet the revamp requirement.
All other equipment appear to be adequate.

Distillate Unionfining Unit.

The Distillate Unionfining Process Unit hydro treats a kerosene range material to meet the Molex Process Unit feed specifications. The flow scheme is typical of a hydro-processing unit and consists of a reactor section, makeup gas section and a stripping section. The feed to the unit is a kerosene “heart cut” (C10-C13 range) from the Rerun Column in the Kerosene Prefractionation Unit.
There is nitrogen in the feed at about the 8 wt. ppm level. Also there is chlorides of up to 3 wt. ppm in

the feed. This unit was not designed for any chlorides in the feed. Chlorides can lead to stress corrosion cracking of the valve trims in the Separator and Stripper overhead. It is recommended to upgrade air cooler tubes and header to Alloy 625. In addition the piping from the air cooler to the Separator will be upgraded to Alloy 625 replacing the 300 series stainless steel valve trims for these services with Monel trims. To achieve the revamp capacity, the Reactor internals need major modifications or replacement. An additional shell of exchange be added in series to the Combined Feed Exchanger in order to retain the existing Product Condenser. The operating pressures of the 3rdand the 4th stages of the Makeup Gas Compressor needs to be raised in order to reduce the volumetric flow of the inlet gas. For the Stripper Overhead Trim Condenser, replace the existing exchanger to increase the operational flexibility of the Stripper.

<u>Molex Process Unit</u>

The Molex Process is a adsorptive separation method that utilizes molecular sieves for the separation of n-paraffins from branched and cyclic hydrocarbons. The separation occurs in the liquid phase under isothermal conditions. Hydotreated kerosene from Unionfining is feed to the Molex Unit

All equipment was evaluated for both the High Molecular Weight case (HMW) and the Low Molecular Weight (LMW) case. The majority of the equipment was governed by the HMW case. The feed rate for both cases was set at rates to produce 130 KMTA n-paraffins.
New Raffinate Bottoms Trim Cooler is required. The extract Column bottoms trim cooler can be replaced with Raffinate Bottoms Trim Cooler. The existing trays in Raffinate Column and Extract Column need to be replaced with new UOP Simul Flow Trays and PFMD High Capacity trays, respectively. The Desorbent Stripper needs to be replaced with a new column or the existing shell be retained, the trays replaced with high-capacity ECMD trays and relaxing the desorbent specifications.
The existing tube bundles need to be replaced with High Flux tube bundles within the Raffinate Column Reboiler, Desorbent Stripper Reboiler and Extract Column Reboiler. An additional shell in series is required for the Raffinate Column Bottoms-Desorbent Exchanger. Replacement impellers are required for the Chamber Circulation, Raffinate Column Overhead, Raffinate Column Bottoms, Raffinate Column Side cut, Desorbent Stripper Bottoms, Extract Column Bottoms, Extract Column Side cut and Desorbent Pumps. The Charge Pumps need to be operated in parallel.
All other equipment appears to be adequate.

<u>Pacol with DeFine Process Unit</u>

The Pacol Process is a fixed bed catalytic process to selectively dehydrogenate a high purity, normal paraffin feed to the corresponding mono-olefin product. A DeFine reactor downstream reduces the di-olefins in the Pacol product. A stripping column is provided to remove light ends from the product before it is sent to the PEP unit.

<u>PEP Process Unit</u>

The Pacol Enhancement Process (PEP) unit is a fixed bed adsorption unit for the selective removal of aromatic components from the Pacol product stream.

Existing adsorbers will be adequate for the revamp conditions. However, once the unit is in operation, an adjustment in cycle time may be required. It is expected that the desorbent and purge rates are to maintain the same as originally designed. Hence, all the equipment downstream of the adsorbers will be suitable for the revamp conditions. Due to changes in the Detal Unit, the temperature of the desorbent entering the PEP Unit has increased. As a result, two new coolers are required to replace the existing Desorbent-Pacolate Exchanger which will be deleted for the revamp. The design of the coolers will be such that the purge exchangers (Pacolate-Purge Exchanger and Purge Heater) will be adequate.

Detal Process Unit

The Detal Process is a catalytic process to alkylate benzene with linear olefins to prepare linear alkylbenzene (LAB).

All equipment was evaluated for both the High Molecular Weight (estimated LAB MW = 240.8) and the Low Molecular Weight (estimated LAB MW = 237.2) feed cases.

For the revamp study, 20% increase in Detal catalyst volume based on 12% paraffin to olefin conversion in the Pacol Unit. Also, the Benzene to Olefins ratio remain unchanged at 30:1, reduced splits in the Recycle Paraffin Stripper, and the proposed re-use of the Detal's regenerant benzene effluent as desorbent to the PEP unit (for assessing the Benzene Column). It requires modifications to Detal Reactor that include either increasing the effective tangent length or replacing existing reactors with two new reactors.

Implementing new benzene flow scheme utilizing spent regenerant benzene as desorbent in the PEP unit to reduce the benzene circulation load.

Retaining all of the columns in the Detal Unit as-is, with the exceptions of the Benzene Column trays and the contact condensing packing of the Recycle Paraffin Stripper and Paraffin Column.

In order to supply the additional cooling duty required for revamp operation, the addition of three new water trim coolers is required. These services are the Paraffin Column, LAB Column, and Finishing Column overheads.

All the exchangers appear to be adequate for the Detal Process Unit with the exceptions of the Reactor Charge Heater, Benzene Column Reboiler, Paraffin Column Reboiler, LAB Clay Treater Effluent Exchanger, Finishing Column Reboiler, Finish Column Preheater, Net LAB Trim Cooler, Benzene Column Condenser, Paraffin Column Overhead Cooler, and Finishing Column Overhead Cooler, which may require replacement or modification.

Most of the pumps appear to require either replacement or modification for the Detal Process Unit with the exception of the Desorbent Pumps, Benzene Column Bottoms Pumps, Recycle Paraffin Stripper Bottoms Pumps, Paraffin Column Bottoms Pumps, LAB Column Bottoms Pumps, and Off-Spec Pump which appear to be adequate for the revamp operation.

Hot Oil Unit

The Hot Oil System is a heat source for a number of exchangers within the LAB Complex. The transfer of heat is accomplished by pumping hot oil (Therminol 66) through a recirculation network between the various complex units. After the exchange of heat, the cooled oil is returned to the Hot Oil Surge Drum. The accumulative heat loss from the hot oil users is replenished with a fired heater that increases the hot oil temperature back up to the original supply temperature.

No apparent revisions are required to the hot oil system.

UTILITY SUMMARY: AS-BUILT

Sr. No.	Utility	Unit	Prefract-ionation	Unionfin-ing	Molex	Pacol	PEP	Detal	Hot Oil	Common	Total
1	HPS	tph	0.0	0.0	0.0	0.0	0.0	0.0	-25.6	0.0	-25.6
2	MPS	tph	0.0	0.0	0.0	-1.5	0.0	0.0	-4.0	0.0	-5.5
3	LPS	tph	0.0	0.0	0.0	1.5	0.0	0.0	25.6	3.3	30.4
4	BFW	tph	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.3	-3.3
5	Cold Cond.	tph	-1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.5

6	Loss	tph	1.5	0.0	0.0	0.0	0.0	0.0	4.0	0.0	5.5
7	CW	m^3/hr	-98.8	-148.8	-82.0	-56.3	-62.8	-259.2	-51.9	0.0	-759.7
8	Service Water	m^3/hr								-10.0	-10.0
9	Drinking Water	m^3/hr								-15.0	-15.0
10	Instrument Air	Nm^3/hr								-320.0	-320.0
11	Plant. Air	Nm^3/hr								-20.0	-20.0
12	Nitrogen	Nm^3/hr	-57.8	-8.7	0.0	-17.3	0.0	-1136.0	-12.0	0.0	-1231.8
13	Fuel Gas (Note 1)	kg/hr	0.0	-171.0	0.0	-1010.0	0.0	0.0	-7484.0	-363.0	-9028.0
14	Fuel Oil (Note 2)	kg/hr	0.0	0.0	0.0	0.0	0.0	0.0	-8455.0	0.0	-8455.0
15	Power (Absorbed)	kW	-370.8	-1624.3	-658.1	-3363.3	-220.6	-1245.7	-805.7	0.0	-8288.5

Notes

1. Flow rate is based on Fuel Gas only.
2. Flow rate is based on Fuel Oil only.

UTILITY SUMMARY: POST REVAMP

The estimated utility requirements after revamp are tabulated below:

Sr. No.	Utility	Unit	Prefract-ionation	Unionfin-ing	Molex	Pacol	PEP	Detal	Hot Oil	Common	Total
1	HPS	tph							-26.4		-26.4
2	MPS	tph				-1.5			-2.2		-3.7
3	LPS	tph				1.5			26.4	3.3	31.2
4	BFW	tph								-3.3	-3.3
5	Cold Cond.	tph	-1.5								-1.5
6	Loss	tph	1.5						2.2		3.7
7	CW	m^3/hr	-188.7	-131.6	-143.6	-281.1	-54.8	-383.5	-9.7		-1192.8
8	Service Water	m^3/hr								-10.0	-10.0
9	Drinking Water	m^3/hr								-15.0	-15.0
10	Instrument Air	Nm^3/hr								-320.0	-320.0
11	Plant. Air	Nm^3/hr								-20.0	-20.0
12	Nitrogen	Nm^3/hr	-59.8	-8.7		-17.3		-1136	-12.0		-1233.8
13	Fuel Gas (Note 1)	kg/hr		-143		-2125			-10832	-363	-13463
14	Fuel Oil (Note 2)	kg/hr							-12780		-12780

15	Power (Absorbed)	kW	-450.1	-1843.3	-1064.0	-3933.8	-235.8	-1398.5	-804.7	0.0	-9730

Notes

1: Flow rate is based on Fuel Gas only.

2: Flow rate is based on Fuel Oil only.

The incremental annual utility consumption post revamp will be.

- Power = 1441.5 KW
- Cooling water = 433.1 m3/hr =3464800 m3/year
- Fuel = 4.4 tph =35200 MT/year
- DM water = 1 m3/hr = 8000 MT/year

Prefractionation	**Adequate (Yes/No)**	**Comments**
Stripper Column	Yes	Vessel adequate. Trays marginally adequate. More detailed evaluation of trays in next phase.
Rerun Column	Yes	Vessel adequate. Trays marginally adequate. Contact condenser packing should be replaced. More detailed evaluation of trays in next phase. Replace contact condenser packing.
Unionfining	**Adequate (Yes/No)**	**Comments**
Charge Heater	Yes	No change foreseen.
Reactor	Yes	Vessel adequate, but new Internals required.
Stripper	Yes	Shell and trays are adequate. Review bottom trays with vendor in next phase
Combined Feed Exchanger	No	Add another shell in series
Recycle Gas Compressor	Yes	Add pilot operated pressure relief valve because of lower pressure margin.
Make-up Gas Compressor	No	Maximize first two stages, then make up with PSA H2.Increase operating pressure of 3rd and 4th stages.Modification to control scheme recommended. Add pilot operated relief valves because of lower margin
Molex	**Adequate (Yes/No)**	**Comments**
Adsorbent Chambers	Yes	Adequate.
Adsorbent Chamber Control System		No change
Rotary Valve	Yes	Adequate.
Raffinate Column	Yes	Vessel adequate, but trays must be replaced with high capacity trays.
Desorbent Stripper	No	Vessel inadequate
Extract Column	Yes	Vessel adequate. Replace existing trays with high capacity trays

Pacol & Define	Adequate (Yes/No)	Comments
Charge Heater	Yes	Replace existing burners
Pacol Reactor	Yes	Keep reactor shell. Modify internals to increase catalyst volume. New catalyst batch size will be 7.68 MT (9.1 m3) against the current batch size of 5.25 MT.
DeFine Reactor	Yes	No change
Product Stripper	Yes	Vessel adequate. Replace bottoms section trays.
Combined Feed Exchanger	Yes	Pressure drop across spray bar is high. Replace the spray bar distributor.
Recycle Gas Compressor	Yes	Keep compressor. Replace gear box to meet minimum H2/HC ratio of 4.0 in PACOL reactor.
PEP	**Adequate (Yes/No)**	**Comments**
Adsorbers	Yes	No changes
Desorbent Column	Yes	No changes
Depentanizer	Yes	No changes
Detal	**Adequate (Yes/No)**	**Comments**
Reactors	No	Add 2500 spool piece to top bed of each reactor. LHSV inadequate to meet target linearity and catalyst life expectations.
Benzene Column	Yes	Implement new benzene flow scheme. Keep shell. Replace trays with high capacity trays in required sections.
Recycle Paraffin Column	Yes	Keep shell and trays. Replace packing in contact condenser section.
Paraffin Column	Yes	Keep shell and trays. Packing should be reviewed
LAB Column	Yes	Contact condenser requires new packing
Finishing Column	Yes	No change
Hot Oil section	**Adequate (Yes/No)**	**Comments**
All equipments	Yes	No change

Project Description

As a part of integrating its Petrochemicals value chain, IOCL intends to install an integrated complex comprising of Acrylic Acid (AA), Synthesis Gas, Oxo Alcohol (Normal Butanol) and Butyl Acrylate (BA) Units based on propylene potential from its various refineries, such as Gujarat and Mathura.

The basic objective of the Acrylics Oxo project is the installation of new Butyl Acrylate production facility consisting of installation of (i) Oxo Alcohol unit (90kTA of Normal Butanol), (ii) Modification of existing HGU-II unit at Gujarat Refinery to produce 8500 Nm3/hr of Syn. Gas and 4300 Nm3/hr of Hydrogen inside Gujarat refinery premises along with installation of (iii) Acrylic acid unit (90 kTA) & (IV) Butyl Acrylate unit (150 kTA) at Dumad near Gujarat Refinery.

Propylene is raw material to Normal Butanol unit at Gujarat refinery & Acrylic acid unit at Dumad. Out of total 120 kTA propylene requirement for the project, 75 kTA Propylene will be available from PRU unit proposed at Gujarat refinery under the J-18 capacity expansion project. Balance quantity will be met by propylene tankers from IOCL Mathura refinery for which unloading & storage system is envisaged at Dumad.

Normal Butanol will be produced from Propylene, Syn Gas & Hydrogen and Acrylic Acid will be produced from Propylene. Normal Butanol and Acrylic Acid will be utilized for production of Butyl Acrylate.

Units at Gujarat Refinery:

(i) Synthesis Gas Unit: Modification of existing HGU-II unit at Gujarat Refinery has been envisaged to produce Syn Gas (capacity=8500 Nm^3/h) and Hydrogen (capacity=4300 Nm^3/h), the key raw materials for production of Oxo Alcohol. The unit is designed to process both Naphtha / Natural gas feedstock depending on availability.

(ii) Normal Butanol Unit: A new Oxo Alcohol Unit with capacity to produce 90 KTA Normal-Butanol (NBA), a major feedstock for Butyl Acrylate production, has been considered. Oxo unit utilizes propylene and Syn gas as feedstock. Iso-butanol (~2.57 KTA) is a byproduct from the Unit and is intended for merchant sale.

Units at Dumad:

(i)Acrylic Acid Unit: Propylene from Mathura and Gujarat refinery along with air is the major feedstocks for the Acrylic Acid unit (90 KTA capacity). Acrylic acid is produced by oxidation of propylene in presence of oxidation catalyst.

(ii)Butyl Acrylate unit: NBA and Acrylic Acid undergo esterification in BA Unit (150 KTA capacity) to produce Butyl Acrylate, the main product from the project.

Following project configuration has been considered for the project: