HETERO

HETERO INFRASTRUCTURE SEZ LTD.
[illegible]
N. Narasapuram [illegible]
Nakkapalli [illegible]
[illegible]
Tel: [illegible] Fax: [illegible]

24th May 2024

Letter NO: HIS/EHS/MoEF&CC/2024-25/04

Joint Director (S)
Integrated Regional Office (IRO),
Ministry of Environment, Forest & Climate Change.
Green House complex, Gopala Reddy Road,
Vijayawada - 520010,
Andhra Pradesh.

Dear Sir,

Sub : Submission of six-monthly compliance report of Environmental Clearance issued to M/s Hetero Infrastructure SEZ Ltd, Nakkapalli, Visakhapatnam – Regarding

Ref : Environmental Clearance No: 21-641/2007-IA. III (I) Dated 25/10/2010

With reference to the above, please find enclosed six-monthly compliance report of Environmental Clearance of M/s Hetero Infrastructure SEZ Ltd, for the period 1st October 2023 to 31st March 2024 with all necessary enclosures for your kind information and perusal.

You are requested to kindly acknowledge the receipt.

Thanking you,

Yours faithfully,
For Hetero Infrastructure SEZ Ltd

S. Kullayi Reddy
Associate Vice President -EHS

Enclosures : As above

COMPLIANCE REPORT TO CONDITIONS OF ENVIRONMENTAL & CRZ CLEARANCE F.NO: 21-641/2007-IA, III DATED. 25TH OCTOBER 2010

PERIOD OF COMPLIANCE: 1ST OCTOBER 2023 TO 31ST MARCH 2023

<table>
<tr><th>S.No.</th><th>Condition</th><th>Compliance</th></tr>
<tr><td colspan="3">Part-A, Specific Conditions</td></tr>
<tr><td colspan="3">Construction Phase</td></tr>
<tr><td>(i)</td><td>Consent for Establishment” shall be obtained from Andhra Pradesh Pollution Control Board under Air and Water Act and a shall be submitted to the Ministry before start of any construction work at the site.</td><td>Complied.

The industry has obtained Consent for Establishment from AP Pollution Control Board vide Order No: 219/PCB/CFE/RO-VSP/HO/2010-2355, date:13/12/2010 and is being updated/Amended from time to time.

The details of the CFE’s are as below:
<table><tr><th>CTE Order No</th><th>Date of issue</th></tr><tr><td>219 /APPCB/CFE/RO-VSP/HO/ 2010</td><td>13/12/2010</td></tr><tr><td>CFE Amendment Order</td><td>14/09/2018</td></tr><tr><td>CFE Amendment Order</td><td>13/11/2018</td></tr><tr><td>CFE (Expansion) Order</td><td>15/07/2020</td></tr></table></td></tr>
<tr><td>(ii)</td><td>Sufficient dilution shall be ensured to meet the ambient parameters within 50 m distance from outfall.</td><td>Complied.

Out fall pipeline has been laid as per NIO recommendations for having sufficient dilution at the point of outfall.</td></tr>
<tr><td>(iii)</td><td>Regular Independent monitoring of marine water quality including temperature and salinity at the outfall shall be undertaken through an authorized agency and submitted along with six monthly monitoring report to the ministry.</td><td>Complying.

The industry is taking expertise of NIO for conducting the studies and conducting the studies on yearly basis. The report is being submitted to APPCB (RO & ZO) and IRO, MoEF&CC, Vijayawada. Copy of the latest report submitted by NIO in Feb 2023 has been submitted to MoEF&CC along with previous compliance report and Issued Work Order on National Institute of Oceanography for study during 2023-24 and expecting the report in 6 months’ time. Copy of work order issued to NIO is enclosed as Annexure-I</td></tr>
<tr><td>(iv)</td><td>Filters in the way of extruders shall be provided at the intake point to prevent fishes entering in the system.</td><td>Complied by the industry.

Strainers are provided at the intake point to prevent fish entry into the system. Photographs of the strainers installed at</td></tr>
</table>

		the sea water intake point are enclosed as ***Annexure-II***.
(v)	The recommendations of EIA and DMP shall be strictly complied with.	**Complied.** The industry is complying with all recommendation of EIA & DMP. The detailed report on the EIA recommendations is enclosed as ***Annexure-III***.
(vi)	Lighted buoys shall be provided at intake and out fall location as indicators.	**Complied.** Marker Buoys which were installed at the intake & Outfall points as indicators have been damaged due to various reasons like fishing activities, Boats Movement and intentional damage by the fisherman. Now the industry has installed new marker buoys during annual maintenance in March 2023 and in January 2024. Photographs of the marker buoys installations is enclosed as ***Annexure-IV***.
(vii)	The pipeline shall be buried at least 2 m depth in onshore area and 4 mts in the offshore area. Necessary permission with regard to the pipeline burial and laying shall be obtained from maritime Board to ensure that the pipeline route does not fall in the navigation channel. Accordingly, the details of the laying of the pipeline shall be provided.	**Complied by the industry.** Pipeline has been laid as per the recommendations made by NIO. The industry is paying annual charges for pipelines to Maritime Board regularly. The payment made to maritime Board is enclosed as ***Annexure-V***. The pipeline route is not falling in the navigation channel and the routing of the pipeline is enclosed as ***Annexure-VI***.
(viii)	The pipeline shall not pass through any sand dunes/mangroves. The project shall be implemented in such a manner that there is not damage whatsoever to the mangroves/other sensitive coastal ecosystem. If any damage to mangroves is anticipated/envisaged as a result of project activates then the clearance shall stand cancelled, and the proponents shall seek fresh approval from the Ministry.	**Not applicable.** There are no mangroves and sand dunes in the area where pipeline has been laid. The industry is taking all precautions to avoid damage to the marine environment.
(ix)	The reject shall meet the standards prescribed by Andhra Pradesh Pollution Control Board before disposal.	**Please Refer below.** There are no specific CPCB/APPCB standards for Desalination rejects. Copy of

		latest analysis report of Rejects is enclosed as ***Annexure -VII***.
(x)	A continuous and comprehensive post project marine quality monitoring programmed shall be taken up. This shall include monitoring of water quality sediments quality and biological characteristics and report submitted every 6 months to Ministry's Regional Office at Bangalore.	**Being followed.** The industry is conducting post project marine monitoring through NIO regularly for water quality, sediments quality and biological characteristics. Copy of the latest report (Feb 2023) is enclosed as ***Annexure-VIII*** and the same has been submitted to IRO, Vijayawada. Work is going on for the year 2024 & industry is waiting for the report.
(xi)	It shall be ensured that there is no displacement of people, houses or fishing activity as a result of the project.	**Complied by the industry.** The Land of the project used to be a vacant land & used for aquaculture in the past. There is no displacement of people, houses or fishing activity as a result of the project. The details of the fish catch data given by the Joint Director-Fisheries, Govt. of AP in Visakhapatnam has been submitted to IRO, MoEF&CC along with earlier Compliance report.
(xii)	There shall be display boards at critical locations along the pipeline viz. road / rail/ river crossing giving emergency instructions. This will ensure prompt information regarding locations of accident during any Emergency. Emergency information Board shall contain emergency instruction in addition to contact details. Proper lighting shall be provided all along the road.	**Complied by the industry.** The pipeline is completely laid in M/s Hetero Infrastructure SEZ Ltd area and only one crossing is there (Creek & Village Road) along the pipeline. Display Boards have been installed at the crossing and the photographs of the Display Board is enclosed as ***Annexure-IX***. Industry has taken all necessary precautions at the crossing. 24x7 security surveillance is in place all along the pipeline and Emergency contact details are available in the ECC & also at Security. Lighting has been provided all along the roads.
(xiii)	There shall be no withdrawal of ground water in CRZ area for this project.	**Complied by the industry.** The total water requirement of the facility is being met through Sea water Desalination plants and not drawing ground water for any purposes of the industry.

(xiv)	No other activities except the permissible actions under CRZ Notification 1991 shall be carried out with CRZ areas.	**Please refer below:** The industry has installed Desalination plant in the existing buildings of Ex. Vijaya Marines in CRZ area due to lack of awareness & clarity on CRZ notifications as the plant was installed before CRZ Notification 2011. The industry in in the process of getting the Desalination plant regularized in CRZ area as this is the permissible activity as per CRZ Notification 2011 & 2019 and accordingly applied to APCZMA for regularization of Desalination plant in CRZ area as per Office Memorandum of MoEF&CC vide F. No:19-27/2015.IA.III dated 19th February 2021 and obtained recommendations of APCZMA for Regularization of Desalination plant in CRZ area. Copy of Recommendations obtained from APCZMA are enclosed as **Annexure-X.** The industry applied to MoEF & CC for the same on 16/11/2023 vide single window No: SW/151124/2023 and the same has been returned by the Ministry & advised the industry to apply for amendment in existing EC&CRZ clearance of Hetero Infrastructure SEZ Ltd. The industry is in the process of applying for amendment in existing EC & CRZ Clearance.
(xv)	Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contamination.	**Complied.** The industry is conducting the analysis of soil & ground water periodically to check the contamination (if any). Copy of analysis report is enclosed as ***Annexure – XI***.
(xvi)	Construction spoils, including bituminous material and other hazardous materials must not be allowed to contaminate water courses and the dump sites for such material must be secured so that they should not leach into the ground water.	**Complied.** The industry is not using any bitumen for construction of roads as all the roads are made of concrete only. There are no dump sites for waste material around the factory premises.
(xvii)	Any hazardous waste generated during construction phase should be disposed off as per applicable rules	**Complying.**

	and norms with necessary approval of the Andhra Pradesh state Pollution Control Board.	The industry has disposed waste generated during construction phase as per applicable rules and norms of APPCB. At present there are no major construction activities at site.
(xviii)	The diesel generator sets to be used during construction phase should be low Sulphur diesel type and should conform to Environment (Protection) Rules prescribed for air and noise emission standards.	**Complied.** The industry is using only low Sulphur diesel for operation of DG sets and all DG sets are provided with acoustic enclosures to control noise.
(xix)	The diesel required for operation DG sets shall be stored in underground tanks and required clearance from Chief Control of Explosives shall be taken.	**Please Refer below:** As such there is no diesel storage in the premises of Hetero Infrastructure SEZ Ltd and the units which are located in SEZ area are storing the diesel in above ground storage tanks as approved by the Chief Controller of Explosives Copies of Explosive Licenses of SEZ units are enclosed as ***Annexure-XII*** for your information and perusal.
(xx)	Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emission standards and should be operated only during non-peak hours	**Complied by the industry.** All vehicles hired by the company are in good condition and having pollution check certificates. The vehicle movement in the premises is restricted to daytime only. *At present are no major construction activities at site.*
(xxi)	Ambient noise levels should conform to residential standards both during day and night. Incremental pollution loads on the ambient air and noise quality should be closely monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level during construction phase, so as to conform to the stipulated standards by CPCB/SPCB	**Complied.** *At present there are no major construction activities at site* The industry is monitoring the noise levels in house and through third party (Approved by MoEF&CC) regularly and the records are being maintained. As per records noise levels found to be within the standards prescribed by the CPCB/SPCB. Copy of the latest report is enclosed as ***Annexure-XIII*** for your information.
(xxii)	Fly ash should be used as building material in the construction as per the provision of Fly ash Notification of	**Complied.**

	september,1999 and amended as on 27th August,2003	The industry utilized & using fly ash Bricks for the construction purposes. At present there are no major construction activities at site. Fly ash generated from Boilers is being disposed to Brick Manufacturing units as per the guidelines.
(xxiii)	Ready mixed concrete must be used in building construction	**Complied.** Ready mix concrete was used for the construction of buildings during construction phase. At present there are no major construction activities at site.
(xxiv)	Storm water control and its re-use as per CGWB and BIS standards for various applications.	**Please refer below:** The industry has approached CGWB, Irrigation Department, Got. Of AP and APWALTA (Department of Rural Development) etc. for technical suggestions & permissions (if any) for storm water control & its reuse. But no department is giving clarity on the same and finally APWALTA informed us to approach irrigation department for necessary approvals. Irrigation Department, Govt. of Andhra Pradesh has issued permission to store the rainwater in the pond within the premises of the industry. Copy of the letter issued by Irrigation department, Govt. of AP is enclosed as ***Annexure- XIV***.
xxv	Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred	**Complied.** The industry used Ready mix concrete for the construction and used curing chemicals for curing purpose. At present there are no major construction activities at site.
xxvi	Permission to draw ground water shall be obtained from the competent Authority prior to construction/operation of the project.	**NOT APPLICABLE** The industry is not drawing ground water for any purpose of the industry as the total water requirement of the plant is being met through Sea water desalination plant.
xxvii	Regular supervision of the above and other measure for monitoring should be in place all through the	**Complied.**

	construction phase, so as to avoid disturbance to the surroundings.	There are no villages adjacent to the project site (within 1 Km Radius). However, regular supervision is being done by the Environment Department head to avoid disturbance to the surroundings.
xxviii	Under the provisions of Environment (protection) Act,1986, legal action shall be initiated against the project proponent if it was found that construction of the project has started without obtaining environmental clearance	**Agreed and accepted.** The industry has started construction activities after getting Environmental Clearance only.
II. Operation Phase		
I	The installation of the Effluent Treatment Plant (ETP) should be certified by an independent expert and a report in this regard should be submitted to the Ministry before the project is commissioned for operation. Treated effluent emanating from ETP shall be Recycled/ Reused to the maximum extent possible.	**Complied.** The industry has constructed full-fledged ETP for the treatment of Effluents at a cost of Rs.80.00 Cores. The ETP design was certified by the third party at the time of installation. ETP performance evaluation has been done through the third party (approved Laboratory by MoEF&CC) and the copy of ETP performance evaluation report has been submitted to the IRO, Vijayawada along with previous compliance reports. Now the industry is in the process of installing new 1 MLD ETP in addition to the existing ETP after obtaining CTE from APPCB. The designs of the plant have been verified by the Third party and submitted feasibility report. Copy of the feasibility report is enclosed as ***Annexure-XV***.
ii	The solid waste generated should be properly collected and segregated. Wet garbage should be composed and dry/inert solid waste should be disposed off to the approved sites for land filling after recovering recyclable material	**Complied.** Dedicated places have been provided for storing solid waste. Installed Organic Waste Converter & Vermi-compost plant for disposing wet garbage and canteen waste. Photograph of the Vermi Compost plant and its design capacity is enclosed as ***Annexure-XVI***. Inorganic salts are being disposed to TSDF Visakhapatnam whereas the organic

		wastes are being disposed to cement plants for co-incineration (Alternate Fuel) as per the conditions stipulated by the APPCB in CTO. Types of hazardous waste and its mode of disposal is enclosed as ***Annexure-XVII.***
Iii	Diesel power generating sets proposed as sources of backup power for elevators and common area illumination during operation phase should be of enclosed type and conform to rules made under the environment (protection) Act,1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use low sulphur diesel. The location of the DG sets may be decided with in consultation with Andhra Pradesh State Pollution Control Board.	**Complied by the industry.** The Diesel generators are provided with acoustic enclosures and adequate stack height as per the norms prescribed by the Board. Copies of DG set photographs are enclosed as ***Annexure-XVIII***. Using only low Sulphur diesel for operation of the DG sets.
Iv	Noise should be controlled to ensure that it does not exceed the prescribed standards. During nighttime the noise levels measured at the boundary of the periphery of the plot shall be restricted to the permissible levels to comply with the prevalent regulations.	**Complied.** The industry is regularly monitoring the noise levels in & around the factory premises and found values are well within the norms. The industry is taking all possible measures to control the noise pollution. Latest reports of Noise levels are enclosed as ***Annexure-XIII***.
V	The green belt of adequate width and density preferably with local species along the periphery of the plot shall be raised so as to provide protection against particulates and noise.	**Complied.** The industry has planted more than 500000 saplings in and around the premises. Photographs of the Green belt is enclosed as ***Annexure-XIX***.
vi	Weep holes in the compound walls shall be provided to ensure natural drainage of rain water in the catchment area during the monsoon period	**Complied by the industry.** Weep holes are provided in the compound walls to ensure natural drainage of rainwater in the catchment area during the monsoon period. In addition to that Well-designed drainage system is in place for the entire premises.
vii	Rainwater harvesting for roof run-off, as plan submitted should be	**Please refer below:**

	implemented. Before recharging the surface run off. pre-treatment must done to remove suspended matter,	The rainwater of the entire premises is being collected in a pond within the industry for naturally recharging the ground water and the same is being reused for utilities (if requirement arises).
viii	The ground water level and its quality should be monitored regularly in consultation with Central ground water authority	**Complied by the industry.** Industry has provided 04 piezo wells within the factory premises for monitoring the Ground water Levels and quality. These wells are being monitored on quarterly basis through third party (MoEF&CC approved Laboratory). Copy of ground water report is enclosed as ***Annexure -XX.***
ix	Traffic congestion near the entry and exit points from the roads adjoining the proposed project site must be avoided. Parking should be fully internalized and no public space should be utilized	**Complied.** There is no traffic congestion near entry & exist points as the industry has constructed its own Road from the National Highway and is using the same Road for transportation purposes. Also provided adequate parking area to park vehicles and no public spaces are being utilized.
x	A report on the energy conservation measures confirming to energy conservation norms finalized by Bureau of Energy should be prepared incorporating details about building materials & technology & Factors etc and submit to the Ministry in three months' time.	**Complied.** The study has been done on energy conservation measures and report is in place. The industry has appointed one expert energy auditor on permanent roles of the Company for Energy management & auditing. Regular reports are being generated on Energy conservation and will be produced to inspecting officers of the MoEF&CC and APPCB. Industry has carried Energy Audit through National Productivity Council, Hyderabad in the year 2017 and the same report is enclosed as ***Annexure-XXI***.
xi	Energy conservation measure like installation of CFLs/TFLs for the lighting the areas outside the building should be integral part of the project design and should in place before project commissioning. Use CFL and TFLs should be properly collected and	**Complied.** CFLs/TFLs for the lighting area was an integral part of the project and the industry has replaced all CFL/TFL s with LED lights for lighting purpose in and around the premises.

	disposed off/sent for recycling as per the prevailing guidelines/rules of the regulatory authority to avoided mercury contamination. Use of solar panels may be done to the extent possible.	Electrical and electronic waste is being disposed to Recyclers Authorized by APPCB. Copy of recent disposal of Electrical & electronic waste is enclosed as ***Annexure-XXII.***
PART-B, GENERAL CONDITIONS		
i	The environmental safeguards contained in the EIA report should be implemented in letter and spirit.	**Complied.** The industry has implemented the environmental safeguards contained in the EIA report. Copy of compliance report is enclosed as ***Annexure -III.***
ii	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (hard copies as well as by e -mail) to the respective Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.	**Complied.** The industry is regularly submitting the condition wise EC compliance reports to Regional Office to MoEF & CC. The same report is being submitted to APPCB.
iii	Officials from the Regional Office of MoEF, Bangalore who would be monitoring the implementation of environment safeguards should be given full cooperation, facilities and documents /data by the project proponents during their inspection. A complete set of all the documents submitted to MoEF should be forwarded to the CCF, Regional Office of MoEF, Bangalore.	**Noted and is being followed.**
iv	In the case of any change(s) in the scope of the project, the project would require a fresh appraisal by this Ministry	**Agreed to comply.** There are no changes in the project. The industry will approach the Ministry in case of any changes in the scope of the project.
v	The ministry reserves the right to added additional safeguard measures subsequently if found necessary, and to take action including revoking of the environment clearance under provisions of the environmental (protection) Act,1986, ensure effective implementation of the suggested safeguard measures in a time bound and satisfactory manner.	**Noted and agreed to comply.**

vi	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of explosive, Fire Department, Civil Aviation department, forest Conservation Act 1980 and Wildlife (Protection) Act 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	**Complied.** The industry obtained the approval for storage of Diesel in the individual units of SEZ vide Letter Nos as mentioned below: **Hetero Labs Ltd, Unit-IX**: P/HQ/AP/15/3853 (P250194) dated 02/22/2015 valid up to 31/12/2024 **Hetero Drugs Ltd, Unit-IX**: P/HQ/AP/15/3852 (P250196) dated 23/12/2014 valid up to 31/12/2024. **Honour Lab Ltd, Unit-III:** P/HQ/AP/15/4097 (P321361) dated 24/10/2016 valid up to 31/12/2025. The industry has obtained Fire NOC from AP State Disaster Response and Fire Services Department in the name of M/s Hetero Infrastructure SEZ Ltd vide **RC.NO: 15566/VSP/RFO/2020 MSB-ER. SDP Dated:22-07-2022.** Copies of PESO Licenses of SEZ units and Fire NOC of Hetero Infrastructure have already submitted to IRO, Vijayawada.
vii	These stipulation would be enforced among others under the provisions of Water (prevention and Control of pollution) Act 1974, the Air(Prevention and control)act1981 the Environment (protection) Act 1986 ,the public Liability insurance)Act 1981 and EIA Notification,2006	**Noted and will be followed.** The industry is having public liability insurance policy, and the details are as under: **Policy No: 96000036233300000024** **Validity: 10/11/2024.** Copy of PLI policy is enclosed as ***Annexure-XXIII***.
viii	The project proponent should advertise in at least two local Newspapers widely circulated in the region one of which shall be in the vernacular language informing that the project has been accorded Environmental Clearance and copies of clearance letters are available with the Kerala Pollution Control Board and may also be seen on the website of the Ministry of Environment and Forest at http;// www.envfor.nic.in The advertisement should be within 10 days from the date of receipt of the Clearance letter and a copy of the	**Noted and complied.** The industry has advertised about Environmental clearance in in two local newspapers and the copies already submitted to the Regional Office. As informed earlier, we couldn't find/ misplaced the advertisement published in English paper due to shifting of the office several times since 2010. Copy of the Paper advertisement has already submitted to IRO, Vijayawada along with earlier compliances.

	same should be forwarded to the Regional office of this Ministry at Bangalore.	
ix	Environmental clearance is subject to final order of the Hon'ble supreme court of India in the matter of Goa Foundation V/s Union of India in Writ petition (Civil) No.460 of 2004 as may be applicable to this project.	**Noted and agreed.**
x	Any appeal against this Environmental Clearance shall lie with the National Environment Appellate Authority, if preferred, with a period of 30 days as prescribed under section 11 of the National Environment Appellate Act,19987	**Noted and accepted**
xi	A copy of the clearance letter shall be sent by the proponent to concerned panchayat, Zilla parishad/Municipal Corporation, Urban Local Body and the Local NGO, if any from whom suggestions/representation, if any were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent	**Complied.** The industry has submitted Copy of Environmental Clearance letter to the concerned Village Panchayat.
xii	The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall update the same periodically .It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely; SPM, RSPM, SO2, NOx (ambient levels as well as stack emissions) or critical sect oral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.	**Complied.** EC Letter & Its compliance status is available in the Company website www.hetero.com. Compliance of EC conditions are being sent to Regional Office, MoEF & CC regularly. Monitoring data is being submitted regularly to SPCB on monthly basis. The industry has Installed 03 No CAAQM stations in the premises and the data is being displayed at the Main Gate through Digital/LED display.
xiii	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment(protection) Rules,1986,	**Complying.** The industry is regularly submitting Environmental statement to APPCB before 30th September of every year and is

	as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEF by e-mail	uploaded in Company website www.hetero.com. Copy of latest Environmental statement is enclosed as ***Annexure-XXIV***.

For Hetero Infrastructure SEZ Ltd

Place: Nakkapalli
Date: 24/05/2024

S. Kullayi Reddy
Associate Vice President -EHS

HETERO ANNEXURE-I

SERVICE PURCHASE ORDER

Vendor Name & Address 900386 NATIONAL INSTITUTE OF OCEANOGRAPHY REGIONAL CENTRE,176,LAWSONS BAY C VISAKHAPATNAM,530017 **GSTIN Number:**	PO NO. : 4900228061 PO Date : 12.10.2023 Amendment Date : Quotation No & Date :
	Payment Terms : 50% ADV , 50% AFTER COMPLETION OF Insurance : Delivery Terms : DAPAT THE SITE
With reference to your above quotation, we request you to supply the following materials / services subject to terms and conditions mentioned	**GSTIN NUMBER :** 37AABCH6897E3Z6 **CIN No. :** U24239TG2005PTC047265

S.No.	Service Code Service Description	Qty (UOM)	Unit Rate (INR)	Total Value (INR)
1	POST PROJECT MARINE MONITORING STUDIES			
	3000033 GENERAL SERVICE FOR R/M JOB WORKS	1.000 AU	1,950,000.00	1,950,000.00
	Post project monitoring of likely affected physico_chemical, biological, microbiological and sedimentological parameters at and around the MOP in the coastal waters off Nallamattipalem, near Nakkapalli during the post SW monsoon of 2023			
	SAC CODE :998711			
	Subtotal ------------->			1,950,000.00
	Delivery Date:31.12.2023			
	GrandTotal ----------->			1,950,000.00

Other Terms & Conditions

Special Instructions:

1.COA, MOA,MSDS,Validation Documents & Duplicate for Transporter Invoice must be accompany with the Consignment

	Delivery Address: HETERO INRFASTRUCTURE SEZ LIMITED SY.No.150,286,312 N. NARASAPURAM NAKKAPALLY (M) RAJAYAPETA (VILL) VISAKHAPATNAM-531081	For HETERO INFRASTRUCTURE SEZ LTD This Document is Electronically Apporoved. Hence, Signature is not Necessary

TERMS AND CONDITIONS

ACCEPTANCE: IF NO FORMAL ACCEPTANCE IS RECEIVED WITHIN 7 DAYS FROM THE DATE OF THIS PURCHASE ORDER , THE SAME SHALL BE DEEMED TO HAVE BEEN ACCEPTED BY YOU.

QUALITY: THE MATERIAL SUPPLIED AGAINST THIS PURCHASE ORDER MUST IN ALL RESPECTS CONFIRM TO THE SPECIFICATIONS STATED THEREIN OR AS PER SAMPLES APPROVED BY US.EACH CONSIGNMENTS OF THE MATERIAL DESPATCHED BY YOU SHOULD BE ACCOMPANIED BY A CERTIFICATE OF ANALYSIS.THE MATERIALS SUPPLIED WILL BE EXAMINED AT OUR LABORATORY AND THE REPORT WILL BE FINALAND BINDING ON THE PARITES. THE MATERIAL NOT CONFIRMING TO THE SPECIFICATIONS / APPROVED SAMPLES WILL BE REJECTED. THE MATERIALS REJECTED SHOULD BE IMMEDIATELY REMOVED BY YOU OR BY YOUR NOMINEES FROM OUR WORKS. IN CASE THE REJECTED MATERIAL REMAINS LYING AT OUR WORKS FOR ANY REASONS THE SAME WILL BE ENTIRELY AT YOUR RISK AND RESPONSIBILITY.IF SO DESIRED BY YOU THE REJECTED MATERIAL WILL BE DESPATCHED BY US TO YOU ON 'FREIGHT TO PAY BASIS' AND THE TRANSIT INSURANCE FOR SUCH RETURNS HAS TO BE ARRANGED BY YOU.WE WILL ALSO RAISE DEBIT NOTE FOR INCOMING FREIGHT CHARGES, IF ANY PAID BY US.

WEIGHT: UNLESS OTHERWISE STIPULATED WEIGHT / VOLUME RECORDED AT OUR PREMISES SHALL BE DEEMED AS FINAL.

VALIDITY: THE MATERIAL MUST BE AIR FREIGHTED / SHIPPED AS PER INSTRUCTIONS STIPULATED IN THE PURCHASE ORDER. TIME IS ESSENCE OF THIS PURCHASE ORDER. IN CASE THERE IS DELAY IN DESPATCH OF THE MATERIAL BY YOU, YOU WILL BE RESPONSIBLE FOR ALL DAMAGES AND LOSSES AS MAY ARISE AS A CONSEQUENCE THEREOF.

LIQUIDATED DAMAGES: IN CASE OF DELAYED SUPPLIES LIQUIDATED DAMAGES @ 2% PER MONTH OR PART THERE OF FOR THE VALUE OF DELAYED SUPPLIES SHALL BE PAYABLE.

DELIVERY SCHEDULE: SUPPLIES SHOULD BE ACCOMPANIED BY DELIVERY CHALLAN , BEARING THE REFERENCE OF THE PURCHASE ORDER.

SUSPENSION: IN THE EVENT OF STRIKES , ACCIDENTS OR ANY OTHER DISABLING CIRCUMSTANCES BEYOND OUR CONTROL , DELIVERIES AGAINST THE ORDER SHALL BE LIABLE FOR SUSPENSION AT OUR REQUEST.

PRICE: SUPPLIES IS EFFECTED AT A PRICE HIGHER THAN THOSE GIVEN IN THE PURCHASE ORDER WITHOUT OUR CONFIRMATION IN WRITTEN BEING FIRST OBTAINED, WILL BE LIABLE FOR REJECTION. WHERE THE ORDER IS PLACEDON FOR-OUR-FACTORY OR FREE DELIVERY AT WORKS BASIS, BOTH FREIGHT AND INSURANCE CHARGES SHALL BE PRESUMED TO HAVE BEEN INCLUDED IN SUCH PRICE, AND THE LOSS, BREAKAGE OR ANY DAMAGE DURING TRANSIT DUE TO ANY CAUSE WHATSOVER SHALL BE BORNE BY THE SUPPLIER. WE WILL BE ENTITLED TO DEDUCT SUCH SUMS OF MONEY AS MAY BE REMAINING OUTSTANIDNG ON ANY ACCOUNT OUT OF THE SUMS AS MAY BE REMAINING OUTSTANDING ON ANY ACCOUNT OUT OF THE SUMS AS MAY BE PAYABLE BY US TO YOU.

PAYMENT: UNLESS OTHERWISE STIPULATED PAYMENT WILL BE MADE WITHIN 30 DAYS OR SUCH OTHER LONGER PERIOD AS MAY BE AGREED TO FROM THE DATE OF RECEIPT OF GOODS AND BILLS IN DUPLICATED COMPLETE IN ALL RESPECT, BEARING THE REFERENCE TO THE ORDER, YOUR CHALLAN REFERENCE AND ACCOMPANIED BY REQUISITE DOCUMENTS. HOWEVER, NO INTEREST WILL BE PAYABLE BY US ON OVERDUE ACCOUNT. DESPATCH MUST REACH US IN TIME TO TAKE DELIVERY OF THE GOODS FREE OF DAMAGE AND ANY SUCH CHARGES IF INCURRED SHALL BE TO YOUR ACCOUNT.

FREIGHT & INSURANCE: UNLESS AND OTHERWISE EXPLICITLY STATED FREIGHT &INSURANCE CHARGES SHALL BE BORNE BY YOU.

INSPECTION: ALL GOODS SUPPLIED AGAINST THE ORDER SHALL BE SUBJECT TO OUR INSPECTION AND APPROVAL AT ANY TIME WITHIN THIRTY DAYS OF THE DATE OF THE RECEIPT AND / OR USE WHICHEVER IS LATER , ANY REJECTION ,SHORTAGE, DAMAGE, BREAKAGE ETC SHALL BE TO YOUR ACCOUNT. ALL GOODS REJECTED FOR ANY REASON WHATSOEVER SHALL BE RETURNED OR REPLACED FREE OF COST AT OUR OPTION. IN THE EVENT OF REJECTION OR REPLACEMENTS THE INWARD / OUTWARD FREIGH AND OTHER INCIDENTAL CHARGES SHALL ALSO BE BORNE BY YOU. YOU KEEP US INDEMNIFIED AGAINST ANY ACTION, LOSS PENALITIES AND DAMAGES IF GOODS SUPPLIED AGAINST THE PURCHASE ORDER INFRINGES ANY DESIGN, PATENT OR TRADE MARK.

SPARES & ACCESSORIES: MACHINERY DESPATCHES / RECEIVED WITHOUT ALL THE REQUISITE SPARES AND ACCESSORIES SPECIFIED BY US ARE LIABLE FOR REJECTION AND RETURN AT YOUR RISK AND COST.

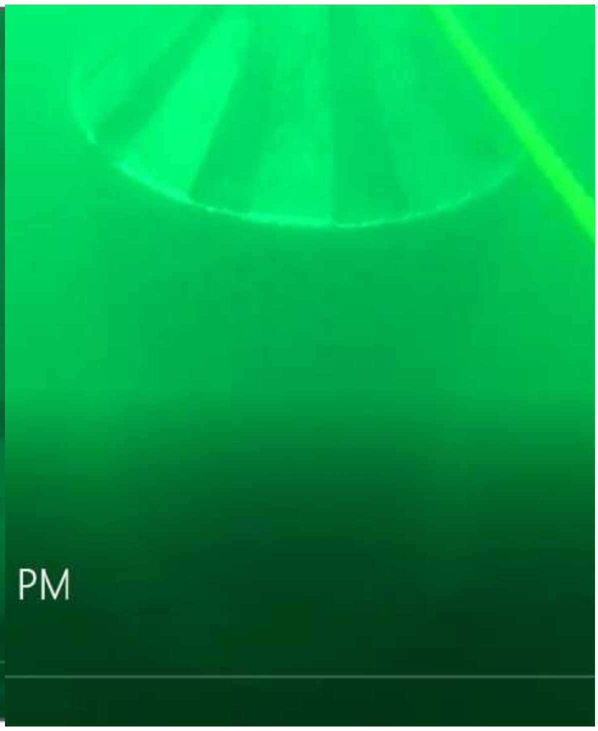
CONSIGNMENT: OUT-STATION SUPPLIER SHOULD MENTION LR-RR-PWB-AW-BILL-POST PARCEL NUMBER ETC . ON REFERENCE THEIR INVOICE.

FORECE MAJEURE: THE COMPANY WILL NOT BE IN ANY WAY LIABLE FOR NON - PERFORMANCE EITHER IN WHOLE OR IN PART OF ANY CONTRACT OR FOR ANY DELAY IN PERFORMANCE THEREOF AS A CONSEQUENCE OF STRIKE, SHORTAGE OF LABOUR OR COMBINATION OF WORKMEN OR LOCK-OUT BREAKDOWN OR ACCIDENT TO MACHINERY OR OTHER ACCIDENT TO MACHINERY OR OTHER ACCIDENT OF WHATEVER NATURE OR FAILURE ON THE PART OF THE RAILWAYS TO SUPLY SUFFICIENT WAGONS TO CARRY ESSENTIAL MATERIALS TO AND THE FINISHED PRODUCTS FROM THE WORKS AND ALL CAUSE OF WHATEVER NATURE BEYOND THE COMPANY'S CONTROL.

ARBITRATION: ANY DISPUTES ARISING OUT OF THIS CONTRACT SHALL BE WITHIN THE JURISDICTION OF COURT IN HYDERABAD.

ANNEXURE-II

STRAINERS INSTALLED AT INTAKE POINT



ANNEXURE-1

HETERO INFRASTRUCTURE SEZ LTD

COMPLIANCE REPORT ON THE RECOMMENDATIONS/ MITIGATION MEASURES MENTIONED IN THE EIA REPORT

ENVIRONMENTAL ISSUES/ IMPACTS (As per EIA)	ENHANCEMENT/ MITIGATION MEASURES (As per EIA)	MANAGEMENT ACTION/COMPLIANCE
Reduction of trees in the site: cutting of 25 trees	• Initiate and complete the process of compensatory trees plantation. Number of trees to be planted 25000.	This is to bring to your kind notice that, the total site was used for aquaculture farms in the past and hence there was no greenery/trees in the site while starting the project. However, the industry has planted more than 5.0 Lac plants in & around the industry site. The species used are as below: ➢ Ganuga ➢ Neem ➢ Acacia ➢ Pinto farm ➢ Kona Carpus ➢ Coconut and ➢ Medicinal plants The photographs of the green belt in and around the industry premises are enclosed as ***Annexure-I*** for your information.
Soil Erosion during construction and sediment load on the Storm water drains	• Earth works specifications to include provision for silt fence. • Construction during non-monsoon season	The industry has ensured that there is no soil erosion during the construction of industry and ensuring there is no sediment load on the storm water drains. The industry is cleaning/desilting the storm water drains regularly to avoid sediment deposition in the storm water drains. The natural drain which is passing adjacent to the industry premises is being cleaned regularly to avoid stagnations in the catchment area.
Sanitation facilities during construction	• Proper availability of drinking water and Sanitation facilities	During construction phase, the industry has provided labour sheds for the construction labour, adequate drinking water points and sanitation facilities. Photographs of the labour sheds and drinking water points are enclosed as **Annexure-II** for your information.

HETERO INFRASTRUCTURE SEZ LTD * N Narasapuram * HETERO

Fire Prevention during construction	• Adopt safe work practise and have adequate firefighting facilities.	The industry has adopted and being adopted the safe work practices during the construction. Some of the safety practices followed are as below: ➢ Provisioning of Personal Protective Equipment ➢ Provisioning of fall protection equipment ➢ Regular Medical check-ups etc. The industry has provided adequate firefighting facilities in the industry. Details of firefighting facilities provided in the industry are enclosed as ***Annexure-III.***
Pollution of land, ground water and surface water arising from sanitary and other wastes and Spillages	• During Construction it will be ensured that contractor does not dispose off debris in water bodies.	This is to bring to your notice that, all the contractors are advised to dispose the debris in such a way that, it should not enter the water bodies. There are no water bodies in and around the project site.
	• Soil laden run off will not be diverted to water bodies.	Not Applicable. There are no water bodies to divert overloaded soil into the water bodies.
	• Vehicle maintenance and refuelling will be confines to areas under construction yard to trap discarded lubricant and fuel spills.	Regular vehicle maintenance and refuelling is being done outside the site in an authorised workshops and petrol pumps. In case of emergency maintenance of vehicles, the waste is disposed to Incineration along with other wastes.
	• Sanitation waste from will not be diverted to construction water bodies.	Sanitation waste is being collected separately and disposed to either incineration or to the treatment as applicable.
	• Contractor's to prepare, for the works sites, which make adequate provision for safe disposal of all wastes and prevention of spillages, leakage of polluting materials etc.	The contractors are advised to dispose the waste properly to avoid nuisance to the surroundings and also advised to not to use polluting materials like Bitumen, Waste oils etc in the construction.
	• Contractor to be required to pay all costs associated with cleaning up any pollution caused by their activities and to pay full compensation to those affected.	Major construction works have been completed and only few modifications works & repair works are going on at site. Till now there are issue associated with pollution caused due to the activities of contractors.

Groundwater abstraction for construction activities	• Contractor to ensure optimisation of water abstraction.	During major construction, the industry has used curing chemical, ready mix concrete etc. for optimum usage of water in construction. Photograph of the Ready-mix concrete plant working in the factory premises is enclosed as **Annexure-IV** for your information.
Construction traffic causing pavement and structure damage due to overloading, increasing congestion and increased road safety hazards on the Nakkapalli-Rajayyapeta road.	• Contractors to use appropriate vehicles and to comply with legal gross vehicle and axle load limits. • Contractors to repair damage at own expense. • Contractors to minimise road safety hazards and inconvenience to other road users by taking appropriate measures.	The industry has laid own road to the factory from National Highway and hence there is no traffic congestion, inconvenience to the other public and road safety issues. Drawing and Photographs of the Road are enclosed as **Annexure-V.**
Air Pollution from batch mix plants, construction yard due to movement of mechanical compactor and other vehicles.	• Trucks carrying construction material will be covered with tarpaulin to avoid spilling.	Instructed all truck owners to cover the trucks with tarpaulins and is being followed strictly.
	• Water Sprinkling will be carried out in mornings and evenings on haul roads and compact surface.	Industry used to sprinkle water on the roads during initial stages of construction and at present all roads are either concreted or black top,
	• Vehicles and construction machinery will be maintained to conform emission standards specified by SPCB.	Maintaining Vehicles and construction machinery in good working condition so that it will meet the emission standards specified by APPCB
	• Stock piled sand and stone will be wetted before loading. • Construction debris shall be disposed only at designated sites.	• There is no sand stocks at the site. • Construction debris is being disposed at designated places only.
Noise Levels	• Construction yard will be located at 500m away from habitation.	There is no construction yard near to the habitation.
	• All equipment will be maintained in good working order, properly designed engine enclosures and intake silencers.	All vehicles are provided with silencers and maintaining in good working condition. All DG sets are provided with acoustic enclosures. Photographs o the DG sets are enclosed as **Annexure -VI.**
Water Logging and cross Drainage.	• Storm water drain on the North Eastern side of the site connecting to the	Storm water drain on the eastern side of the factory is being maintained in good condition so that

HETERO INFRASTRUCTURE SEZ LTD HETERO N. Narasapuram

	creek and drains within the site.	there will not be nay water logging in the catchment area. Drawings of the storm water drain on the eastern side of the factory is enclosed as **Annexure-VII**.
Negative impact on flora due to Flora due to cutting of trees.	• To compensate for 25 number of trees to be cut, 25000 number of trees will be planted.	Industry has planted more than 500000 plants in the premises. Photographs of the green belt are enclosed as **Annexure-VIII.**
Occupational Safety and Health	• Construction workers be provided with personal protective equipment (PPE) such as earplugs, helmets, safety shoes, gloves, etc.	All workers are being provided with suitable PPE like Shoes, Helmet, Goggles Gloves, Ear plugs etc. depending on the work. The PPE Matrix and protocols are enclosed as **Annexure-IX** for your information
Environmental monitoring during construction phase	• Ambient Air Quality to be measured once in a season (except monsoon) at location specified in monitoring plan	Ambient air quality monitoring is done continuously through 03 Nos of CAAQM stations. Conducting ambient air quality monitoring through third party once in a month and reports are being submitted to RO, APPCB, Visakhapatnam.
	• Water Quality (ground and surface) to be monitored once in a season (except monsoon season) at locations specified in monitoring plan.	The industry has provided 04 nos of piezo wells in the factory premises for monitoring the ground water quality and is being monitored once in 03 months. Reports are being submitted to MoEF&CC along with compliance reports. Layout of piezo wells installed in the plant is enclosed as **Annexure-X.**
	• Noise levels to be monitored once in a season at locations specified in monitoring plan.	Regular noise monitoring is being done internally and records are being maintained,
	• Soil quality to be monitored once a year .	Soil quality is being monitored once in six months and the reports are being submitted to MoEF&CC along with compliance reports,
	• Monitoring of Construction sites for arrangements made for protection measures at storage areas, and drainage.	Regularly monitoring the construction sites for arrangements made.
Occupation Phase		
Air Pollution From Boilers	• Effective stack heights and bag filters.	The industry is having 04 nos of boilers and the details are as below:

HETERO INFRASTRUCTURE SEZ LTD N. Narasapuram HETERO

<table>
<tr><td></td><td></td><td><table><tr><td>Capacity of Boiler</td><td>Stack Height</td><td>APCD</td></tr><tr><td>45 TPH</td><td>53 m</td><td>Electrostatic Precipitator (ESP)</td></tr><tr><td>20 TPH</td><td>33 m</td><td>Dust collector followed by Bag filter</td></tr><tr><td>12 TPH</td><td>30 m</td><td>Bag filters</td></tr><tr><td>10 TPH</td><td>30 m</td><td>Bag filters</td></tr></table></td></tr>
<tr><td>Air Pollution From DG sets</td><td>• Effective stack heights as per CPCB Formula</td><td>All DG sets are provided with adequate stack height as per the CPCB formula.</td></tr>
<tr><td>Air Pollution from Incinerator</td><td>• Provision of Scrubbers.</td><td>No Hazardous waste Incinerator is installed at site.</td></tr>
<tr><td>Diffuse emissions from, reactors, multiple effect evaporators, strippers etc.</td><td>• Provision of vent condensers.</td><td>• All reactors are provided with dual stage condensers to avoid process emissions entry into the atmosphere
• All reactor vents in which acidic reactions are being carried are connected to scrubbers.
• Stripper vent is connected to dual stage condensers.</td></tr>
<tr><td>Fugitive Emissions from accidental spills</td><td>• Containment measures like dykes for bulk solvent storage, periodic maintenance.</td><td>All solvent storage tanks are provided with sufficient dykes (110% of tank capacity) and provided Dump tanks in all solvent storage yards to control the spills.
Photographs of the solvent yard is enclosed as Annexure-XI.</td></tr>
<tr><td>Water Resources</td><td>• Source: YLB Canal supply.</td><td>As per EC, the industry has installed Sea water Desalination plant for meeting the water requirements of the industry.</td></tr>
<tr><td>Effluents from Process:</td><td></td><td></td></tr>
<tr><td>Organic Wastes</td><td>• Incinerator
• Stripper followed by distillation or incineration.</td><td>Sending to cement Industries, pre-processing units for incineration purpose as directed by the Board.</td></tr>
<tr><td>High TDS Effluents</td><td>• Evaporator followed by Filter Press condensate From Evaporator for Biological treatment followed by tertiary treatment and marine disposal .</td><td>HTDS effluents are being treated in Multiple Effect Evaporator (MEE) followed by biological treatment and tertiary treatment before disposing into the Sea.</td></tr>
<tr><td>Low COD and Low TDS Effluents</td><td>• Activated Sludge process followed by tertiary treatment and marine disposal.</td><td>All LTDS effluents along with MEE Condensate is being treated in Bio-tower followed by Dual stage activated sludge process and then to RO plant before disposing into the Sea.
Details and photographs of the Stripper/MEE/ATFD & Biological Treatment are enclosed as Annexure -XII.</td></tr>
</table>

Effluents from utilities	• Primary treatment followed by marine disposal.	Effluents from utilities is being treated along with LTDS effluents.
Domestic Effluents	• Sewage treatment plant and treated water for on Land Irrigation.	Domestic effluents are being treated in sewage treatment plant of 300 KLD capacity and treated sewage is recused for gardening purpose. Details of STP and photograph are enclosed as **Annexure-XIII**.
Solid Wastes		
Coal ash from Boiler	• Supply to Brick manufacturers and Cement Manufacturers	Sending to Brick manufacturing units.
Garbage	a) Biodegradable for vermicomposting and Reuse for horticulture development b) Recyclable Wastes Like Paper, plastic to recyclers. c) Non-Biodegradable for disposal to local authorities. d) STP Sludge for compost and reuse as manure.	a) Installed organic waste converter for converting the biodegradable waste into manure. b) LDPE paper and plastic waste is being sent to recyclers. c) Non-Biodegradable waste is being disposed as per the guidelines. d) Using STP sludge in Vermi compost plant to maintain moisture and then for gardening purpose as manure. Photograph of the vermi-compost plant is enclosed as **Annexure-XIV**.
Hazardous wastes		
a) Forced Evaporation salts b) Solvent Residues c) Process residues d) ETP sludge e) Waste Oils f) Used Batteries g) Waste Containers	• Temporary Storage Facility with 3 Months storage capacity And Sent To TSDF, Visakhapatnam sent to authorized recyclers Detoxification resultant effluent to ETP and sold to authorised vendor.	Hazardous wastes are being disposed as per the conditions stipulated by APPCB in the **CTO**. Minimum stocks are being maintained in the Hazardous waste storage yard. Detoxification of containers/Liners is being done in Detoxification yard and wash water is being routed to ETP for treatment. Hazardous waste and mode of disposal specified by the APPCB in **CTO** is enclosed as **Annexure-XV**.
Noise Pollution from DG Sets, Motors, Compressors etc.	• Provision of Acoustic enclosures for DG Sets provision of noise absorption pads at the foundation levels Green Belt.	All DG sets are provided with Acoustic enclosures and thick green belt is being maintained in & around the factory premises for minimising the noise.

Green Belt	• Provision of Avenue plantation and 50 m wide green belt all around the estate	Thick green belt is being maintained in & around the factory premises.
Occupational safety	• Provision of PPE, and Health centre. • Periodic Health Check-ups. • Occupational Safety training.	• The industry has provided 02 no's of Occupational health centres with ambulances (mini trauma) within the industry premises. Full time doctors are deployed in the OHC and Round the clock male nurses/ paramedical staff are available in the factory for taking care of health issues of employees/emergencies. • Periodical medical examination of the employees is being carried as per the Factories Act. • Occupational safety training is the part of Safety induction training and also during regular trainings.
Community Development	• Extension of Medical facilities by way of health camps, Improvement of educational facilities, Empowerment of Women in Surrounding villages.	The industry is extending medical support to the nearby villagers by way of: ➢ Conducting medical camps in the nearby villages regularly through mobile medical van of the Company and giving free medicines. ➢ Established Eye hospital at Nakkapalli for the eye care of the nearby villagers. This includes free testing, providing goggles, medicines, Cataract surgeries etc. ➢ Financial assistance to the people suffering with health ailments. ➢ Sanitation facilities during calamities. For education, the industry is carrying following activities: ➢ Providing the infrastructure to all nearby Govt. schools like construction of toilets, Compound walls, classrooms etc. ➢ Providing furniture to the Govt Schools. ➢ Providing Study material for school going children ➢ Drinking water facilities (RO Plants) in the schools. ➢ Rewards for the meritorious students.

HETERO INFRASTRUCTURE SEZ LTD

		➢ Celebration of national events in schools ➢ Providing lighting & sport kits to the schools etc. For women empowerment, the industry is providing jobs to the women and promoting them to take self-decisions both at home and workplace by way of providing training to the women employees. The details are enclosed as **Annexure-XVI**

Submitted to the IRO, MoEF&CC, Vijayawada for information and perusal.

For Hetero Infrastructure SEZ Ltd

Date :23/12/2022

S. Kullayi Reddy
Associate Vice President -EHS

Annexure-I

GREEN BELT PHOTOS

ANNEXURE-II

LABOUR SHED & DRINKING WATER

Drinking Water

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ANNEXURE-III

Hetero Complex Safety Equipment's				
S. No	**Name of the Equipment**	**Capacity / UoM**	**Total Quantity**	**Photograph**
1	Fire Extinguishers	Nos	2238	
2	ARFFF (Foam)	Lts	47960	
3	Fire hydrant points	Nos	462	
4	Fire hose cabinet	Nos	436	
5	First aid hose reel	Nos	176	
6	Fire hydrant monitors	Nos	74	
7	Fire hydrant gate valves	Nos	314	
8	Fire blanket	Nos	148	
9	Eye & Body wash unit	Nos	105	

10	Personal protective Equipment in Blocks	Nos	74	
11	Eye wash bottle	Nos	327	
12	SCBA	Nos	38	
TYPE OF FIRE EXTINGUISHER				
1	CO2	2 kg	96	
2		4.5 kg	567	
3		5 kg	10	
4		22.5 kg	275	
5		45 kg	91	
6	Foam	9Lts	112	
7		50Lts	373	
8	DCP	9Kg	78	
9		10Kg	120	
10		25Kg	282	
11		50Kg	81	

<table>
<tr><td>12</td><td rowspan="4">D-Type</td><td>9Kg</td><td>4</td><td rowspan="2"></td></tr>
<tr><td>13</td><td>10 Kg</td><td>27</td></tr>
<tr><td>14</td><td>25 Kg</td><td>15</td><td rowspan="2"></td></tr>
<tr><td>15</td><td>50 Kg</td><td>11</td></tr>
<tr><td>16</td><td>ABC</td><td>2Kg</td><td>80</td><td></td></tr>
<tr><td>17</td><td>DCP / Clean Agent Modular</td><td>10 Kg</td><td>672</td><td></td></tr>
</table>

HETERO COMPLEX FIRE HYDRANT PUMP HOUSE DETAILS

PUMP HOUSE NO	PUMP HOUSE –I			PUMP HOUSE-II			PUMP HOUSE-III		
PUMP DESCRIPTION	JOCKEY PUMP	MAIN PUMP	DIESEL PUMP	JOCKEY PUMP	MAIN PUMP	DIESEL PUMP	JOCKEY PUMP	MAIN PUMP	DIESEL PUMP
PUMP HEAD (Mt)	88	88	88	88	88	88	95.1	88	88
PUMP FLOW (m3/hr)	25	410	410	25	410	410	61	273	273
PUMP HP	25	215	231	25	215	231	20	150	133
PUMP RPM	2900	2900	1800	2900	1480	1800	2920	1480	1800
PUMP LPM	416	6833	6833	416	6833	6833	1000	4550	4550
AUTO START (Kg/cm2)	5	5	5	5	4	2	5	4	Manual shut off
AUTO SHUT OFF (Kg/cm2))	7	Manual shut off	Manual shut off	7	Manual shut off	Manual shut off	7	Manual shut off	Manual shut off
Water Storage Capacity	600 KL			1200 KL			1000 KL		

HETERO INFRASTRUCTURE SEZ LTD

HIGH PRESSURE WATER MIST FIRE TENDER		
UNIT	Fire Engine -1	Fire Engine-2
Engine model	EICHER 10.95	EICHER 10.95
Water tank capacity	3500ltrs	2000ltrs
Foam Tank capacity	350L	400L
Foam Water monitor capacity	2000Lpm@100bar	1000Gpm@7kG/cm2
DCP Tank capacity	….	250 Kgs
High pressure pump	150Lpm @ 100bar	150Lpm @ 100bar
High pressure hose pipe (60mtrs length)	02 no's	02 no's
Type	Advances water mist and Foam type	Advanced water Mist, Foam and Dry Chemical Powder

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ANNEXURE-IV

READY-MIX CONCRETE PLANT

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – V

HETERO COMPLEX ROAD

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – VI

DG SETS

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – VII

STORM WATER DRAIN POINT

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – VIII

GREEN BELT PHOTOS

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – IX

PPE MATRIX

Area/Activity	PPEs REQUIRED BEFORE STARTING ACTIVITY			
PPE mandatory before entering in to any work Areas.	Safety Shoes		Nose Mask	
	Safety Goggles			
	Safety Helmet			
Handling of Flammable Solvents with Proper Earthing and bonding	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Nitrile Gloves	
	Safety Helmet		PAPR	
	Full Face Mask			
Toxic Material Handling (Like NH3, bromine etc)	Safety Shoes		PVC Air Line Suit	
	Safety Helmet		PVC Hand Gloves	
	Full Face Mask		PAPR	
Charging/ Handling of corrosive chemical (NaOH, H_2SO_4)	Safety Shoes		PVC Apron	
	Safety Goggles		PVC Hand Gloves	
	Safety Helmet		PAPR	
	Full Face Mask		Other	
Charging/Handling powder (powder Milling, sifting, dispensing and charging in to reactor Etc)	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Nitrile Gloves	
	Safety Helmet		PAPR	
	Dust Mask			
Hot material handling, Abrasive material handling	Safety Shoes		FR Suit /Apron	
	Safety Goggles		Heat Resistant glove	
	Safety Helmet			
	Nose Mask			
Rescue operation in Fire	Safety Shoes		Fire Proximity Suit	
	Safety Goggles		Fire Proximity Glove	
	Safety Helmet			
	Full Face Mask		SCBA	
Rescue operation in toxic, corrosive atmosphere.	SCBA		PVC hand Gloves	
	PVC Suit/Apron		Safety Helmet	
	Safety Gum Shoe			
Laboratory works	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Lab Apron	
	Nose Mask			
Detoxification Works	Safety Shoes		PVC Suit	
	Safety Goggles		Hand Gloves	
	Safety Helmet		PAPR	
Monitoring activities in plant and warehouse	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Nose Mask	
	Safety Helmet			
Road Tanker Sampling and Unloading	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Safety Belts	
	Safety Helmet		Nitrile Hand glove	
	Full Face Mask			

Area/Activity	PPEs REQUIRED BEFORE STARTING ACTIVITY			
Flammable Gas handling like Hydrogen etc.	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Nitrile Hand glove	
	Safety Helmet		SCBA	
Boiler house	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Heat Resistant glove	
	Safety Helmet		Ear Plug/Muff	
	Dust Masks			
Opening of Pipe lines	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Hand Gloves	
	Safety Helmet		Nose Mask	
Utility and DG Set areas	Safety Shoes		Hand gloves	
	Safety Goggles		Ear Plug/Mug	
	Safety Helmet		FR Suit	
	Nose Mask			
Working at effluent sumps, water, sumps, cooling towers, aeration tanks, etc.	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Safety Belts	
	Safety Helmet		Hand gloves	
	Nose Mask		Life Buoys	
Working at heights, painting, and Civil constructions.	Safety Shoes		Life Lines	
	Safety Goggles		Safety Belts	
	Safety Helmet		Hand gloves	
	Nose Mask			
Hot Works like welding, cutting , grinding , heating , chipping etc.	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Safety Belts	
	Safety Helmet		Hand gloves	
	Nose Mask			
Confined Space Entry	Safety Shoes		Safety Belt/Ladder	
	Safety Goggles			
	Safety Helmet			
Working on MCC, SFU, Isolator, capacitors underground cable	Insulative Shoe		Arc Suit	
	Safety Goggles		Electrical Resistance Gloves	
	Safety Helmet			
Excavation work	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Hand Gloves	
	Safety Helmet			
Gas cylinder Handling	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Hand Gloves	
	Safety Helmet		Face Shield	
Powder Handling	Safety Shoes		FR Suit with Hood	
	Safety Goggles		Nitrile Hand gloves	
	Safety Helmet		PAPR	
	Nose Mask			

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – X

LAYOUT OF PIEZO WELLS

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HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – XI

SOLVENT YARD

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – XII

STRIPPER/MEE/ATFD & BIOLOGICAL TREATMENT

Multiple effect evaporator

Stripper

ATFD

HETERO INFRASTRUCTURE SEZ LTD

Biological treatment

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – XIII

SEWAGE TREATMENT PLANT

HETERO INFRASTRUCTURE SEZ LTD

ANNEXURE – XIV

VERMI COMPOST PLANT

Annexure-XV

HAZARDOUS WASTE AND MODE OF DISPOSAL

Hazardous wastes are being disposed as per the conditions stipulated by APPCB in the CTO. Minimum stocks are being maintained in the Hazardous waste storage yard.

Hazardous waste and mode of disposal specified by the APPCB in CTO is mentioned below:

S.No	Details of waste	Mode of Disposal
1	Process Solid waste	To TSDF, Parawada, Anakapalli Dist. for secured Land filling
2	MEE/ Forced Evaporation Salt	
3	Incineration Ash	
4	ETP Sludge	
5	Solvent Residue/Organic Residue	Shall be incinerated to sent to Cement industries for Co-incineration/Co-processing/ Pre-processing units
6	Spent Carbon	
7	Damage or Rejected APIs/products	
8	Damaged or Expired Raw materials	
9	Used PPEs	Shall be incinerated in in-house incinerator or sent to Cement industries for incineration.
10	Used Oils	To Re-processing units authorized by APPCB
11	Used Batteries	Shall be sent to suppliers on buy back basis
12	e-Waste/ electrical waste	Sent to Authorized Recyclers approved by APPCB/CPCB.
13	Empty Drums/ Containers/ Liners contaminated with Hazardous chemicals/waste	To outside agencies after complete detoxification.
14	Empty barrels / containers / liners contaminated with hazardous chemicals / wastes	
15	LDPE Paper	To authorized Recyclers/ outside agencies
16	Coal Ash from Boilers	To Brick manufacturing units
17	Spent Solvents	Shall be recycled within the units of Hetero Infrastructure SEZ Ltd or sold to outside agencies
18	Recovered Solvents	

A Brief Report of CSR activities in Nakkapalli plant areas

December 2022

About Hetero

Hetero is one of India's leading generic pharmaceutical companies and is one of the world's largest producers of anti-retroviral drugs for the treatment of HIV/AIDS. With more than 20 years of expertise in the pharmaceutical industry, Hetero's strategic business areas include APIs, generics and biosimilars. Hetero also offers custom pharmaceutical services to its partners around the world. The company is recognized for its strengths in Research and Development, manufacturing, and commercialization of a wide range of products.

Hetero is the first company in India to launch the generic version of Remdesivir injection, COVIFOR, in India, which is used to treat hospitalization cases of COVID-19.

Corporate Social Responsibility

At Hetero, we value health and prosperity for all. Our passion for improving quality of life extends beyond our business and transcends everything we do. While we work towards making medicines affordable and accessible to society at large, we also continuously seek opportunities to help the society through our corporate social responsibility initiatives. Since its inception, Hetero has been directly supporting with healthcare programmes, drinking water & sanitation, educational and welfare activities in communities surrounding the company's factories. The company also extends its support beyond its operational vicinities depending on the community needs and emergencies.

As a Hetero group we will focus on the following thematic areas to implement CSR activities in Nakkapally Region. Following activities have been implemented in 26 number of villages with an outreach of 16,800 households, 32 schools 31 Anganwadi centers etc.

1. Quality Education
2. Health Care Services
3. Village Infrastructure.
4. Drinking Water & Sanitation

1. Quality Education

Quality Education is one of the flagship programs for Hetero Company. We are working in 32 Schools & 31 Anganwadi Centers. Goal is to address the root causes of education quality challenges. We identified several challenges among the marginalised students studying especially in govt schools.

To provide quality education:

- Supported **32 vidya volunteers** in schools to balance the student teacher ratio. Purpose of vidya volunteers is to address the root causes of lack of required teaching staff in select schools. Vidya volunteers are well trained on various participatory didactic learning/teaching methods. Vidya volunteers help the school students through language and numeracy improvement. Also helps in various behavioural change trainings to students.

- Provided **uniforms, bags, stationery, notebooks & furniture** to schools to bring the uniformity among the students (till the year 2019). The intent of providing the above is to enable children studying in the schools to have a better access to learning materials.
- Provided **outdoor playing equipment** to Anganwadi schools to encourage the children to attend regularly. In several Anganwadi centers, it was observed that the children do not have access to required outdoor playing equipment.
- Constructed **RO Water Plant** in Schools to address the clean and safe drinking water.
- Provided **Cooking Wessels** to Schools.
- **Merit Awards** to students to encourage higher education.
- Provided **Reading Material** to 10th class students
- Constructed **25 toilets in Schools for Boys & Girls** to prevent the transmission of communicable diseases.

2. Health Care Services:

Health is the other flag ship program for Hetero Company, under health, we are working in following segments:

2.1 Vision Health Care Centre:

To Address the eyesight issues of marginalised communities, Hetero opened a Vision centre at Nakapally Village in collaboration with Sankurathri Foundation. The Vision centre equips latest technologies, well trained staff. Communities from neighbouring villages visits the Vision center, get the eye tests done, and for needed patients, undertake surgeries by specialist Surgeons.

Objective of the Centre:

To Support the needy villagers, who are having vision problem and not able to bare the expenses for eye surgeries.

So far, served **42,958 members**, distributed **17,983 spectacles** & conducted **1,806 eye surgeries.**

2.2 Mobile Medical Van:

The main purpose of this activity is to serve the underprivileged society and especially focus on seasonal diseases like fever, cold, allergies etc, blood pressure & sugar/diabetes.

Through this project, so far, we conducted **1,973 camps** and reached **1,04,612 members** & distributed medicines. A qualified medical doctor provides required medical support to the patients in the village itself. Once the testing is one, required medicines are provided to the patients free of cost. Interactions with few patients inferred that, on an average each patient save around Rs. 1000 per visit if they go and get the same medical support from nearby town.

2.3 Covid 19 response:

During Covid, every **15 days** we have done sanitation in the whole village to stop the spread of virus in the villages.

During lock down we have distributed groceries to the people in and around Nakkapally Region. We have organized special vaccination drive to the villagers.

Under this project we covered 27 villages and distributed **16,000 Grocery kit** (Dal, Rice, Sugar, oil packet etc) to the Villagers.

3. Village Infrastructure:

Under this project 27 villages are adopted by Hetero Group and constructed the following infrastructure in the villages.

- Constructed 6 Community Halls.
- Laying of CC Roads & Gravel roads
- Construction of Toilets
- Laying of Electrical Lines.
- Provided Solar lamps to the fisherman community
- Provided streetlights
- Construction of compound walls to Graveyards.
- Planted trees in the community.

4. Drinking Water & Sanitation:

Under this project following activities are completed.

- 14 RO Plants are installed in various villages to provide clean and neat drinking water.
- Provided running water to the whole community.
- Constructed Overhead tanks.
- Drilled 12 bore wells
- Constructed drainages in the community
- Created awareness on Swachh Bharath

Annexure-iv

Lighted Marker buoys installed at

Sea water intake and Marine Outfall pipelines

Annexure-V

TAX INVOICE

ANDHRA PRADESH MARITIME BOARD
BEACH ROAD, KAKINADA, AP-533007
GSTIN 37AAAGA2316N1ZJ
PAN AAAGA2316N

INVOICE # 3761/2023-2024
INVOICE DATE 2023-08-01

AGENCY [illegible]
GSTIN No 37AA[illegible]
PORT Kakinada
DEPARTMENT PO KKD

S.no	Description of Services	Type of Services	SAC Code	Service Amt
1	As per the G.O.Ms.No.2 [illegible] E.(B) (Ports-II) Department dated [illegible] Lease charges for drawl of Sea Water for the year 2023-24, Rs.[illegible]/-	Drawl of Sea Water (Lease Charges)	[illegible]	[illegible]
				272750

Note: This is a system generated invoice, it doesnt require any signatures

Andhra Pradesh Maritime Board

PAYMENT RECEIPT

Transaction ID	1pdadflm6suyf
Invoice Type	miscellaneous
Invoice Number	3751/2023-2024
Transaction Date	Sep 7, 2023 1:25:38 PM
Payment Status	Success
Success Info	
Service Head	01
Total Payment Amount	Rs: 273750
Service Amount	Rs: 273750

PORT OFFICER

Andhra Pradesh Maritime Board

system generated receipt, 05/09/2023 at 4:19PM

TAX INVOICE

INVOICE #: 3744/2023-2024
INVOICE DATE: 2023-[illegible]

ANDHRA PRADESH MARITIME BOARD
BEACH ROAD, KAKINADA, AP-533007
GSTIN: 37AAAGA2316N[illegible]
PAN: AAAGA2316N

AGENCY: [illegible] Infrastructure SEZ Ltd
GSTIN No: 37AABCH6897E[illegible]
PORT: Kakinada
DEPARTMENT: PO KKD

S.no	Description of Services	Type of Services	SAC Code	Service Amt
1	As per the G.O.Ms.No.2 [illegible] (Ports) Dept, Dt.[illegible] and based on the physical inspection conducted by the Port Officials and previous measurements submitted by the Executive Engineer, Marine Division, Kakinada vide his letter [illegible] and request made by the firm [illegible]. Fee towards way leave charges calculated as follows: A) [illegible] 1) Port Land for laying pipeline in land side area [illegible] = 46.00 [illegible] Rs 785x46/10 = Rs [illegible] for one year i.e., from [illegible] to 28.06.2024 = Rs [illegible] 2) Port Land for laying pipeline in the Sea Side area [illegible] = Rs [illegible] for one year i.e., from [illegible] to 28.06.2024 = Rs 46,538/- Total A (1+2) = [illegible] B) [illegible] 1) Port Land for laying pipeline in land side area [illegible] = Rs 4,[illegible] for 1 (one) year i.e., from [illegible] to 28.06.2024 = Rs [illegible] 2) Port Land for laying pipeline in the Sea Side area [illegible] = Rs 62,[illegible] for (one) year i.e., from [illegible] to 28.06.2024 = Rs [illegible] Total B (1+2) = [illegible] Total Way Leave Charges (A+B) = Rs 1,17,022/- [illegible] Note: 1) Invoice prepared based on the previous information furnished by the firm. 2) The Superintending Engineer will visit the site and after verification of the actual installation facilities of your firm, if any due amount will be informed at later stage. Pending amount would be cleared after raising revised final invoice. 3) Payment will be done within 15 days from date of invoice raised by this office. If failed making payment within due date penalty will be levied as per the rules in force.	Way Leave Charges	[illegible]	117022
				117022

Note: This is a system generated invoice, it doesn't require any signatures

Andhra Pradesh Maritime Board

PAYMENT RECEIPT

Transaction ID	[illegible]
Invoice Type	miscellaneous
Invoice Number	2744/2023-2024
Transaction Date	Sep 7, 2023 1:23:26 PM
Payment Status	Success
Success Info	
Service Head	81
Total Payment Amount	Rs. 117022
Service Amount	Rs. 117022

PORT OFFICER

Andhra Pradesh Maritime Board

system generated receipt 09/09/2023 at 4:14PM

TAX INVOICE

ANDHRA PRADESH MARITIME BOARD
BEACH ROAD, KAKINADA, AP-533007
GSTIN 37AAAGA2316N1ZJ
PAN AAAGA2316N

INVOICE # 2746/2023-2024
INVOICE DATE 2023-08-01

AGENCY [illegible]
GSTIN No [illegible]
PORT Kakinada
DEPARTMENT PO KKD

S.no	Description of Services	Type of Services	SAC Code	Service Amt
1	Towards Collection of GST on the Invoice No. 2746/2023-2024, Dt 01.08.2023	GST		11064
				11064

Note: This is a system generated invoice, it does not require any signatures

Andhra Pradesh Maritime Board

PAYMENT RECEIPT

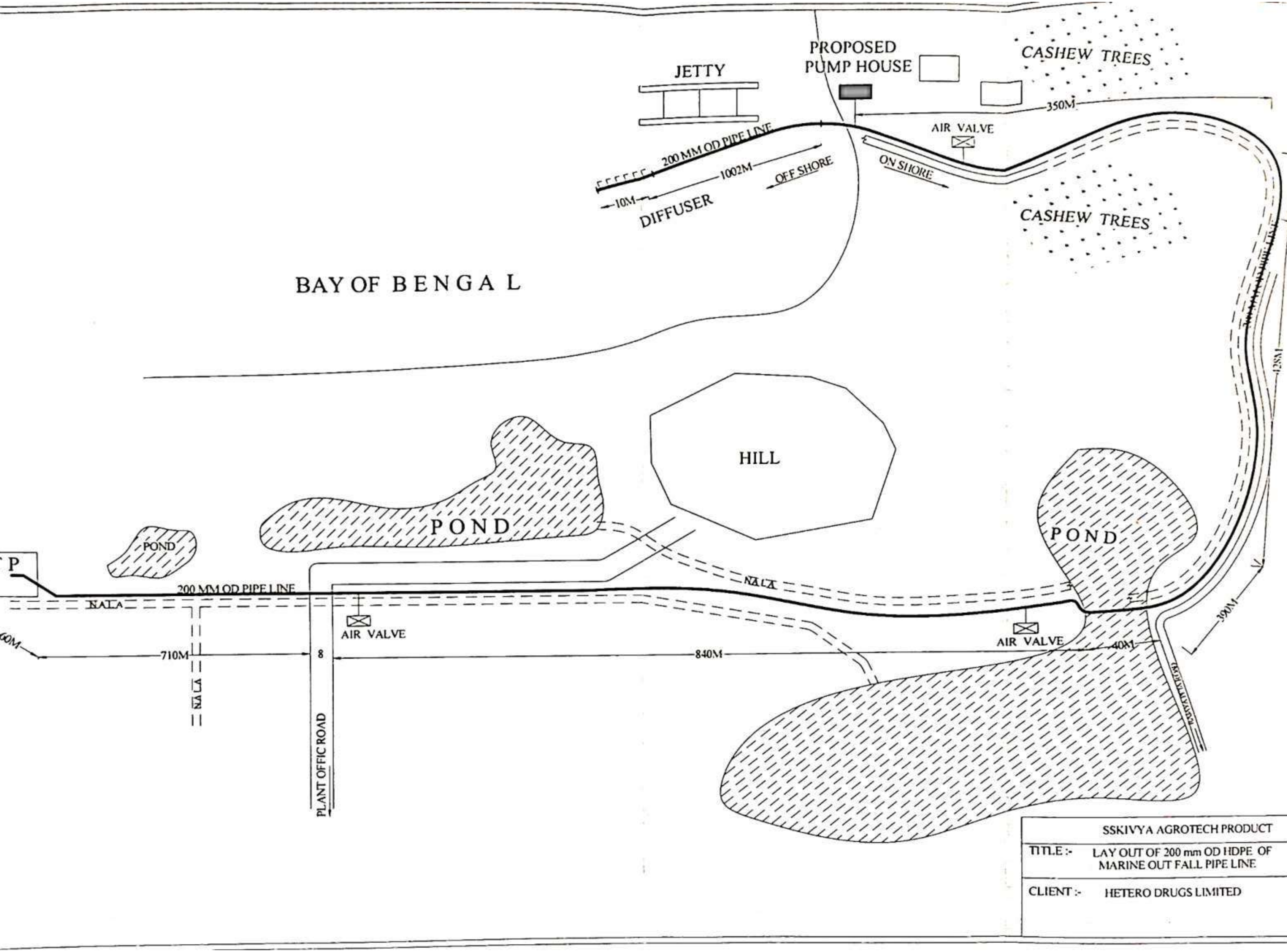
Transaction ID	1pdadbsin8vb7xy
Invoice Type	miscellaneous
Invoice Number	3/45/2023 2024
Transaction Date	Sep 7, 2023 [illegible] 20 [illegible] PM
Payment Status	Success
Success Info	
Service Head	GST
Total Payment Amount	Rs. 21064
Service Amount	Rs. 21064

PORT OFFICER

Andhra Pradesh Maritime Board

system generated receipt 09/09/2023 at 4:17 PM

ANNEXURE-VI



SSKIVYA AGROTECH PRODUCT

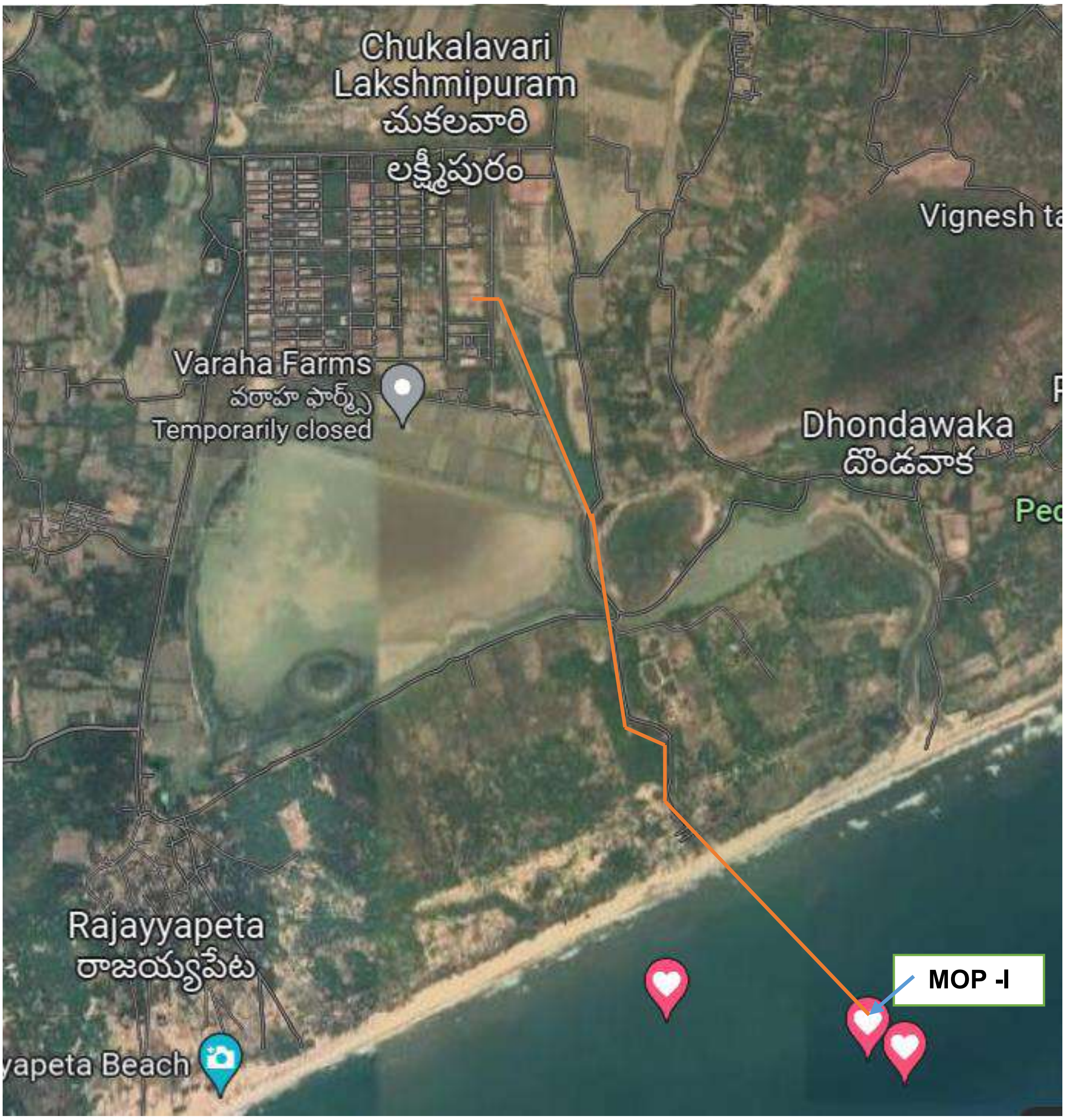
TITLE :- LAY OUT OF 200 mm OD HDPE OF MARINE OUT FALL PIPE LINE

CLIENT :- HETERO DRUGS LIMITED

HETERO INFRASTRUCTURE SEZ LTD

N.Narasapuram(V), Nakkapalli (M), Anakapalli Dist

MARINE DISPOSAL PIPELINE ROUTING FROM PLANT TO SEA



SV ENVIRO LABS & CONSULTANTS

(ENVIRONMENTAL ENGINEERS & CONSULTANTS IN POLLUTION CONTROL)

Corporate Office & Laboratory : [illegible]

Hyderabad: [illegible]

[illegible] svenviro [illegible]

Recognised by Govt. of India-MoEF & CC New Delhi Accredited by : NABL & NABET

Annexure-IX

Annexure-VII

Ref: SVELC/[illegible]

Date: 29-04-2024

NAME AND ADDRESS	:	M/s. HETERO INFRASTRUCTURE SEZ LIMITED, N. Narasapuram Village, Nakkapally Mandal, Visakhapatnam (Dt).
SAMPLE PARTICULARS	:	WATER
SOURCE OF COLLECTION	:	DESALINATION REJECT WATER
DATE OF COLLECTION	:	18-04-2024
DATE OF RECEIPT	:	19-04-2024

TEST REPORT

S.NO	PARAMETER	UNIT	RESULT	METHODS
1.	Turbidity	NTU	[illegible]	APHA 2130-B, 24th Edition
2.	pH	-	7.52	APHA 4500-H B, 24th Edition
3.	Total Dissolved Solids	mg/l	44925	APHA 2540 C, 24th Edition
4.	Total Alkalinity as $CaCO_3$	mg/l	172	APHA 2320-B, 24th Edition
5.	Total Hardness as $CaCO_3$	mg/l	10700	APHA 2340-C, 24th Edition
6.	Calcium as Ca	mg/l	[illegible]	APHA 3500-Ca B, 24th Edition
7.	Magnesium as Mg	mg/l	2122	APHA 3500-Mg B, 24th Edition
8.	Chlorides as Cl	mg/l	26540	APHA 4500-Cl B, 24th Edition
9.	Fluoride as F	mg/l	[illegible]	APHA 4500 F D, 24th Edition
10.	Nitrate as NO_3	mg/l	2.54	APHA 4500 NO_3 B & C, 24th Edition
11.	Sulphate as SO_4	mg/l	3748	APHA 4500-SO_4^{2-} E, 24th Edition

CHECKED BY

SV ENVIRO LABS & CONSULTANTS VISAKHAPATNAM

SV ENVIRO LABS & CONSULTANTS

ANNEXURE-VIII

Restricted distribution

NIO/SP- 04/2023
(SSP-3462)

Monitoring Study around the marine outfall point of Hetero Infrastructure SEZ Ltd. in the coastal waters off Nallamattipalem

Sponsored by

HETERO

Hetero Infrastructure SEZ Ltd.

February 2023

सीएसआईआर – राष्ट्रीयसमुद्रविज्ञानसंस्थान
CSIR-NATIONAL INSTITUTE OF OCEANOGRAPHY
(वैज्ञानिकतथाऔद्योगिकअनुसंधानपरिषद)
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
दोना पावला, गोवा भारत / DONA PAULA, GOA - 403004 India
फ़ोन/Tel : 91(0)832-2450450/ 2450327
फैक्स /Fax: 91(0)832-2450602
इ-मेल/e-mail : ocean@nio.org
http:// www.nio.org

DISTRIBUTION RESTRICTED

Monitoring Study around the marine outfall point of Hetero Infrastructure SEZ Ltd. in the coastal waters off Nallamattipalem

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(Council of Scientific & Industrial Research)
Regional Centre, Visakhapatnam – 530 017

February 2023

CONTENTS

PREFACE

M/s. Hetero Infrastructure SEZ limited, Rajayyapeta village, Nakkapalli Mandal, Visakhapatnam district approached CSIR-National Institute of Oceanography (CSIR-NIO), Regional Centre at Visakhapatnam to carry out the post project monitoring of marine environment at its marine outfall point (MOP) to know the impacts, if any on the ecology, water and sediment quality due to the release of treated effluent from Hetero chemical complex. In this connection, CSIR-NIO received a service order (No. 4900198745) from Hetero Infrastructure SEZ Limited on 29th April 2022. CSIR-NIO conducted a field campaign on 7th May 2022 in the marine outfall region of M/s Hetero Chemical Complex for *in-situ* observations and sample collection for the comprehensive study on water quality, biological, microbiological and sediment characteristics of the region. The following studies were carried out:

- Monitoring of physico-chemical, biological, micro-biological and sedimentological parameters in the marine environment to assess the present status of marine ecology.
- Toxicological studies to know the survival rate of the test species with the treated effluent from the guard pond of M/s Hetero Infrastructure SEZ Limited.

This report describes the results of the above studies and provides recommendations to M/s Hetero Infrastructure SEZ limited to maintain the sea water quality and health of the ecosystem in the coastal waters off Rajayyapeta.

Station: Visakhapatnam **(M S KRISHNA)**

Date: 06.02.2023 (Project Leader)

List of Contributors to the project

Scientist-In-Charge

Shri. G. P. S. Murty

Project Leader

Dr. M. Sri Rama Krishna

Data Collection, Processing & Analysis

Physico-chemical studies

Dr. V.V.S.S. Sarma

Dr. M. Sri Rama Krishna

Mr. R. Gangadhar Raju

Mr. K. Suresh Kumar

Mr. I Dhanunjaya Rao

Mr. Dipin Ghosh

Mr. Shirish Varshishth

Mr. M. Sree Lakshmi

Biological studies

Dr. T.N.R. Srinivas

Dr. L. Jagadeesan

Ms. M. Sravani

Mr. Joseph Ignitious

Acknowledgements

This work was sponsored by M/s. Hetero Infrastructure SEZ Limited, Rajayyapeta, Visakhapatnam. CSIR-National Institute of Oceanography (NIO), Regional Centre, Visakhapatnam acknowledges **Shri Kullayi Reddy Sane,** Associate Vice President, EHS**,** Hetero Infrastructure SEZ Limited for his keen interest, involvement, support and continuous interaction throughout the project tenure. We are thankful to **Dr. Sunil Kumar Singh,** Director, CSIR-NIO for his support and encouragement to carry out this study.

Executive Summary

CSIR-National Institute of Oceanography (CSIR-NIO) received a work order from M/s Hetero Infrastructure SEZ Limited to conduct post project monitoring study of the marine environment around its marine outfall point (MOP) in the coastal waters of Rajayyapeta. Accordingly, CSIR-NIO carried out a field campaign in the coastal waters off Rajayyapeta on 7th May 2022 for *in-situ* observations and sample collection for physico-chemical, biological, microbiological and sedimentological parameters. Eco-toxicology (bioassay) test was conducted for four days on the treated effluent collected directly from the guard pond of M/s Hetero Infrastructure SEZ Limited using zebra fish following CPCB norms. The salient features of our investigations in this study are given below.

- ✓ The range of values observed for temperatures and salinities of the study region is normal and consistent with coastal waters of east coast of India.
- ✓ The range of concentrations observed for chemical parameters such as dissolved inorganic nutrients (nitrite, nitrate, phosphate and silicate) is normal and is concurrent with the coastal waters along the east coast of India.
- ✓ The range of values observed for pH and total suspended matter in the study region is normal and are well within the values reported for coastal waters of east coast of India. However, the range of total petroleum hydrocarbons (TPHC) found in the surface and bottom waters of this study (10.0-22.1 μg/L and 2.1-37.4 μg/L, respectively) are relatively higher than those found in the previous monitoring study conducted in this region in 2017 (1.3-10.5 μg/L and 1.7-4.7 μg/L, respectively), indicating that there is a slight increase in recent years in the TPHC input from local sources into the coastal waters of Rajayyapeta.

- ✓ Mean dissolved oxygen (DO) concentrations in the surface (6.1±0.2 mg/L) and bottom (5.8±0.5 mg/L) waters of the study region are well above the threshold limit of DO concentrations for good quality of seawater (5.0 mg/L), indicating that coastal waters of this region are healthy with respect to DO concentrations.
- ✓ Mean values of biochemical oxygen demand for three days (BOD_3) in the surface and bottom waters of this study (1.9±0.7 mg/L and 2.1±1.0 mg/L, respectively) are well within the reported BOD_3 values for east Indian coastal waters. The BOD_3 values found in this study indicate that there is no significant pollution of labile organic matter from external sources in this region during the study period.
- ✓ Phytoplankton biomass, in terms of Chlorophyll-a (chl-a), varied from 0.23 to 0.56 mg/m^3 (mean: 0.37 mg/m^3) and it is considerably lower than those found in this region in 2017 monitoring study (1.2 to 7.44 mg/m^3). Mean phytoplankton abundances found in the surface and bottom waters of this study (4646 Nos./L and 5675 Nos./L, respectively) are considerably lower than those reported in the previous monitoring study conducted in this region in 2017 (10860 Nos./L and 10698 Nos./L, respectively), indicating that decreased primary production in the study region when compared to 2017. However, phytoplankton diversity increased as the range of number of phytoplankton genera recorded in surface waters of this study (15-27) is considerably higher than those reported in 2017 (12-19). Though the diatoms are the most predominant contributors to the total phytoplankton abundance, their mean contribution to the total phytoplankton decreased to ~60% in this study compared to ~97% in 2017. On other hand, dinoflagellate contribution increased from ~4% in 2017 to ~23% in the present study. Cynobacterial contribution to the total phytoplankton abundance is 4.2% only. Dominant and consistently occurring species were *Chaetoceros sp., Skeletonema sp., Rhizosolenia sp., Cyclotella sp., Nitschia sp.,*

Navicula sp., Ceratium sp., Gymnodinium sp., Trichodesmium sp., Cyanobacteria, *Thalassiothrix sp*., etc.

✓ Meso-zooplankton abundance in the present study (mean: 395 Nos./m^3) is less than one-fourth of the zooplankton abundance reported in previous monitoring study (1776 Nos./m^3) conducted in this region in 2017. Copepods are predominant in the total zooplankton abundance, with a mean contribution of 89.2% (range: 79.5-94.3%). Chaetognatha contributes from 0.7% to 9.4% (mean: 3.4%) to the total zooplankton abundance. Decapod larve are the third dominant groups in the total zooplankton abundance, with a mean contribution of 1.8% (range: 0.4-4.9%). The lowest abundant groups that contribute <1% to the total zooplankton abundance are Bivalve larvae (mean: 0.8%), Cladocerans (mean: 0.6%) and Thaliacea (0.4%).

✓ The range of macro faunal density found in this study (2650 to 3200 ind/m^2) is comparable to those found in surface sediments of east coast of India. A total of 20 fauna was found and is dominated by families of Polychaeta, with a mean contribution of ~68.3% to the total abundance. In particular *Nephteidae, Orbinidae, Eunicidae, Tereellidae, Opheliidae, Nereidae* and *Spionidae* families are common in all stations. The second largest group was Arthropoda and it was dominated by Amphipoda and Isopoda. Sipancula and Nematoda were present at all the stations. The wet weight of biomass was in the range of 4.05 to 11.27 g/m^2. The meiofauna represent the intermediate size group among the benthos. A total of 7 taxa were identified in the study area and the meio fauna was dominated by nematode, harpacticoid copepod, polychaeta, turbellaria, foraminifera, ostracoda and nauplii of crustacean group.

✓ The range of TVC found in the surface (2.9-24.6 x 10^3 CFU/mL) and bottom (0.9-34.8 x 10^3 CFU/mL) waters of this study are comparable with those reported in the previous monitoring study conducted in this region in 2017 (5.6-13.6x10^3 CFU/mL and 3.2-33.0 x10^3 CFU/mL, respectively). However, total coliform counts in this study (1.4-8.4 x10^3 CFU/mL in surface and 0.01-10.0 x10^3 CFU/ mL in bottom water) are considerably higher than those reported in the previous monitoring study conducted in 2017 (0.3-0.8 x10^3 CFU/ mL and 0.2-1.2 x10^3 CFU/ mL, respectively). The range of *Escherichia coli* like organisms (ECLO) found in this study (NG to 3.2 x10^3 CFU/ mL and NG to 3.1 x10^3 CFU/ mL, respectively) is comparable with those found in the previous monitoring study conducted in 2017 (1.5-3.7 x10^3 CFU/ mL and 0.7-7.4 x10^3 CFU/ mL, respectively). The *Enterococcus faecalis* like organism counts were NG to 22.9 x10^3 CFU/ mL in surface water and NG to 1.6 x10^3 CFU mL in bottom water. The *Vibrio* like organism (VLO) counts were NG to 3.0 x10^1 CFU/ mL in surface water and NG to 1.0 x10^1 CFU/ mL in bottom water. *Vibrio cholerae* like organism (VCLO) counts were NG to 3.0 x10^1 CFU/ mL in surface water and NG to 1.0 x10^1 CFU/ mL in bottom water. There is no growth of *Vibrio parahaemolyticus* like organism (VPLO) in both surface and bottom waters.

✓ ECLO and EFLO counts were observed in most of the stations which showed the influence of anthropogenic activities such as domestic and industrial discharge, recreational activities, open defecation in coastal (beach) regions (in villages), fisherman activities etc. The counts were higher than the reported from the coastal waters and as per standards of coastal recreational waters. VLO and VCLO counts were observed only in two stations out of the 12 stations sampled in the coastal waters off Rajayyapeta.

✓ Eco-toxicology (bioassay) test was conducted for four days (96 hrs) on the treated effluent collected from M/s Hetero Infrastructure SEZ Limited using zebra fish. During the test period of 96 hours, no mortality was observed in the control treatment and the effluent concentrations of 10%, 20% and 30%. The effluent of 50% concentrations recorded 5% mortality during the last 24 hours. Whereas, 60% effluent concentration recorded 5% mortality during the last 48 hours. The 90% effluent recorded 10% mortality while the 100% effluent recorded 25% mortality during the test time of 96 hours. These results indicate that the treated effluent collected from the guard pond of M/s Hetero Infrastructure SEZ Limited did not fulfill the CPCB norms for the bio-assay test, i.e., 90% of survival of zebra fish in 100% of treated effluent after the test time of 96 hours.

✓ Based on the median lethal concentrations (LC_{50}), the acute toxicity unit (TUa) of the treated effluent of M/s Hetero Infrastructure SEZ Limited was determined as 0.56 (range: 0.35 to 0.71) for zebra fish. Therefore, the quality of the treated effluent from M/s Hetero Infrastructure SEZ Limited is graded as Limited Toxic (TUa: <1).

✓ Based on the results of investigations carried out in the coastal waters of Rajayyapeta (large variability in the abundances of phytoplankton and zooplankton), it is recommended to carry out yearly monitoring study in the coastal waters of Rajayyapeta for next couple of years

✓ Based on the observations and eco-toxicology test results, it is recommended to prevent the extensive growth of algae in guard ponds of the industry in eco-friendly manner to improve the quality of treated effluent in order to comply with the CPCB norms of bioassay test for the treated effluent.

LIST OF TABLES

Table 3.26 Trace metal concentrations in the treated effluent collected from the guard pond

LIST OF FIGURES

LIST OF PLATES

Chapter 1
INTRODUCTION

1.1 Background information

M/s. Hetero Infrastructure SEZ Limited is a bulk drugs manufacturing company situated at Rajayyapeta village in Nakkapalli Mandal of Visakhapatnam District, Andhra Pradesh (Fig. 1.1). This plant is producing bulk drugs and their intermediates for the past few years. The industry is discharging the treated effluents into the sea through a marine disoposal pipeline at a distance of 980 m from the coast, a safe disposal point for quick dispersion, as recommended by the National Institute of Oceanography in their Rapid Marine Environmental Impact Assessment report of 2006. As per the conditions of Environmental Clearance (EC) issued by MoEF&CC, Govt. of India and consent for operation issued by APPCB, the industry is carrying regular post-project monitoring studies in the marine environment and bioassay tests for the treated effluents as a mandatory for a coastal based industry. Accordingly, CSIR-National Institute of Oceanography (CSIR-NIO), Regional Centre, Visakhapatnam has carried out post project monitoring studies in 2010, 2012, 2014 and 2017 to know the impacts if any due to the discharge of treated effluents on the seawater quality and health of the ecosystem. As part of the post project monitoring of the marine environment, once again M/s Hetero Infrastructure SEZ Limited approached CSIR-NIO, Regional Centre, Visakhapatnam for these studies to know the cumulative effects, if any, on the ecology, water quality and sediment quality due to the discharge of treated effluents into the marine environment in April 2022. After examining the proposal, CSIR-NIO agreed to carry out the study to generate one time site-specific data on oceanographic parameters and bioassay studies on the treated effluents as part of the post project monitoring.

Fig. 1.1.: Hetero chemical complex

1.2 Objectives and scope of the Study

The generation of site-specific environmental data base is a prerequisite for the assessment of probable impact of any coastal based industry. The main objective of the study is to understand the cumulative impact, if any, on the ecosystem in the coastal waters off Rajayyapeta due to the release of treated effluent from M/s Hetero Infrastructure SEZ Limited. Hence, the scope of the present study includes the generation of reliable data, at least one time, in respect of physico-chemical, biological, micro biological and sedimentological parameters to understand the water quality and sediment quality at and around the marine out fall point (MOP; discharge point) covering 12 stations. Since the toxicological studies are important to assess the survival rate of test species in the treated effluent, the scope of the work also includes to carry out the bioassay test for four days (96 hours) on the treated effluent collected from the guard pond of M/s Hetero Infrastructure SEZ Limited using pink zebra fish as test species. The results of the monitoring study conducted in the coastal waters off Rajayyapeta on 7th May 2022 and the toxicological studies conducted on the treated effluent are given in this report.

1.3 Company Profile

M/s Hetero Infrastructure SEZ Limited is a Bulk Drug Manufacturing Complex with four units situated at N. Narasapuram, Nakkapalli Mandal, Visakhapatnam district of Andhra Pradesh. Out of four units, one unit is in the non-Special Economic Zone (SEZ) and the other three units are in the SEZ. M/s Hetero Infrastructure SEZ Ltd is providing utilities & common facilities like Water, Steam, Effluent Treatment, Sewage Treatment, Scrap Yard, Hazardous waste handling etc. to all the manufacturing units located in this area.

The industrial estate is situated in Sy. Nos: 215, 286/1, 286/2, 283/1 in Ch. Laxmipuram village, 312/1 to 312/5, 312/10 to 312/12, 313/1 to 313/7 of Rajayyapeta village, 19(part) in Peda Teenarla village, 117/1 to 117/3, 119/1, 119/2, 120/1, 120/2, 125, 126, 129/1 to 129/9, 138, 142, 150, 215, N. Narsapuram village, Nakkapalli Mandal, Visakhapatnam District spread over an area of 139.856 ha. The various units which are working at present are as below:

- Hetero Labs Limited, Unit-III (Non SEZ)
- Hetero Drugs Limited, Unit-IX (SEZ)
- Hetero Labs Limited, Unit-IX (SEZ)
- Honour Lab Ltd, Unit-III
- Hetero Infrastructure SEZ Ltd (common facilities)

The Hetero complex (Fig. 1.2) is surrounded by open lands & salt lake in the south direction, open lands in the east direction, open lands in north direction and road connecting Upamaka village with Rajayyapeta village in the West direction, The NH 16 is in the north direction at a distance of 4 km, the nearest railway station is located at

Narsipatnam at a distance of 9 km in the north direction. The nearest airport is located at a distance of 70 km in the north east direction at Visakhapatnam. The Bay of Bengal is in the south eastern direction of the site at a distance of 1.2km. The area is drained by the Varaha River in the northern direction up to a distance of 13km, and the Tandava River in the south west direction at a distance of 14km.

Fig. 1.2: Synoptic view of the Hetero Complex

The capital cost of the project is Rs 1500 Crores. The SEZ is designed on the basis of required infrastructure for pharmaceutical manufacturing facilities like, road, storm water network, common utilities, storage facilities for raw materials, solvents, parking areas, pollution control facilities etc.

The water requirement of the project is being met with the sea water desalination plants (Fig. 1.3) installed in the premises of Hetero Infrastructure SEZ Ltd. Vermi Compost and sewage treatment plants (Figs. 1.4 and 1.5) are provided to treat the waste water and effluent treatment plant, containing different stages of treatment (Figs. 1.6 to

1.11) for industrial waste water. Water conservation measures were incorporated in the plumbing designs. Water recycling / reuse were adopted by way of using treated sewage for green belt development. The storm water from the site is collected in a storage tank and the same is reused for various purposes (as and when required), while the over flow is let out into the natural drain adjacent to the site. The required power is drawn from the AP TRANSCO and adopted energy efficient design for lighting and utility systems to optimize the energy requirement. Construction material was drawn from local sources. The industry installed a 6.1 MW Captive power plant for the generation of power and uses power from Hetero Wind Power.

Amenities and utilities:

A number of amenities and utilities were implemented during the operation phase to provide common infrastructure and pollution control facilities.

Fig. 1.3: Desalination plant in the Hetero Premises

Fig. 1.4: Vermi Compost Plant

Fig. 1.5: Sewage Treatment Plant (STP)

Fig. 1.6: Stripper and MEE (I & II)

Fig. 1.7: ATFD Connected to MEE I & II

Fig. 1.8: HTDS Tanks covered with Hoods and connected to Scrubbers

Fig. 1.9: Biological system for LTDS & Condensate of MEE & ATFD

Fig. 1.10: Guard ponds for storage of treated Effluent

Fig. 1.11: Aeration tanks

Baseline environment:

The baseline environment of the project impact areas (PIA) spread over 25km radius from the site was studied for air, water, soil, noise, ecological and social economic status. The baseline status is found to be within the prescribed limits in all respects except the noise levels which are found to be above the prescribed limits during day time in the PIA.

1.4 Major Products:

Table 1.1: Hetero Labs Limited (UNIT – III) – regular products

S. No	Name of the Product	Quantity (Kg/Day)
1	Abacavir sulphate	166.67
2	Capecitabine	133.33
3	Cefidinir	166.67
4	Cefixime Trihydrate	1000
5	Cefoxitin Sodium	333.33
6	Cefpodoxime Proxetil	666.67
7	Cefuroxime Axetil	666.67
8	Citicoline Sodium	100
9	Darunavir	250
10	Dolutegravir Sodium	167
11	Domperidone	166.67
12	Efavirenz	333.33
13	Fluconazole	166.67
14	Folic acid	100
15	Gliclazide	166.67
16	Hydralazine Hydrochloride	200
17	Irbesartan	166.67
18	Lamivudine	2333.33
19	Levetiracetam	1500
20	Losartan Potassium	866.67
21	Nevirapine	1000
22	Omeprazole	166.67
23	Pamidronate sodium	166.67
24	Phenylephrine.HCl	166.67
25	Pioglitazone Hydrochloride	166.67
26	Quetiapine fumarate	333.33
27	Ritonavir	100
28	Rosiglitazone maleate	166.67

29	Rosuvastatin calcium	100
30	Telmisartan	100
31	Tenofovir Disproxil fumerate	666.67
32	Terbinafine HCl	166.67
33	Tranexamic acid	100
34	Valsartan	500
35	Zidovudine	1166.67
Total Production capacity worst case scenario		**11816.67 Kg/day**

Table 1.2: Hetero Labs Limited (UNIT – III) – Campaign Products

S.No	Name of the Product	Quantity (Kg/Day)
1	Acyclovir	33.33
2	Alendronate Sodium Trihydrate	3.33
3	Alfuzosin Hydrochloride	26.67
4	Aliskiren Hemifumarate	6.67
5	Amlodipine Besylate	25
6	Anastrozole	1
7	Aripiprazole	33.33
8	Atazanavir Sulphate	33.33
9	Atomoxetine HCl	33.33
10	Atorvastatin Calcium Trihydrate	33.33
11	Benazepril HCl	3.33
12	Benfotiamine	66.67
13	Bicalutamide	66.67
14	Butenafine Hydrochloride	0.67
15	candesartan cilexetil	16.67
16	Cefditoren pivoxil	66.67
17	Cilazapril Monohydrate	3.33
18	Cilostazol	25
19	Citalopram Hydrobromide	66.67
20	Clopidogrel Hydrogen Sulfate	26.67
21	Daclatasvir	13.33
22	Deflazacort	1.67
23	Desloratadine	1.67
24	Didanosine	3.33
25	Dorzolamide HCl	5
26	Duloxetine HCl	25
27	Eletripton	16.67
28	Emtricitabine	33.33
29	Eplerenone	1.67
30	Eprosartan Mesylate	16.67
31	Erlotinib Hydrochloride	16.67

32	Escitalopram Oxalate	16.67
33	Esomeprazole Megnesium	33.33
34	Etoricoxib	25
35	Ezetimibe	16.67
36	Famciclovir	26.67
37	Febuxostat	16.67
38	Fosamprenavir Calcium	66.67
39	Fosinopril Sodium	33.33
40	Glimpiride	26.67
41	Indinavir	16.67
42	Itraconazole	25
43	Lacosamide	33.33
44	Lansoprazole	33.33
45	Ledipasvir Premix	16.67
46	Letrozole Intermediate	33.33
47	Levo Milnacipran	16.67
48	Levofloxacin	25
49	Lisinopril Dihydrate	20
50	Lopinavir	66.67
51	Loratadine	6.67
52	Maraviroc	16.67
53	Methyl Cobalamin	16.67
54	Mifepristone	3.33
55	Miglitol	1.67
56	Milnacipran	16.67
57	Milnacipran HCl	1.67
58	Montelukast sodium	25
59	Moxifloxacin	26.67
60	Moxonidine	16.67
61	Nadifloxacin	0.67
62	Nelfinavir	3.33
63	Olanzapine	33.33
64	Oseltamivir phosphate	25
65	Ozagrel HCl	3.33
66	Pantoprazole Sodium	25
67	Perindopril	16.67
68	Phthalazinone	33.33
69	Posaconazole	33.33
70	Rabeprazole Sodium	25
71	Raltegravir	50
72	Ramipril	33.33
73	Ranolazine di HCl	16.67
74	Rasagiline Mesylate	3.33
75	Residronate Sodium	3.33
76	Rifaximin	33.33
77	Roflumilast	3.33
78	Rufinamide	20

79	Rupatadine fumarate	3.33
80	Sequinavir Mesylate	26.67
81	Sertaconazole	16.67
82	Sertraline HCl	25
83	Simvastatin	66.67
84	Sofosbuvir	50
85	Stavudine	16.67
86	Sumatriptan Succinate	3.33
87	Tazarotene	1.67
88	Tegaserod Maleate	1.67
89	Temozolomide	2.67
90	Tiagabine	23.33
91	Tioconazole	26.67
92	Topiramate	16.67
93	Torsemide	2.67
94	Valacyclovir	50
95	Velpatasvir	16.67
96	Venlafaxine	16.67
97	Voriconazole	27.33
98	Zonisamide	33.33
99	Voglibose	1.66
	Total Production capacity worst case scenario	**1183.33 Kg/day**

The total Production Capacity Per Month is 390T

Table 1.3: Hetero Labs Limited (UNIT – IX) – Regular Products

S.No	Name of the Product	Quantity (Kg/Day)
1	Abacavir Sulphate	333.34
2	Atorvastatin Calcium	333.33
3	Darunavir	333.33
4	Dextromethorphan	333.33
5	Diltiazem	150
6	Dolutegravir Sodium	666.67
7	Efavirenz	666.67
8	Emtricitabine	333.33
9	Irbesartan	100
10	Lamivudine	3333.34
11	Levetiracetam	1333.34
12	Lopinavir	166.7
13	Losartan potassium	666.7
14	Naproxen	100
15	Nevirapine	500
16	Olmesartan	333.34
17	Quetiapine Hemifumerate	333.34

18	Stavudine	1000
19	Telmisartan	666.67
20	Tenofovir disproxil fumerate	666.67
21	Trazodone	333.34
22	Valsartan	666.67
23	Zidovudine	666.67
	Total Production capacity worst case scenario	**7666.69Kg/Day**

Table 1.4: Hetero Labs Limited (UNIT – IX) – Campaign Products

S.No	Name of the Product	Quantity Kg/Day
1	Aripiprazole	16.67
2	Atazanavir Sulphate	33.34
3	Atomoxetine HCL	33.34
4	Butenafine HCL	16.66
5	Candesartan CilexetilL	33.34
6	Cilazapril Monohydrate	16.67
7	Desloratadine	16.67
8	Didanosine	8.33
9	Entacapone	33.34
10	Escitalopram Oxalate	33.34
11	Etoricoxib	100
12	Etravin	8.33
13	Ezitamibe	33.34
14	Finasteride	20
15	Fosampravior	10
16	Hydralazine HCL	20
17	Levodopa	100
18	Loratadine	33.34
19	Merviroc	33.34
20	Milanacipron	8.33
21	Moxanidine	0.033
22	Nelfinavir Mesylate	8.3
23	Osaltavir Phosphate	100
24	Pioglitazone HCL	66.67
25	Ramipril	33.34
26	Rilpivirine	8.33
27	Ritonavir	66.67
28	Saquanavir Mesylate	8.33
29	Simvastatin	33.34
30	Spironolactone	33.34
31	Terbinafine	200
32	Toresemide	33.34
33	Verapamil	66.67

34	Voricanazole	16.66
35	Zonisamide	66.67
	Total Production capacity worst case scenario	**866.7Kg/Day**

Table 1.5: Hetero Drugs Limited (UNIT – IX) – Regular Products

S.No	Name of the Product	Qty per Day in Kgs
1	Acyclovir	333.33
2	Bupropion	500
3	Celecoxib	333.33
4	Citaloparm hydro bromide	133.33
5	Diclofenac Diethyl amine	333.33
6	Diclofenac Potassium	333.33
7	Diclofenac Sodium	800
8	Diolat-12	150
9	Divalproex sodium	333.33
10	Esomeprazole Magnesium Di Hydrate	133.33
11	EsomeprazoleMagnesium Tri Hydrate	233.33
12	Fenofibrate	333.33
13	Fexofenadine	300
14	Gabapentine	400
15	Metaxalone	166.67
16	Nabimitone	100
17	Pregabalin	200
18	RitanovirPremix Amorphous &Form)	666.67
19	Sevelamer Carbonate	100
20	Sertraline HCl Form-I & II	600
21	Topiramate	200
	Total Production capacity worst case scenario	**3166.66Kg/day**

Table 1.6: Hetero Drugs Limited (UNIT – IX) – Campaign Products

S.No	Name of the Product	Quantity per day (in Kgs)
1	Carbidopa	20
2	Cinacalcet	16.66
3	Dabigatran Etexilate Mesylate	33.33
4	Eletripan Hydrobromide	16.67
5	Febuxostat	33.33
6	Fesoterodine	6.67
7	Ivacaftor(Premix)	10
8	Lacosamide	50
9	Levodopa	33.33
10	Lopinavir	66.67
11	Lurasidone	40
12	Mamantine HCL	33.33

13	Mexiletine Hydrochloride	80
14	Mirabegron Alpha	20
15	Mirabegron Beta	33.33
16	Pitavastatin	16.67
17	Prasugrel Hydrochloride	17
18	Relaxifene Hydro chloride	33.33
19	Risidronate Sodium	16.67
20	Rilpivirine Hydrochloride	16.67
21	Rivastigmine Base	50
22	Rizatriptan	16.67
23	Rosuvastin	50
24	Rufinamide Premix	30
25	Rufinamide	33.33
26	Silodosin	6.67
27	Sodium Zirconium Cyclosilicate	50
28	Valgaciclovir	33.33
29	Zafirlukast (Amorphous)	10
30	Zolmitriptan	10
31	2-Acetoxy ethyl acetoxymethylethe	2000
32	Validation batches for Samples	100
	Total Production capacity worst case scenario	**366.66Kg/day**

Table 1.7: Effluent generation per day

S. No.	Unit	HTDS & HCOD (KLD)	LTDS & LCOD (KLD)	RO Rejects (KLD)	Domestic (KLD)	Total Effluent Generation (KLD)
1	HDL - IX	62.16	2.5		25	89.66
2	HLL - IX	101.1	4		25	130.1
3	HLL - III	261	32		60	353
4	Honour	30.87	5.35		10	46.22
5	Hetero Infra	--	35.504	30	8	73.504
Total		**455.7**	**79.354**	**30**	**128**	**692.484**

Table 1.8: Water Consumption as per Consents

S. No.	Unit	PURPOSE (KLPD)				Total Water Consumption (KLPD)
		Process & washings	Cooling	Domestic	Additional Water to RO	
1	HDL - IX	62.79	50	25	0	137.79
2	HLL - IX	101.13	70	25	0	246.13

3	HLL-III	261	161	70	0	492
4	Honour	32.23	80	10	0	122.23
5	Hetero Infra	--	--	10	107	447

Table 1.9: Details of boilers

S. No.	Capacity
1	20 TPH
2	1x 45 TPH
3	1 x 20 TPH
4	1x 12 TPH

1.5 Green Belt Development

Green belt is recommended as one of the major components of the Environmental Management Plan. The existing industry has green belt and the management emphasizes the development of further greening of the site to enhance environmental quality through mitigation of fugitive emissions, attenuation of noise levels, balancing eco-environment, consumption of treated effluent, prevention of soil erosion, and creation of the aesthetic environment. The greenbelt is in an area of 124.5 acres. The enhancement of the green belt involved the plantation of small species. Proper attention and management are being taken up by the firm to maintain the survival rate of the planted species. For plantation of the small plants digging pits are very important for preparing the soil environment near the roots of the plants. The size of the pit will be optimum enough to supply required nutrients to the roots of the plant. The usual method is to dig a pit of required size three to four months before planting of the species, which is generally done at the break of the monsoon. The pits of 45 cm x 45 cm x 45 cm size in the case of hardier spices like Eucalyptus, Shisham, Acacia etc., but larger pit size is preferred for fruit yielding trees like mango, Jamun etc. 1m x 1m x 1m pits may be used for plantation of other trees. The soils of the plant side will be mixed with 1/3 farmyard manure before refilling about a week prior to planting.

M/s. Hetero Labs Ltd. units are having good environment management plan and made this as part of their corporate policies. The firm has considered Safety, Health and Environmental protection as an integral part of their business. As a part of the environmental management plan the firm established and developed a green belt in and around each block of the plant (Figs. 1.13 to1.18).

Fig. 1.12: Green Belt inside the factory

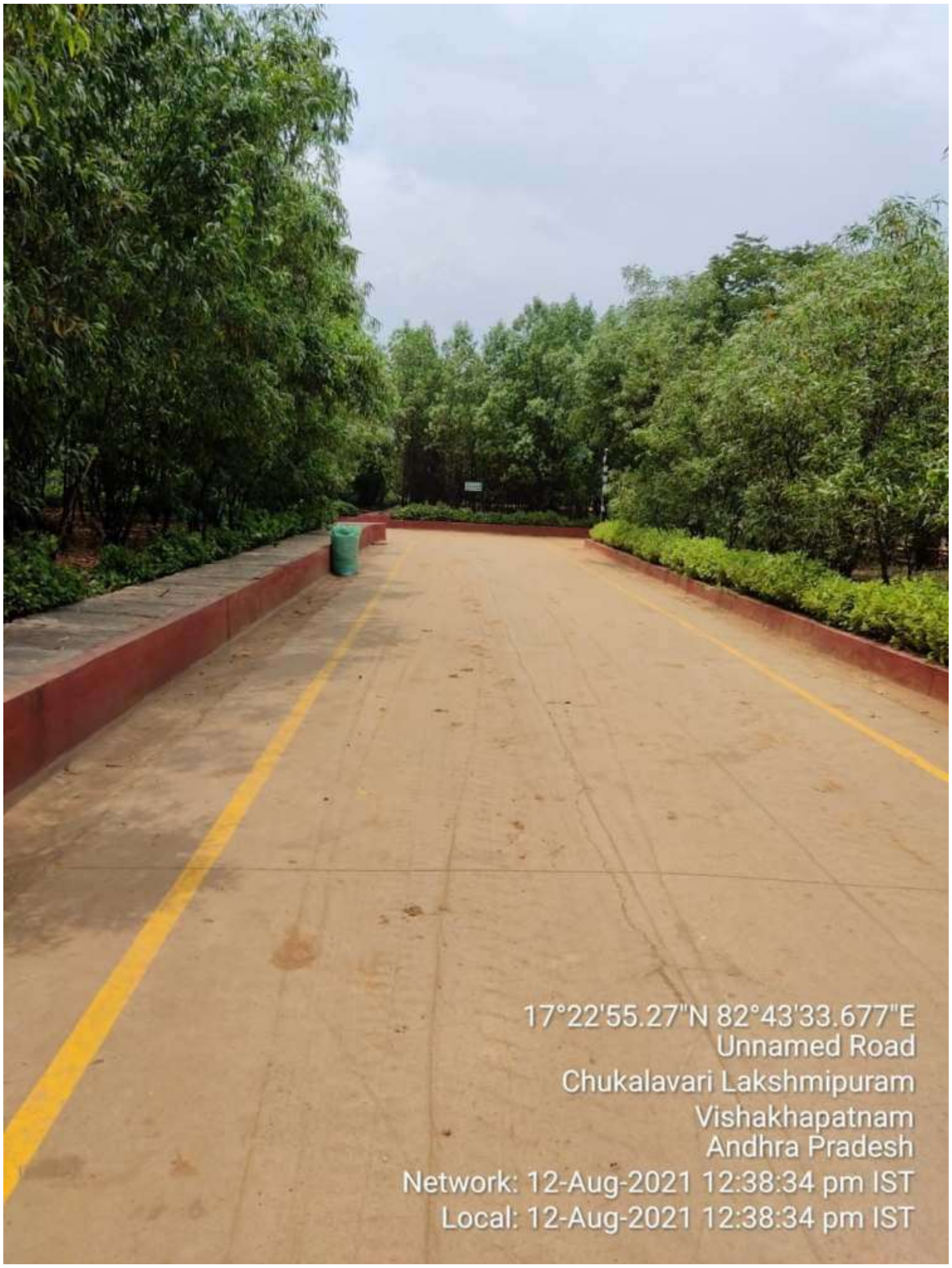

Fig. 1.13: Green Belt within the factory

Fig. 1.14: Green Belt in ETP area

Fig. 1.15: RCC Road connected to Boilers with Green Belt

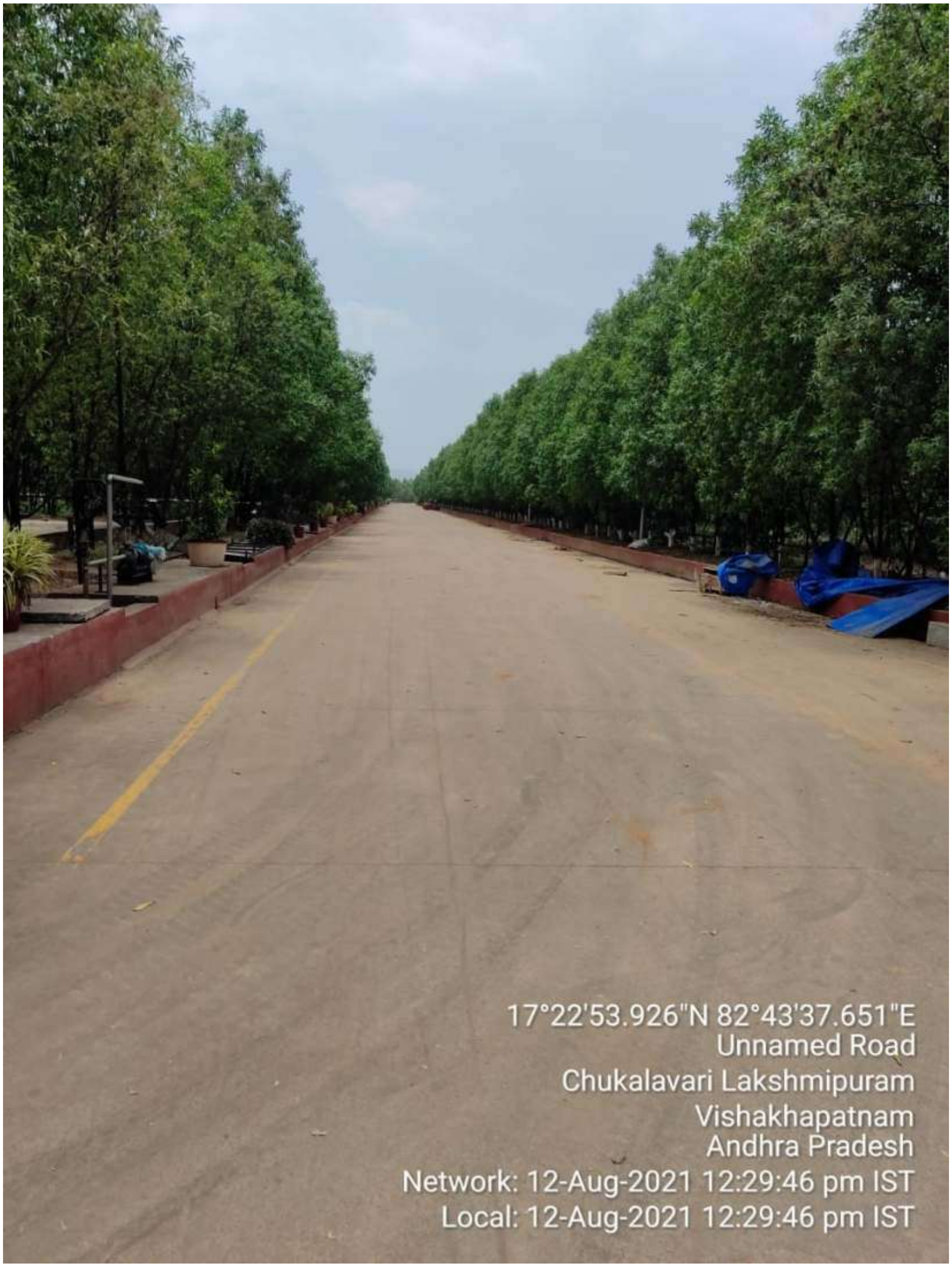

Fig. 1.16: Green Belt in the Hetero premises

Fig. 1.17: Green Belt inside the company

Chapter 2

SAMPLING AND METHODS

1.1. Sample collection

A field campaign for in-situ observations and sample collection in the coastal waters of Nallamattipalem was conducted on 7th May 2022 on a mechanized fishing boat. Samples for physico-chemical, biological, microbiological and sedimentological parameters were collected at selected 12 stations following Paris Commission Guidelines. Stations were fixed in all four directions with a distance of 0.5 km, 1.0 km and 2.0 km from the marine outfall point (MOP) (Fig. 2.1; Table 2.1). Details of the station locations such as latitude, longitude and water column depth were provided in Table 2.1. Treated effluent was collected directly from the guard pond of M/s Hetero Chemical Complex to conduct bio-assay (eco-toxicity) tests and to examine the concentration levels of heavy metals in the treated effluent

A Niskin water sampler (10L, plate. 2.1) was used to collect water samples from surface and near bottom in coastal waters off Nallamattipalem at all stations shown in Figure 2.1. Water samples were collected in pre-cleaned glass/plastic bottles as soon as the water sampler was brought onto the deck (Plates 2.2 and 2.3). The samples in duplicate were fixed immediately for dissolved oxygen (DO) after collection on deck. Samples for phytoplankton were collected in narrow mouth self-sealed 1 litre PVC bottles and added Lugols Iodine (10%) solution as a preservative. Phytoplankton samples were collected in both surface and bottom waters at each station. Meso zooplankton from the surface waters was collected by towing the bongo net fixed with a flow meter. Zooplankton samples collected in the bucket that was fixed at the end of the bongo net were removed and transferred the sampled into a PVC jar as depicted in plates 2.4 and 2.5. The volume of water filtered through the bongo net was calculated from the flow meter reading. Formalin was added as a preservative to the zooplankton sample and brought to the shore laboratory for further analysis. Surface sediment collected using Van Veen grab sampler (Plate 2.6) and sieved for benthic organisms through the benthic sieve (Plate 2.7). Benthic organisms (both macro and meio-fauna) were separated from surface sediment by washing the sediment sample on the benthic sieve with a gentle flow of water to remove clay and silt particles. Benthic organisms retained on the sieve were transferred to a PVC jar and added Rose Bengal as a preservative. Collection and laboratory analysis of phytoplankton, zooplankton and benthic fauna were given in the methodology section (Section 2.2.2).

For Biochemical Oxygen Demand (BOD) samples were collected in air-tight glass bottles and kept in the BOD incubator for five days. After five days, samples were fixed with Winklers A and B reagents for the determination of DO in the sample. Samples for dissolved inorganic nutrients were collected in plastic bottles and kept frozen until the samples reached the shore laboratory. Samples were preserved in a -20^{o}C deep freezer at the shore laboratory until the analysis is performed. Standard methods have been employed to analyse chemical constituents in seawater samples collected for this study. The collection of water samples from Niskin sampler was shown in plates 2.2 and 2.3, and towing of zooplankton (bongo) net and collection of zooplankton sample from net-bucket were shown in plates 2.4 and 2.5. Surface sediments were collected using Van Veen grab sampler (Plate 2.6) and benthic organisms from surface sediment were separated using benthic sieve (Plate 2.7).

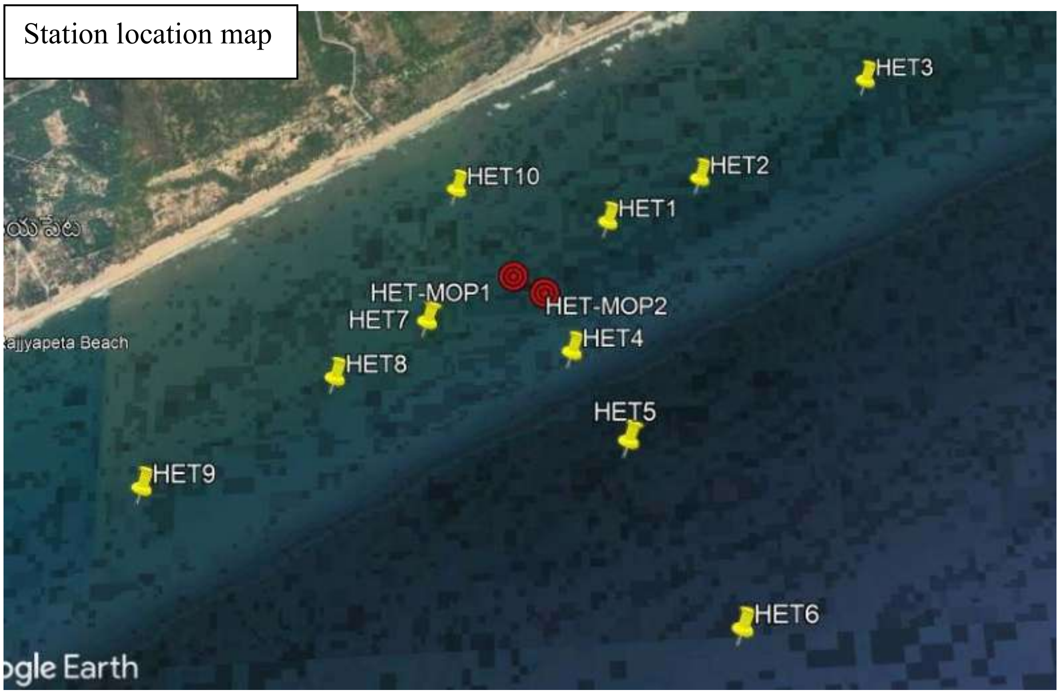

Fig. 2.1: A map showing station locations in the study area, i.e. coastal waters off Nallamattipalem. Red circles show the MOPs of M/s Hetero Chemical Complex. Yellow pins show the stations fixed in all four directions of the MOP with distances of 0.5 km, 1.0 km and 2.0 km from MOP.

Plate. 2.1: Niskin sampler (10L) used for collection of water samples

Plate 2.2: Collection of samples onboard fishing trawler

Plate 2.3: Collection of waters samples from Niskin sampler

Plate: 2.4: Towing of bongo net in surface waters for zooplankton and removal of bucket from bongo net to collect zooplankton sample

Plate: 2.5: Collection of zooplankton sample

Plate 2.6: Van Veen grab sampler

Plate 2.7: Benthic sieve

Table 2.1: Sampling locations in coastal waters off Rajayyapeta

Station Name	Latitude (″N)	Longitude (″E)
HET 1	17°21'13.56"N	82°44'45.84"E
HET 2	17°21'20.16"N	82°45'1.44"E
HET 3	17°21'35.94"N	82°45'30.66"E
HET 4	17°20'52.56"N	82°44'39.18"E
HET 5	17°20'38.22"N	82°44'47.58"E
HET 6	17°20'9.72"N	82°45'3.48"E
HET 7	17°20'58.62"N	82°44'16.02"E
HET 8	17°20'50.34"N	82°44'1.26"E
HET 9	17°20'34.86"N	82°43'31.44"E
HET 10	17°21'20.28"N	82°44'21.00"E
Hetero- MOP1	17°21'7.00"N	82°44'31.00"E
Hetero- MOP2	17°21'04.0"N	82°44'36.0"E

Table 2.2: Names of scientific and technical personnel participated in the field campaign

S. No.	Name of Personnel	Designation
1	Dr. TNR Srinivas	Senior Scientist
2	Mr. I Dhanunjaya Rao	Project Associate
3	Mr. Shrish Vashishth	Project Associate
4	Mr. Joseph Ignitiuous	Project Associate

2.2. Methodology

2.2.1. Physico-chemical characteristics

The Physico-chemical parameters were analysed through the standard procedures following Carrit and Carpenter (1966), Grashoff (1974), Suzuki and Ishimaru (1990) and

Grassoff et al. (1992). The detailed methodology of each parameter is given below, and the instruments used in this study were given in Table 2.3. Temperature and salinity were obtained from CTD (SBE-19plus; Sea-Bird Electronics, USA) profiler.

a) pH

pH of the seawater sample collected in air-tight glass bottle (60ml) was measured using a Metrohm pH analyzer (Titrando 865). Standard buffer solutions (Merck, Germany) were used for calibration of the instrument. Based on the repeated analysis of aliquots of standards and samples, the precision of the analysis for pH is 0.002 units.

b) Dissolved Oxygen (DO)

Winkler's method was adopted for the determination of DO concentrations. A measured volume of water sample was fixed immediately after collection with the reagents Winkler's A (manganous chloride) and Winkler's B (alkaline potassium iodide). Standard titration with sodium thiosulphate (standardized with potassium Iodate, KIO_3) was adopted for the analysis purpose. Concentration of DO was expressed in mg/l. The precision of analysis, expressed as standard deviation with this method was ±0.07%.

c) Biochemical Oxygen Demand (BOD)

Samples for the determination of biochemical oxygen demand were collected in triplicate. The dissolved oxygen concentration was determined using one of the triplicate samples according to Winkler's method, as detailed above. The remaining bottles were kept in the BOD incubator for three days at 20ºC. Dissolved oxygen in these samples was determined after fixing the samples on completion of three days of incubation. BOD_3 was computed from the initial DO concentrations and expressed in mg/l.

d) Ammonium - Nitrogen (NH_4^+ - N)

Ammonical - Nitrogen in seawater samples was determined with the indophenol blue method using trione. Care was taken for the analysis of ammonium and ammonia free distilled water was used for analysis to avoid any contamination as ammonia is highly soluble in water. The absorbance of the coloured complex was measured at 630 nm in Spectrophotometer against a standard. NH_4 - N is expressed in µmol/l and the precision of analysis, in terms of standard deviation, is ±0.02 µM

e) Nitrite - Nitrogen (NO_2^- - N)

Nitrite was determined by the method of Bend Schneider and Robinson whereby the nitrite in the water sample was diazotised with sulphanilamide and coupling with N-1-Naphthyl ethylene diamine dihydrochloride. The absorbance of the resultant azo-dye was measured at 543 nm against a standard solution. Concentrations of NO_2^-- N in seawater is expressed in µmol/l.

f) Nitrate - Nitrogen (NO_3^- - N)

Nitrate in the seawater sample was first reduced to nitrite using heterogeneous reduction by passing the buffered seawater samples through an amalgamated cadmium column and the resultant nitrite was determined as above. The measured absorbance was due to initial nitrite present in the sample and nitrite obtained by reduction of nitrate in the sample. Necessary correction was therefore applied for any nitrite initially present in the sample. Concentrations of NO_3^-- N in seawater were expressed in µmol/l. The precision of analysis for both nitrite and nitrate, in terms of standard deviation, is ±0.02 µmol/l

g) Phosphate - Phosphorus (PO_4^{3-} -P)

Inorganic phosphate was measured by the method of Murphy and Riley in which the samples were made to react with acidified molybdate reagent and then reduced using ascorbic acid. The absorbance of the resultant phosphorous molybdenum blue complex was measured at 880 nm against a standard. Concentrations of PO_4^{3-}- P in seawater were expressed in µmol/l. The precision of analysis, in terms of standard deviation, is ±0.01 µmol/l

h) Silicate - Silicon (SiO_4^{2-} - Si)

Silicate - silicon was also estimated by reaction with acid - molybdate and ascorbic acid in the presence of oxalic acid. The interference of phosphate is prevented by addition of oxalic acid. The absorbance of the resultant silico - molybdenum blue complex was measured at 810 nm in Spectrophotometer against a standard. Concentration of SiO_4^{2-}- Si in seawater was expressed in µmol/l. The precision of analysis, expressed as standard deviation, is ±0.02 µmol/l

i) Total Phosphorus (TP)

The seawater sample was autoclaved with alkaline potassium persulphate in a closed bottle. The solution was neutralized and then estimated for phosphate as described above for phosphate – phosphorous. The total phosphorus is expressed in µmol/l.

µmol/l. The precision of analysis, expressed as standard deviation, is ±0.02 µmol/l

j) Total nitrogen (TN)

Aliquot of the seawater samples were analyzed for total nitrogen (TN) on TOC and TN analyzer (Elementar).

k) Total suspended matter (TSM)

One litre of seawater sample was filtered through a pre-weighed Polycarbonate filter (0.22 µm; Millipore) and after filtration the filter was dried for about 2 days at 60°C. The dried filter was weighed and noted down the reading. The filter was dried again and took the weight measurement. This procedure was continued until the weight loss of the filter due to drying is zero. The weight of the material retained on the filter was considered as TSM concentration and was expressed as mg/L.

l) Petroleum Hydrocarbons (PHC)

Total petroleum hydrocarbons (TPHC) concentrations in seawater samples were determined by a standard liquid-liquid extraction method (LLE, EPA method 3510) (Morries, 2013; Ahmed et al., 2015) using Ultra Violet Spectrofluorometric (UVF) detection technique (Greason, 2009) which is more efficient and reliable for TPHC determination in water samples (Adeniji et al., 2017). Seawater sample (500ml) was extracted with HPLC grade n-hexane (20ml) three times and the combined extract was dried over anhydrous sodium sulphate to remove moisture content. Fluorescence of the extract was measured at an emission wave length of 360 nm (excitation wave length 310 nm) using spectrofluorometer (Cary Eclipse, Varian). Blanks prepared by following the same procedure which was employed for sample collection were used to correct the fluorescence of the samples. PHC concentrations in seawater were calculated from the multi-point calibration established by chrysene as a standard. Results of TPHC concentrations in seawater samples are expressed as chrysene equivalents. Repeated analysis of aliquots of samples and standards yielded ±4% of the precision for the TPHC measurements.

2.2.2. Biological Characteristics

All analyses were conducted as per the NIO methodology manual for biological parameters, an in-house compilation based on internationally used published methods

a) Phytoplankton

1-2 litre of the water samples were collected with the help of a Niskin sampler from the surface and bottom. The collected samples were preserved with lugols iodine (10%) and few drops of 2.5 % buffered formalin. In the laboratory, phytoplankton samples were allowed to settle for 24-48 hrs. in one litre measuring jars. After the gravity settlement, the samples were concentrated into 10ml from which 1ml samples were taken and phytoplankton cells were enumerated using a Sedgwick Rafter counting chamber following a standard protocol (UNESCO, 1978). Phytoplankton cells were identified into the genus/species levels using the Olympus inverted microscope (model: IX 71) with the aid of standard taxonomic literatures of Diatoms, Dinoflagellates and Blue-green algae (Subrahmanyam, 1946).

b) Zooplankton

Zooplankton samples were collected through horizontal hauls of HT net (49.5 cm diameter and 200 µm mesh) attached with the calibrated digital flow meter to measure the amount of water filtered through the net. At each station, the net was operated for 5 minutes as shown in Plate 2.4 and the sample remained in the bucket (Plate 2.5) after filtering the seawater through the 200 µm mesh was collected in a pre-cleaned PVC bottle. The excess waters were removed using bolting paper. Zooplankton biomass was measured through the displacement method (Postel et al., 2000). After the biomass measurements, zooplankton samples were preserved in 4-5% buffered formaldehyde for further analysis. In the laboratory, 25-50% of subsamples were taken using Folsom's plankton splitter the subsamples were analyzed in detailed for quantitative analysis. Zooplankton samples were sorted into group levels using the standard literatures of the Conway et al., 2000 and their abundances were represented in m^3.

c) Benthos

Samples for benthos i.e., bottom living organisms, were collected using a Van Veen grab (Plate 2.6), covering an area of $0.04m^2$ and a penetration depth of 10 cm. Biota (organisms) contained in the sediment were separated by wet sieving (Plate 2.7).

(i) **Meio-fauna**

Sub-samples for meiofauna were collected from the Van Veen grab using a hand core (3 cm diameter) and preserved in formalin-Rose Bengal solution. Samples were passed through a set of two sieves; 0.5 mm and 0.045 mm mesh sieve. The material retained on the finer mesh was used for the analysis of meiofauna. All organisms were sorted and counted under binocular stereoscope microscope in the laboratory. An average of three replicates was taken for the population count and expressed as number per 10 cm^2.

(ii) **Macro fauna**

The sediment samples for macro fauna was washed through a 0.5 mm mesh size sieve and the retained samples were preserved in 10% seawater formalin containing Rose-Bengal stain. In the laboratory, the macro faunal samples were again washed through 0.5 mm mesh sieve in running water to clear adhering sediments. All stained animals were picked and preserved in 5% formaldehyde. Later organisms were sorted and counted group wise under a stereoscope zoom binocular microscope. Wet weight of major macro faunal taxa was recorded on a single pan balance. Fauna was identified as far as possible.

2.2.3. Microbiological parameters

About 100 ml of the sample was sub-sampled into a pre-sterilized bottle for bacterial analysis. All samples were collected with precautions required for microbiological analysis.

Sample serially diluted to 3 times of 10^{-1} to 10^{-3} with sterile salt water. Heterotrophic bacterial counts were determined using R2A agar. Around 100 µl of each serially diluted water samples is plated on R2A agar plates and spread with sterile glass rod and incubated at 37 ºC for 48-72 hours. The colonies formed on the plates are counted using the colony counter and represented as a number of colony forming units (CFU) per ml of water sample after considering dilution factor. Total coliform counts were obtained by plating water samples on MacConkey agar. The colonies formed on the plates are counted using the colony counter and represented as number of colony forming units per ml of water sample after considering the dilution factor. The colonies of pink-red colour and with bile precipitate are counted as ECLO on MacConkey agar plates. The colonies of colourless to pale pink are counted as EFLO on MacConkey agar plates. PALO counts were obtained by plating water samples on Cetrimide agar. The colonies exhibiting fluorescence at 250nm and a blue green pigmentation are considered PALO. VLO counts were obtained by plating water samples on TCBS agar. The colonies formed on the TCBS agar plates are counted as VLO. The colonies of yellow colour are counted as VCLO on TCBS agar plates. The colonies of bluish-green colour are counted as VPLO on TCBS agar plates.

Table 2.3: List of instruments used for this study

S. No.	Name of the instrument	Make & Model	Parameter
1.	CTD Profiler	Sea-Bird Electronics, USA, SBE-19 plus	Temperature and salinity
2.	pH meter	Metrohm, Switzerland Titrando 830	pH
3.	DO titrator	Titrando 835; Metrohm, Switzerland	DO and BOD
4.	Spectrophotometer	Shimadzu, UV-1800	Ammonium
5.	Spectrofluorometer	Turner Designs	Chlorophyll-*a*.
7.	BOD incubator	Tempo Instrument Pvt. Ltd.; TI 500	BOD (incubation)
8.	Auto Analyzer	Skalar, The Netherlands	Nitrite, nitrate, phosphate, silicate
9.	Diaphragm pumps	KNF and Merk Millipore	Separation of particulate matter
10.	Flow Cam	Fluid Imaging Technologies, VSIV	Phytoplankton and Zooplankton
11.	Fluorescence microscope	Olympus (BX51), Nikon (Eclipse80i)	Phytoplankton and Bacteria
12.	Inverted microscope	Olympus, IX 71	Zooplankton
13.	Stereo zoom microscope	Nikon (SMZ 25)	Benthic organisms
14	Precision balance	Sartorius, Cubis	Total suspended matter

2.2.4. Bio-assay (toxicity) test

Discharges into the aquatic environment of contaminated wastewater from various industries represent a major source of aquatic pollution. Aquatic organisms are exposed to a number of pollutants emanating from various types of industries. Concern for the impact of chemical pollution on the quality of aquatic ecosystems has stimulated over 30 years of research on the biological effects of pollutants. Quantifying the ecotoxicological effects of pollutants is critical to the protection of aquatic ecosystems. Determination of water quality criteria for aquatic life is similar to the solving of most biological problems in which experimental data are obtained under controlled laboratory conditions in order to predict effects that might occur under natural conditions.

Physico-chemical parameters are generally used for the evaluation of effluent quality. However, monitoring of these parameters alone cannot provide a measurable quantity in the toxicity assessment. Furthermore, in some cases, the quality of waste water in terms of physico-chemical parameters may conform to the permissible limits, and the wastewater may be toxic to the aquatic flora and fauna. Therefore, toxicity evaluation through bioassays forms an important and cost-effective tool in wastewater quality monitoring programmes.

Acute toxicity tests (bioassays) are generally performed to evaluate the toxicant and other materials used in the coastal environment to determine the relative sensitivity of different living organisms and permissible effluent discharge dose. It is a procedure in which the responses of aquatic organisms are used to detect or measure the presence or effect of one or more substances, in a particular ecosystem. Median lethal concentration (LC_{50}) of a toxicant is the concentration that results in the mortality of a specified portion of the population within a definite period of time. Median lethal concentration (LC_{50}) of a toxicant in an environmental medium which results in 50% mortality of test organisms within a definite period of exposure periods (such as 24 hrs, 48 hrs, 72 hrs and 96 hrs) is called LC_{50}. The LC_{50} values in turn represent the median lethal concentration or median tolerance limit.

In this study, Acute toxicity tests conducted on treated effluents were carried out using Whole Effluent Toxicity (WET) methods of USEPA to assess the potential toxicity of effluents using the zebrafish specimens of 30-35mm in length as test species, as suggested by central pollution control board (CPCB). The results of these tests can be used for a variety of functions including resource consent monitoring and compliance, toxicity identification evaluations and evaluation of effluent treatment processes. WET tests were performed to determine the actual impacts of effluents on organisms residing in receiving waters where the effluents were discharged.

2.2.4.1 Whole Effluent Toxicity (WET) Testing

The establishment of toxicity-based limits relies on the use of standardized laboratory toxicity tests that can assess the potential effect of effluents on aquatic life in the receiving system. Since effluents often contain complex mixtures of chemicals that are poorly characterized, a suite of acute and chronic toxicity tests (termed whole effluent toxicity, or WET, testing) is used to measure the aggregate toxicity of chemicals in an effluent (US-EPA, 1991). Whole Effluent Toxicity (WET) testing is a term used to describe the adverse effects or toxicity to a population of aquatic organisms caused by exposure to an effluent. This toxicity can be experimentally determined in the laboratory by exposing sensitive organisms to effluents using WET tests. Responses assessed usually include survival, growth, and/or reproduction. This type of test can be used to evaluate the toxicity of effluents, storm-water, or ambient surface waters. WET testing is used to assess and regulate the combined effects of all constituents of a complex effluent rather than the conventional methods of controlling the toxicity of single chemicals or constituents.

WET testing exposes laboratory populations of aquatic organisms such as fish, invertebrates, and algae to diluted and undiluted effluent samples under controlled conditions in order to estimate the environmental toxicity of that sample. The information is used to prevent the discharge of toxic amounts of pollutants to surface waters. The standardized procedures of WET tests allow one to determine the actual environmental exposure of aquatic life to effluent or ambient water without knowledge of the chemical, physical, and biological characteristics of that discharge or ambient water. Whole Effluent Toxicity (WET) testing is an important component of the US Environmental Protection

Agency's (USEPA's) integrated approach for detecting and addressing toxicity in surface waters.

Aquatic test organisms are placed in test containers that usually contain a series of concentrations of a sample. Tests usually include 100% sample and sample mixed with various amounts of dilution water (control water containing no sample) to form a series of sample dilutions. Observations of the organism's response, such as mortality, are made at specific time intervals. The duration of the test ranges from periods as short as 40 minutes up to 7 days depending on the organisms used and whether acute or chronic effects are of interest. At the end of the test, the results are used to estimate the toxicity of the sample. Control survival must be 90% or greater for an acceptable test. The test "passes" if survival in the control and effluent concentration equals or exceeds 90%. The test "fails" if survival in the effluent is less than 90%, and is significantly different from control survival (which must be 90% or greater), as determined by hypothesis testing.

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2.2.4.2 Test Species

Acute toxicity test (bioassays) of treated effluent was carried out using the locally available zebrafish specimens of 30-35mm in length as test organisms, as suggested by CPCB (method IS:6582-1971).

Zebrafish (Danio Rerio, F. Hamilton, 1822)

The fish species selected for bioassay experiments were zebra fish, *disambiguation* (Danio rerio). The taxonomic position of the test species is given below:

Phylum: Chordata
Class: Actinopterygli
Order: Cypriniformes
Family: Cyprinidae
Subfamily: Danioninae
Genus: *Danio*
Species: *D. rerio*

The test organism selected for toxicity tests was freshwater fish belonging to the minnow family, Cyprinidae, often called as tropical fish. It is a vertebrate model organism that is widely used in scientific research. This fish is also largely available in private ponds in different varieties. Zebra fish of pink variant was used in this study for bio-assay test on treated effluent.

Plate 2.8: Zebrafish (*Danio rerio*)

A large number (~6000) of healthy zebra fish of pink variety were procured from local commercial sources (Visakhapatnam) and transported to the Laboratory of CSIR-National Institute of Oceanography (CSIR-NIO), Regional Centre, Visakhapatnam in oxygenated polythene bags. After the arrival to the Laboratory, zebrafish were acclimatized by keeping them in large tanks with continuous aeration for a minimum period of two weeks before being subjected to bioassay experiments.

During the acclimatization period, zebra fish were fed with artificial pellet feed twice a day. Before the start of bioassay experiments, the length of the test animals was observed and found to be having a length in the range of 30-35 mm. Physico-chemical parameters of seawater in the acclimation tanks fell within the recommended optimum levels for the rearing of zebrafish: water temperature, (30.3±0.5 ºC), dissolved oxygen (6.8±0.2 mg/l), pH (7.6±0.2) and NH_3/NH_4 (<0.5 mg/l).

2.2.4.3 Experimental Set-up

Ground water was used throughout the experiment for the acclimatization of fish, control tank and as diluent. All the experiments were conducted at room temperature of 28 °C, with a maximum day and night variation of 2 °C. No Feed was given to test animals 48 hrs prior to the experiments or during the experiments. Different concentrations of test solutions of effluent were chosen for the following sets of experiments, under slow continuous aeration. Dissolved oxygen in the experimental and control tanks was always maintained at >5 mg/l throughout the exposure study using artificial aeration. Each set of experiment was accompanied by a Control with three replicates. Appropriate volumes of effluent concentration prepared as above were added to containers tanks containing zebrafish (*Danio rerio*) of the pink variety.

The test containers were inspected at regular intervals for recording mortality at different exposure periods of 1 hr, 6 hrs, 12 hrs and 24 hrs during the first day of the experiment followed by every 12 hrs till completion of the experiment (i.e., 96 hrs) for calculating the LC_{50} values. The dead organisms were removed immediately from tanks in order to avoid any type of bacterial contamination. Records were also maintained for any abnormal behaviour of the test animals. At the end of each test, the organisms were transferred to a clean tank for observing their recovery. The average percent mortality recorded at different test solutions in triplicate test containers during the four exposure periods was determined. The median lethal concentration (LC_{50}) values in the percentage of toxicant for zebra fish exposed to different concentrations of effluent were calculated based on the mortality rates.

2.2.4.4. Data analysis

Mortality of test organisms for different effluent samples over different exposure periods are presented in the Results Section. The mortality values of different effluent water samples for different exposure periods (24 hrs, 48 hrs, 72 hrs and 96 hrs) were calculated following the method of log-probit transformation for time and dose-mortality curves suggested by Finney's method (1971) using LDP line software (http://embakr.tripod.com/ldpline).

Table 2.4: Summary of conditions and acceptability criteria for WET acute Toxicity Test with zebra fish as test species

Type	Comment
Test condition	Static non-renewal
Test duration	96 hrs
Temperature	>28 °C
Photoperiod	12 hrs light: 12 hrs dark
Test chamber size	25 Litres
Age of test organisms	30 Day Post Larvae
No. organisms per test chamber	30 animals
No. replicate chambers per concentration	Three
Feeding	None
Test solution aeration	Yes, >5 mg l^{-1}
Dilution water	Groundwater
Test concentrations	07 effluent concentrations and a control
Dilution series	Effluents: ±0.5 dilution series
Endpoint	Effluents: Mortality
Sample volume	Nil
Test acceptability criterion	90% survival in 100% effluent after 96 hrs

2.2.4.5 Acute Toxicity of treated effluents with a WET test

Acute toxicity of treated effluents with whole effluent toxicity test expressed in terms of median lethal concentrations (LC_{50}) was evaluated by subjecting the acclimatized zebra fish of pink variety exposed to four exposure periods (24 hrs; 48 hrs; 72 hrs and 96 hrs) with seven different concentrations (% v/v) of effluent test solutions. Experiments were conducted under static conditions and all experimental tanks had a triplicate and each experimental set included a Control (0%). The average percent mortality recorded at different test solutions in triplicate test containers during the four exposure periods was determined.

Data on average mortality of test animals (in percentage) in different test concentrations of treated effluent collected from M/s Hetero Infrastructure SEZ Limited over four exposure periods is presented in Table 3.23. The median lethal concentration (LC_{50}) of treated effluent to test species at different exposure periods is shown in Table 3.24. No mortality was observed in control treatment during the exposure period of 96 hrs.

Chapter 3

RESULTS AND DISCUSSION

3.1. Physico-chemical characteristics

Physical parameters such as salinity and temperature in the surface and bottom waters of the station locations were provided in Table 3.1. The results of biogeochemical parameters such as pH and Chlorophyll-*a* were provided in Table 3.2, while the concentrations of dissolved inorganic nutrients were given in Table 3.4.

Temperature ranged from 29.14 to 29.98 ^{o}C in the surface and from 28.96 to 29.66^{o}C in the bottom waters of the study region (Table 3.1), with mean values of 29.59±0.23 ^{o}C and 29.25±0.18 ^{o}C, respectively, during the sampling period.

Table 3.1: Temperature (^{o}C) and salinity in the surface (SUR) and bottom (BOT) waters at the sampling stations in the study region

Station Name	Depth (m)	Temperature		Salinity	
		SUR	BOT	SUR	BOT
H1	13.7	29.98	29.20	33.43	33.38
H2	14	29.81	29.24	33.40	33.42
H3	14.1	29.75	29.29	33.40	33.38
MOP1	13.2	29.73	29.27	33.43	33.40
MOP2	14	29.63	29.38	33.45	33.37
H4	14.6	29.62	29.22	33.03	33.40
H5	17.1	29.70	28.99	33.43	33.47
H6	18.8	29.54	28.96	33.69	33.43
H7	13.1	29.14	29.36	33.69	33.40
H8	13.4	29.36	29.31	33.50	33.40
H9	13.5	29.39	29.15	33.56	33.43
H10	8.5	29.46	29.66	33.18	33.41

Sea surface salinity in the study region varied from 33.03 to 33.69 PSU (Table 3.1), with a mean salinity of 33.43±0.18 PSU. In the bottom waters, salinity ranged between 33.37 and 33.47 PSU (Table 3.1), with a mean salinity of 33.41±0.034 PSU during the study period. The range of salinity values observed in this study are close to those reported previously from this region during April-May.

pH of the study region ranged from 8.18 to 8.28 in the surface and from 7.77 to 8.28 in the bottom (Table 3.2; Fig. 3.1), with mean values of 8.24±0.03 and 8.21±0.14, respectively. These values are concurrent with the range of pH values observed in the coastal waters off Visakhapatnam and Kakinada in the western coastal Bay of Bengal. However, the pH values found in this study are higher when compared to the pH values reported from this region in 2017 (7.4-8.0 and 7.5-8.0 in the surface and bottom waters, respectively). Phytoplankton biomass, expressed in terms of Chlorophyll-*a* (Chl-*a*) concentration, ranged from 0.23 mg/m^3 to 0.42 mg/m^3 in the surface and from 0.31 mg/m^3 to 0.56 mg/m^3 (Table 3.2; Fig. 3.1) in the bottom waters during the study period. Mean Chl-*a* concentrations in the study region are 0.32±0.1 mg/m^3 in the surface and 0.41±0.1 mg/m^3 in the bottom waters. The Chl-*a* values found in this study are remarkably lower than those reported in 2018 from this region both in surface (range: 2.43-7.44 mg/m^3) and in the bottom waters (range: 1.2-5.86 mg/m^3). The range and mean concentrations of Chl-*a* found in this study are considerably lower than those values observed in the coastal waters off Kakinada and Yanam, and in the nearby coastal location in the western coastal Bay of Bengal. Considerably lower phytoplankton biomass (Chl-*a*) in this study may be due to either lower biological production and/or higher grazing pressure.

Table 3.2: pH and Chlorophyll-*a* in the surface (SUR) and bottom (BOT) waters at the sampling stations.

Station Name	Depth (m)	pH		Chl-*a* (mg/m^3)	
		SUR	BOT	SUR	BOT
H1	13.7	8.235	8.256	0.24	0.36
H2	14	8.281	8.228	0.28	0.56
H3	14.1	8.271	8.234	0.36	0.45
MOP1	13.2	8.247	7.769	0.25	0.31
MOP2	14	8.24	8.286	0.23	0.32
H4	14.6	8.27	8.244	0.33	0.32
H5	17.1	---	8.242	0.34	0.42
H6	18.8	8.23	8.238	0.36	0.43
H7	13.1	8.284	8.23	0.42	0.42
H8	13.4	8.245	8.283	0.31	0.38
H9	13.5	8.186	8.283	0.32	0.47
H10	8.5	8.221	8.257	-	-

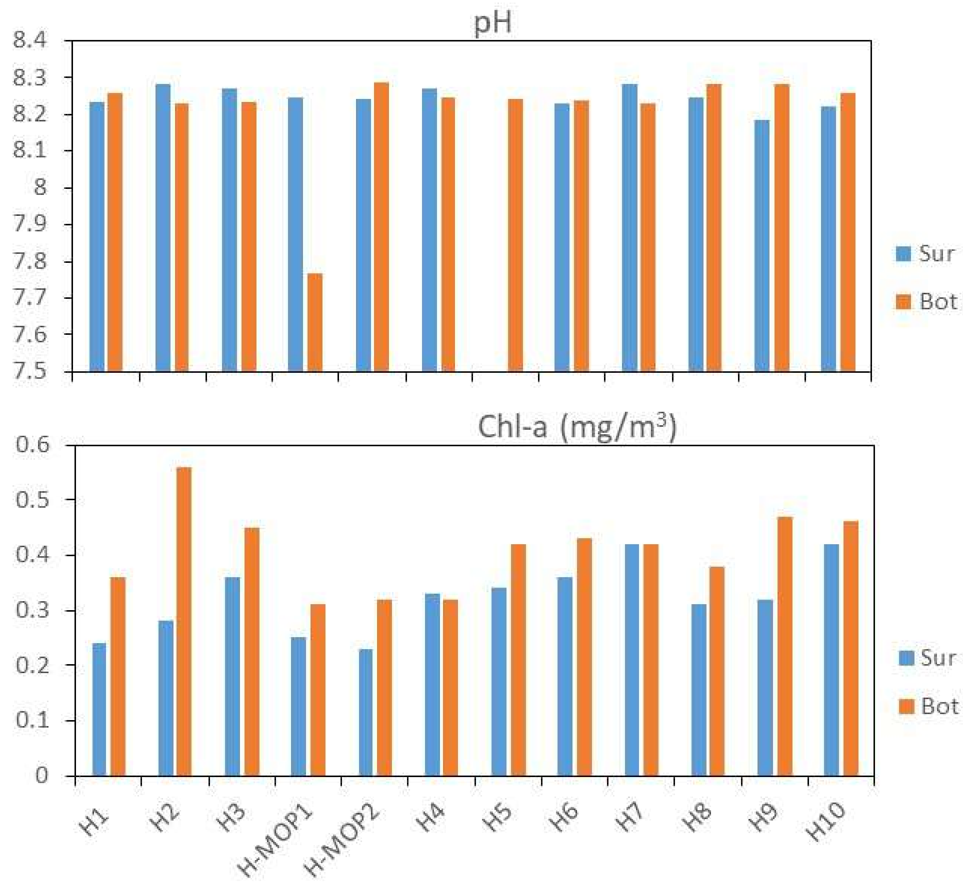


Fig 3.1: Spatial variability of (a) pH and (b) chlorophyll-a (mg/m^3) in the coastal waters off Rajayyapeta during the study period

Dissolved oxygen (DO) concentrations varied from 5.6 to 6.4 mg/L in the surface and from 4.6 to 6.3 mg/L in the bottom waters of the study region (Table 3.3; Fig. 3.2). The mean DO concentrations were 6.1±0.2 mg/L and 5.8±0.5 mg/L in the surface and bottom waters, respectively. DO concentrations found in this study are considerably higher than those found in both surface and bottom waters of this region in 2017 (2.7 – 6.0 mg/L and 3.3-5.9 mg/L, respectively). The DO concentrations found in this study are relatively higher than those found during 2010, 2014 and 2017 monitoring studies conducted in this region and more or less similar to those found during 2007 and 2012 monitoring studies conducted in this region. No significant deviation in DO concentration was found at the

MOP locations compared to the nearby locations around the MOPs in the coastal waters of Rajayyapeta. The mean DO concentrations observed in the surface (6.1±0.2 mg/L) and bottom (5.8±0.5 mg/L) waters of the study region are above the thresh hold limit of 5.0 mg/L for healthy coastal waters. Nevertheless, the observed DO concentrations in this study are comparable to or slightly higher than those reported in the base line data (EIA report of this project) of this region, indicating that no significant change in the DO concentrations of the marine environment. Biochemical oxygen demand for three days (BOD_3) ranged from 0.6 to 3.2 mg/L in the surface and from 0.8 to 4.1 mg/L in the bottom waters during the study period (Table 3.3; Fig. 3.2). The range of BOD_3 values found in this study is relatively higher than the range of values reported from this region in 2017 (0.4-2.75 mg/L and 0.3-2.10 mg/L in the surface and bottom waters, respectively), indicating that increased input of biodegradable organic matter from local sources to this coastal region in recent years. However, mean BOD_3 values in the surface and bottom waters of this study (1.9±0.7 mg/L and 2.1±1.0 mg/L, respectively) indicates no significant pollution of organic matter in this region during the study period.

Concentrations of dissolved inorganic nutrients such as phosphate, silicate, nitrite, and nitrate in the surface and bottom waters of the study region were given in Table 3.4 and Fig. 3.3. Phosphate concentrations ranged from 0.2 to 0.9 µM in the surface and from 0.2 to 1.1 µM in the bottom waters (Table 3.4), with mean phosphate concentrations of 0.5±0.2 µM and 0.5±0.3 µM, respectively. Phosphate concentrations found in this study are slightly lower than those reported in 2017 from this region in both surface (range: 0.45 to 1.39 µM) and bottom (range: 0.85 to 1.47 µM) waters. Dissolved inorganic silicate concentrations during the study period ranged from 6.7 to 28.0 µM and from 4.6 to 25.9 µM in the surface and bottom waters (Table 3.4), with mean silicate concentrations of 13.4±5.8 µM and 13.5±5.9 µM, respectively. In contrast to that of phosphate, silicate concentrations are relatively higher than those observed from this region in 2017 both in the surface (range: 4.9-8.9 µM) and bottom (range: 7.4 – 15.5 µM) waters.

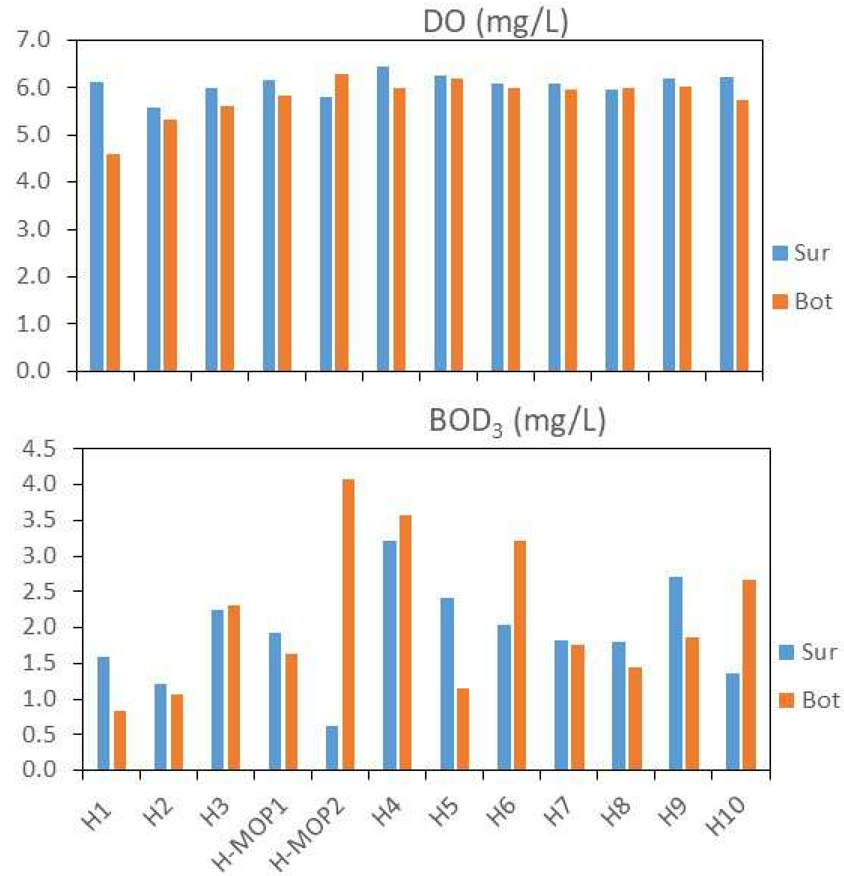


Fig. 3.2: Spatial variability of DO and BOD at various stations in the surface and bottom waters of the study region

Nitrite concentrations varied between 0.02 and 0.52 µM in the surface (mean: 0.13±0.1 µM) waters and between ND and 0.78 µM (mean: 0.23±0.2µM)) in the bottom waters. The range of nitrite concentrations observed in this study in the surface (0.02-0.52 µM) and bottom (ND-0.78 µM) waters are close to the range of values observed in 2017 from this region (0.1-0.6 µM and 0.1-0.5 µM in the surface and bottom waters, respectively). Nitrate concentrations ranged from 8.1 to 23.4 µM in the surface, with a mean nitrate concentration of 15.6±5.1 µM. These concentrations are remarkably higher than those observed in surface waters of this region in 2017 (range: 1.5 – 4.5 µM), whereas, in the bottom waters nitrate concentrations ranged from 5.7 to 19.9 µM, with a mean concentration of 13.0±4.4 µM. Similar to that of the surface waters, bottom waters of this study also recorded significantly higher nitrate concentration compared to those observed in the bottom waters of this region in 2017 (range: 1.5 – 3.8 µM) Both silicate and nitrate concentrations in this study are higher than those reported in 2017 from this region, whereas phosphate concentrations in this study are slightly lower than those reported in 2017 from this region. Nevertheless, nitrate concentrations in this study are relatively higher than those found in this region in 2017 and in coastal waters of the western coastal Bay of Bengal, indicating increased input of nitrate from local sources to this coastal region in recent years.

Table 3.3: Dissolved oxygen (DO; mg/L) and biochemical oxygen demand for three days (BOD_3; mg/L)) in the surface (SUR) and bottom (BOT) waters at the sampling stations.

Station	DO (mg/L)		BOD_3 (mg/L)	
Name	SUR	BOT	SUR	BOT
H1	6.1	4.6	1.6	0.8
H2	5.6	5.3	1.2	1.1
H3	6.0	5.6	2.2	2.3
MOP1	6.2	5.8	1.9	1.6
MOP2	5.8	6.3	0.6	4.1
H4	6.4	6.0	3.2	3.6
H5	6.3	6.2	2.4	1.1
H6	6.1	6.0	2.0	3.2
H7	6.1	5.9	1.8	1.8
H8	5.9	6.0	1.8	1.5
H9	6.2	6.0	2.7	1.9
H10	6.2	5.7	1.3	2.7

Table 3.4: Dissolved inorganic phosphate (µM), silicate (µM), nitrite (µM) and nitrate (µM) concentrations in the surface (SUR) and bottom (BOT) waters at the sampling stations.

Station	Phosphate		Silicate		Nitrite		Nitrate	
	SUR	BOT	SUR	BOT	SUR	BOT	SUR	BOT
H1	0.5	0.3	8.3	11.5	0.06	0.08	11.9	9.1
H2	0.7	0.3	14.8	14.3	0.04	0.06	11.6	19.4
H3	0.3	0.4	28.0	13.2	0.52	0.56	12.7	17.2
MOP1	0.8	1.1	6.7	25.9	0.20	0.78	8.1	5.7
MOP2	0.2	0.3	14.3	15.5	0.26	0.20	22.2	8.8
H4	0.3	0.2	12.6	9.5	0.06	0.26	23.4	9.7
H5	0.5	0.7	11.5	17.8	0.06	0.14	17.9	19.9
H6	0.9	0.5	10.5	9.5	0.20	0.14	14.6	14.0
H7	0.3	0.2	16.8	0.6	0.12	0.12	10.3	14.3
H8	0.4	0.5	18.1	8.0	0.04	0.02	21.4	10.8
H9	0.4	0.6	7.9	18.8	0.02	0.18	19.6	12.5
H10	0.7	0.8	11.2	4.6	0.02	ND	13.9	14.5

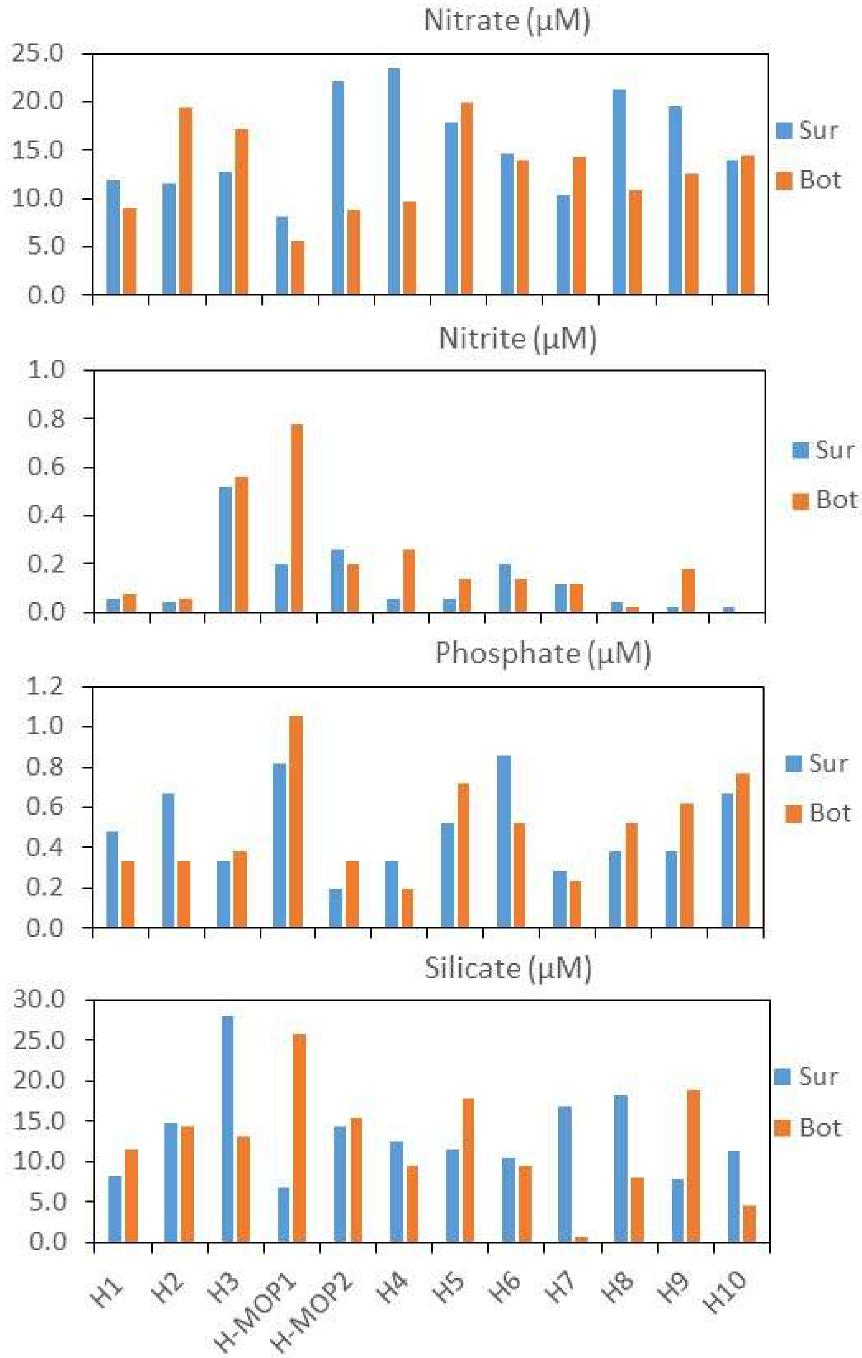


Fig 3.3: Spatial variability of dissolved inorganic nutrients (a) nitrate (µM), (b) nitrite (µM), (c) phosphate (µM) and (d) silicate (µM) in the coastal waters off Rajayyapeta during the study period

Total suspended matter (TSM) concentrations ranged from 20 to 52.3 mg/L (Table 3.5), with a mean value of 33.1±11.5 mg/L in the surface waters of the study region. Bottom waters recorded TSM concentrations between 24 and 51.8 mg/L (mean: 35.4±8.6 mg/L) during the study period. Both surface and bottom waters recorded similar mean TSM concentrations. TSM concentrations found in this study (range: 20–52.3 mg/L; mean: 34.2 mg/L) are consistent with the range of values reported in the previous monitoring studies conducted in this region during 2010, 2014 and 2017, whereas, relatively higher when compared to the values reported during 2007 and 2012 monitoring studies conducted in this region. Total petroleum hydrocarbon (TPHC) concentrations varied from 10.0 to 22.1 µg/L in the surface waters (Table 3.5), with a mean concentration in the study region of 14.9±4.0 µg/L. In the bottom waters, TPHC concentrations varied broadly from as low as 2.1 µg/L to as high as 37.4 µg/L (Table 3.5), with a mean concentration of 16.0±10.2 µg/L. Compared to the TPHC concentrations reported in the previous monitoring study conducted in this region in 2017 (1.3-10.5 µg/L and 1.7-4.7 µg/L in the surface and bottom waters, respectively), TPHC concentrations found in this study (10.0-22.1 µg/L and 2.1-37.4 µg/L, respectively) are relatively higher, indicating a slight increase in the TPHC input from local sources into the coastal waters of Rajayyapeta in recent years. Overall, the concentrations of physico-chemical parameters found in this study are within the range of values reported from the coastal Bay of Bengal.

Table 3.5: Total suspended matter (mg/L) and total petroleum hydrocarbon (TPHC) concentrations in the surface (SUR) and bottom (BOT) waters at the sampling stations.

Station	TSM (mg/L)		TPHC (µg/L)	
	SUR	BOT	SUR	BOT
H1	21.3	37.7	22.1	15.0
H2	20.0	24.0	10.9	---

H3	27.2	29.6	13.7	16.1
MOP1	34.0	30.8	10.0	31.1
MOP2	31.2	35.0	14.2	14.0
H4	21.8	33.0	14.8	17.4
H5	25.8	25.2	18.0	2.1
H6	26.3	32.3	13.7	6.6
H7	52.3	51.8	21.4	12.8
H8	50.5	49.5	12.1	9.5
H9	44.5	41.0	16.7	37.4
H10	42.3	34.3	11.1	14.0

Table 3.6: Comparison of chemical constituents in the coastal waters off Rajayyapeta during different monitoring studies

Parameter	**2007**	**2010**	**2012**	**2014**	**2017**	**2022**
DO (mg/L)	5.1-6.7	3.2-5.6	5.6-7.6	2.3-5.2	2.7-6.0	4.6-6.4
BOD_5 (mg/L)	0.29-1.16	0.13-1.5	0.3-4.3	0.4-2.75	0.3-2.1	0.6-4.1
pH	7.9-8.1	8.0-8.1	8.1-8.2	7.4-8.0	7.4-8.0	7.77-8.29
TSM (mg/L)	10.6-35.2	34.2-69.6	19.0-32.8	16.4-48.8	16.8-45.6	20.0-52.3
NO_2^{-}–N (µM)	0.04-0.31	0.1-0.74	0.04-0.49	0.58-1.27	0.11-0.61	ND – 0.78
NO_3^{-}–N (µM)					1.5-4.5	5.7-23.4
PO_4^{3-}–P (µM)	0.3-1.4	0.1-1.1	0.9-2.5	1.4-4.4	0.5-1.6	0.2-1.1
SiO_4^{2-}–Si (µM)	0.8-5.6	0.7-7.2	3.6-13.6	10.3-14.5	5.0-15.6	4.6-28.0

3.2 Biological Characteristics

4.2.1 Chlorophyll-*a*:

Chlorophyll *a* pigment in surface water ranged between 0.2 mg/m^3 and 0.4 mg/m^3 in the surface and between 0.3 mg/m^3 and 0.6 mg/m^3 in the bottom waters, with mean concentrations of 0.32±0.1 mg/m^3 and 0.41±0.1 mg/m^3, respectively (Table 3.2). The range of Chl-*a* concentrations found in this study is similar when compared to the Chl-*a* concentrations observed in the coastal waters off Kakinada and Yanam, east coast of India.

4.2.2. Phytoplankton

The detailed results of phytoplankton cell count in surface waters of the study region at all stations are given in (Table 3.9). Phytoplankton abundance in surface waters varied from as low as 3200 Nos./L to as high as 6200 Nos./L, with a mean abundance of 4646 Nos./L. The range of phytoplankton abundance found in this study is considerably lower than the range of phytoplankton abundance reported from this region in the year 2017 (range: 5430 – 15390 Nos./L; mean: 10860 Nos./L; Table 3.7). A total of 29 phytoplankton genera were recorded (Table 3.9) in this study. The number of genera recorded at various stations ranged from 15-27 which is relatively higher than the range of genera reported (12-19) in the previous monitoring study conducted in this region in 2017. Predominant species groups and their contribution to the total phytoplankton abundance were shown in Fig. 3.4. Diatoms are the most predominant in the total phytoplankton abundance at all stations (Fig. 3.5). Diatom contribution to the total phytoplankton varied from 53.3% to 76.7% (Table 3.10), with a mean contribution of 61.7% to the total phytoplankton abundance. The contribution of diatoms to the total phytoplankton in this study is relatively lower when compared to those reported in 2017 from this region. Contribution from dinoflagellates to the total phytoplankton abundance ranged from 16.3% to 27.9 %, with an average contribution of 20.8% which is significantly higher than those reported in 2017 from this region (3.8%). Cynobacteria appeared in all stations, except at MOP1 station, and its contribution to the total phytoplankton abundance varied from 1.5% to 8.5% only (mean: 4.2%). Average contribution of different phytoplankton groups to the total phytoplankton abundance was shown in Fig. 3.5. Dominant and consistently occurring species were Chaetoceros sp., Skeletonema sp., Rhizosolenia sp., Cyclotella sp., Nitschia sp., Navicula sp., Ceratium sp., Gymnodinium sp., Trichodesmium sp., Cyanobacteria, Thalassiothrix sp., etc. The species present in samples but in low abundances were *Coscinodiscus sp., Pinnularia sp., Cochlodinium sp., Chroococcus sp.* etc.

Phytoplankton abundance in bottom waters varied from as low as 4100 Nos./L to as high as 7200 Nos./L, with a mean abundance of 5675 No./L (Table 3.11) and it is exceptionally lower than those reported in 2017 monitoring study conducted in this region (5820-18480 Nos./L; mean: 10698 Nos./L). Phytoplankton abundance in the bottom waters (mean: 5675 Nos./L) is more or less similar compared to that of the surface waters (4646 Nos./L) of the study region. In this study, a total of 29 phytoplankton genera were recorded in the bottom waters (Table 3.11) with a range of 14-24, and it is comparable with the range of genera reported in the previous monitoring study conducted in this region in 2017 (15-22). Predominant species groups and their contribution to the total phytoplankton abundance was shown in Fig. 3.6. Diatoms are the most dominant taxa followed by dinoflagellates at all stations (Table 3.12). Diatoms contribution to total phytoplankton abundance ranged from 32.4% to 70.8%, with a mean contribution of 56.8% (Table 3.12; Fig. 3.7) and it is considerably lower than those found in 2018 in this region (mean: 89.1%).

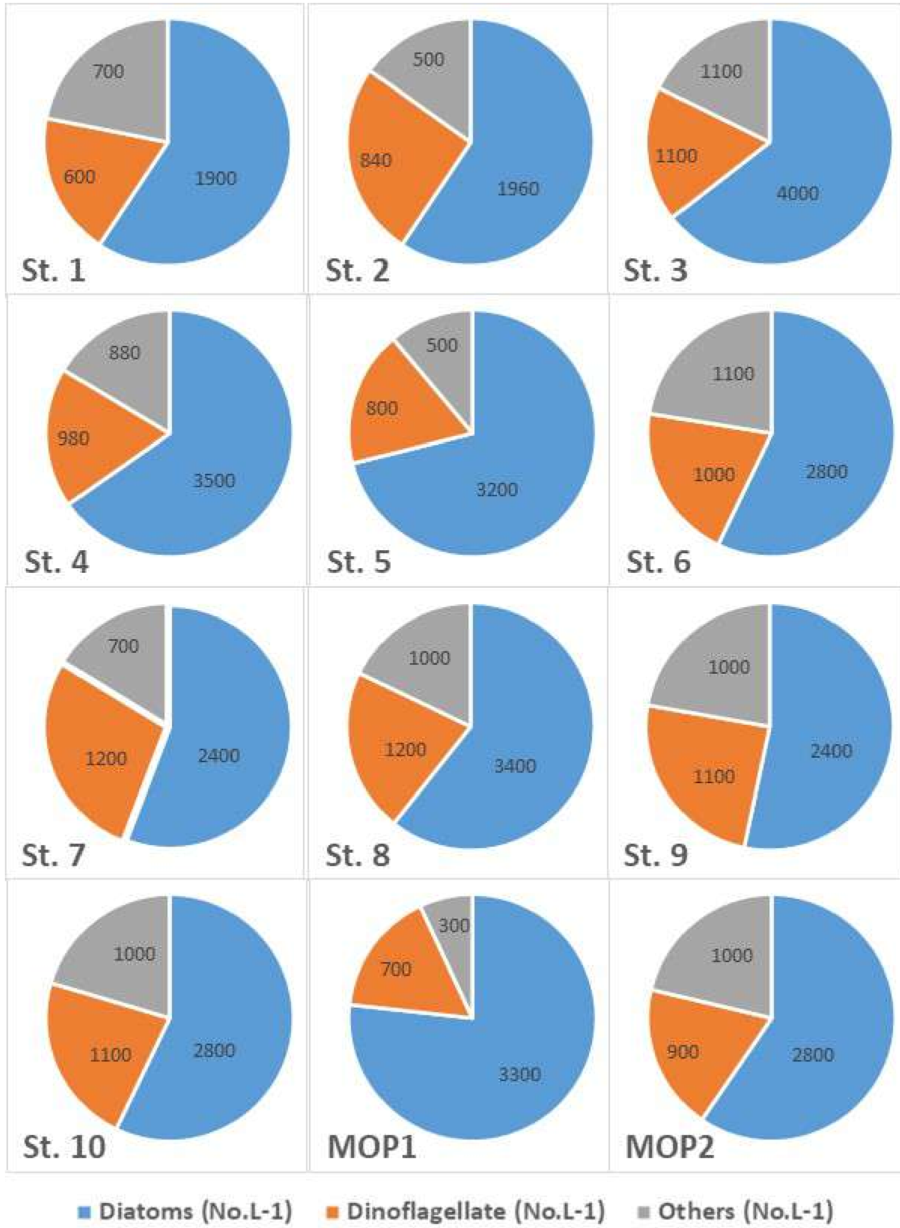


Fig. 3.4: Abundance (No/L) of diatoms and dinoflagellates in the total phytoplankton in the surface waters of the study region

Dinoflagellate's contribution to total phytoplankton abundance varied from as low as 16.7% to 39.7%, with a mean contribution of 25.0% and it is considerably higher than those reported in 2018 (range: 1.5%-5.8%, mean: 4.0%). Cynobacteria contribution to the total phytoplankton is minor as was observed in the surface waters. Compared to surface waters, dinoflagellate's contribution to the total phytoplankton abundance was slightly higher in the bottom waters. Predominant species present in bottom waters are *Skeletonema* sp., Rhizosolenia sp., Nitschia sp., Chaetoceros sp., Cyclotella sp., Thalassiosira sp., Cymbella sp., Peridinium sp., Gymnodinium sp., Cochlodinium sp. The average contribution of diatoms and dinoflagellates to the total phytoplankton in the bottom waters was shown in Fig. 3.7

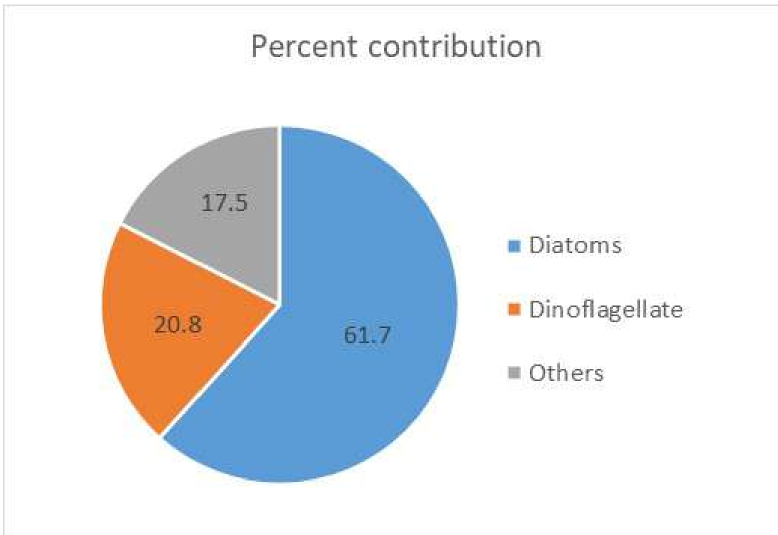


Fig. 3.5: Percent contribution of diatoms and dinoflagellates to the total phytoplankton abundance in the surface waters of the study region

Table 3.7: Comparison of the range of No. of phytoplankton genera and phytoplankton abundance (No./L) during different monitoring studies

Year	No. of Genera (range)		Cell counts (Nos./L)	
	Surface	Bottom	Surface	Bottom
2012	11-17	7-14	200-4800	100-2900
2014	6-20	7-13	2400-16600	3600-18000
2017	12-19	15-22	5430-15390	5820-18330
2022	15-27	14-24	3200-6200	4100-7200

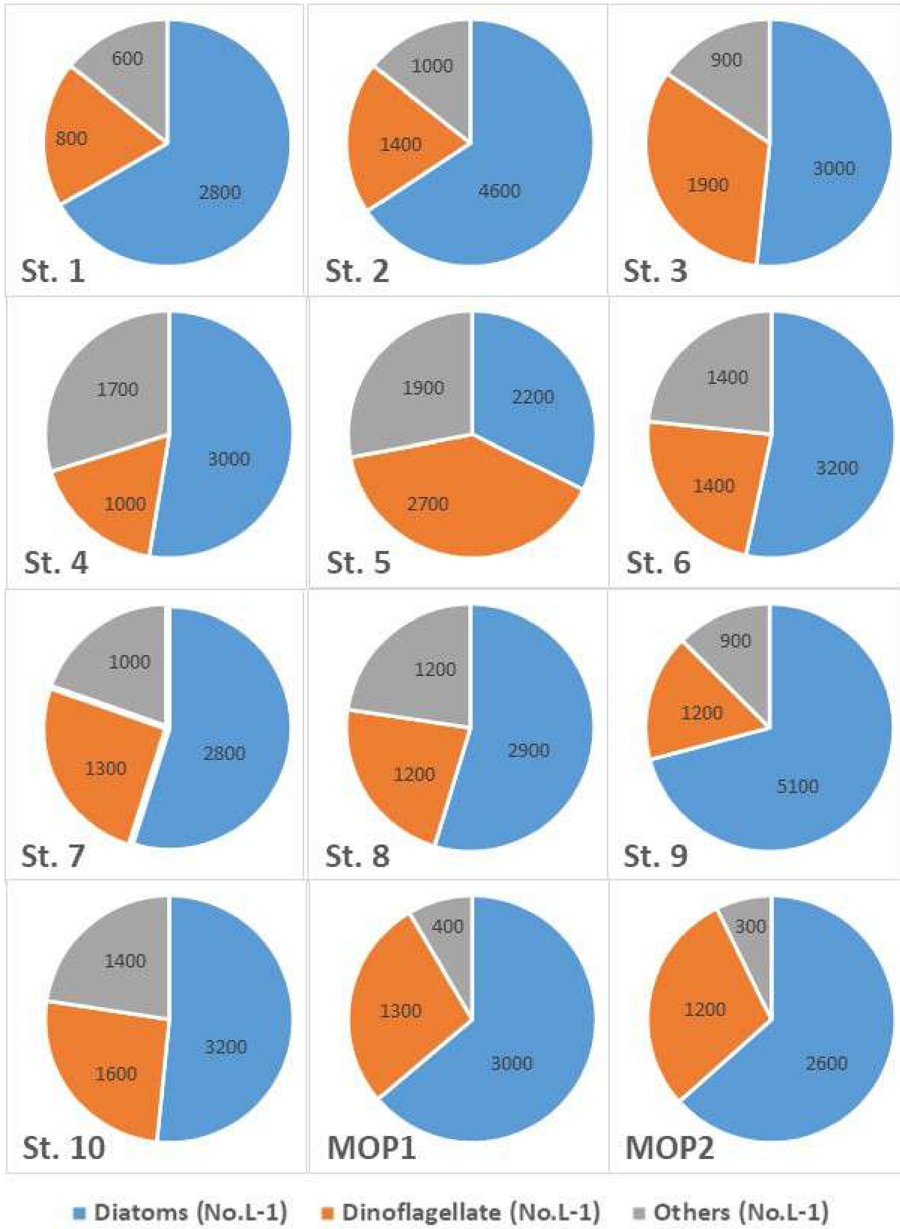


Fig. 3.6: Abundance (No/L) of diatoms and dinoflagellates in the total phytoplankton in the bottom waters of the study region

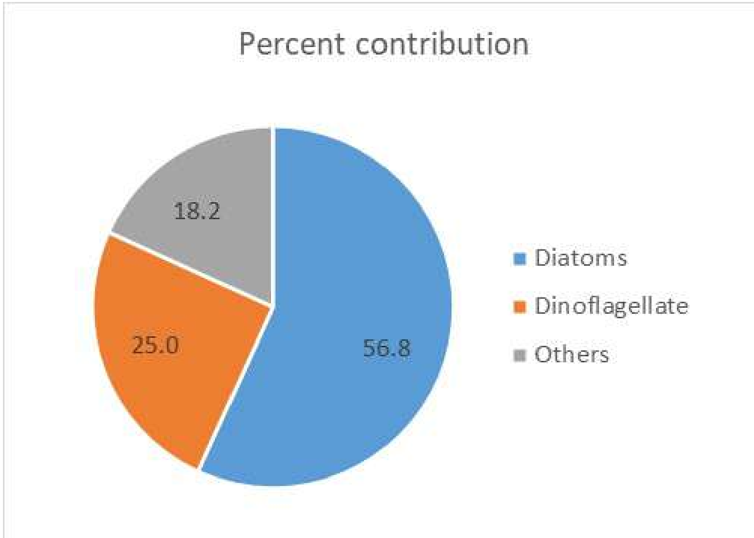


Fig. 3.7: Percent contribution of diatoms and dinoflagellates to the total phytoplankton abundance in the bottom waters of the study region

4.2.3. Zooplankton

The secondary production is the standing stock of zooplankton which feeds on phytoplankton. The seasonal average of zooplankton biomass for the Bay of Bengal (BoB) is 0.43 ml/m^3 in pre-monsoon, 0.24 ml/m^3 in monsoon and 0.99 ml/m^3 in post-monsoon season (Desai & Bhargava, 1998). According to Goswami (1999), the standing stock biomass (ml/m^3) of zooplankton in the Bay of Bengal shows wide variation in space and time in the shelf as well as in the oceanic ecosystems.

Meso-zooplankton abundance in the present study ranged from 208 to 552 No./m^3 with a mean abundance of 395 No./m^3 (Table 3.13; Fig. 3.8). The zooplankton abundance found in this study is considerably lower than the abundance of zooplankton reported in 2017 from this region (range: 500 to 3239 No./m^3; mean: 1776 No./m^3). Also, the range and mean values of zooplankton abundance found in this study are significantly lower than those reported in the coastal waters off Kakinada. However, zooplankton abundance found in this study is considerably higher than those reported in the previous monitoring studies conducted in this region during 2012 (57 No./m^3) and 2014 (98 No./m^3). These results indicate that zooplankton productivity has decreased in the present study region during recent years. Altogether 17 faunal groups were found in the study region. Copepods are predominant in the total zooplankton abundance (Table 3.14; Fig. 3.9) with a mean contribution of 89.2% (range: 79.5%–94.3%) (Table 3.14). Chaetognatha is the second dominant group that contributes 0.7% to 9.4% to the total zooplankton abundance, with a mean contribution of 3.4% (Table 3.14). Decapod larvae are the third dominant groups in the total zooplankton abundance, with a mean contribution of 1.8% (range: 0.4% to 4.9%) (Table 3.14). The zooplankton groups that contribute >1% to the total zooplankton abundance are Appendicularians (mean: 1.6%). The lowest abundant groups that contribute <1% to the total zooplankton abundance are Bivalve larvae (mean: 0.8%), Cladocerans (mean: 0.6%) and Thaliacea (0.4%).

Table 3.8: Comparison of the range and mean of zooplankton abundance (No./m^3) during different monitoring studies.

Year	Zooplankton abundance (No./m^3)	
	range	mean
2012	24-132	57
2014	34-169	98
2017	500-3239	1776
2022	208-552	395

Table 3.9: Phytoplankton abundance (No./L) at the sampling stations in the surface waters of the study region

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MOP1	MOP2
Diatoms												
Chaetoceros sp.,	200	200	200	100	0	100	0	100	300	100	100	100
Skeletonema sp.,	200	100	2000	600	400	200	100	100	200	200	800	900
Rhizosolenia sp.,	400	200	0	200	200	400	400	200	300	100	500	300
Coscinodiscus sp.,	0	0	0	100	0	100	0	0	100	200	300	0
Cyclotella sp.,	200	160	200	400	600	200	400	300	0	0	400	200
Thalassiosira sp.,	100	100	0	200	200	100	200	200	400	100	100	200
Hemidiscus sp.,	0	0	0	100	100	200	400	400	200	400	0	200
Leptocylindrus sp.,	0	0	100	100	0	0	0	100	0	100	0	0
Pleurosigma sp.,	100	100	100	100	200	100	200	200	0	0	0	0
Pinnularia sp.,	0	100	0	0	0	0	0	100	0	100	0	0
Striatella sp.,	0	100	200	100	0	0	0	100	0	200	0	100
Nitschia sp.,	200	200	200	200	600	400	300	400	400	600	600	300
Synedra sp.,	100	100	0	100	200	200	0	100	0	100	0	0
Cymbella sp.,	0	100	0	300	200	200	100	200	300	100	100	200
Navicula sp.,	200	200	200	400	200	100	200	400	0	100	300	0
Thalassiothrix sp.,	100	200	800	400	200	100	0	100	0	0	100	100
Amphiprora sp.,	100	100	0	100	100	400	100	400	200	400	0	200
Dinoflagellate												
Prorocentrum sp.,	0	200	200	100	100	100	0	100	200	100	100	200
Ceratium sp.,	300	100	300	200	300	200	100	200	300	200	300	100
Peridinium sp.,	0	0	200	100	100	100	400	400	0	100	0	0
Gymnodinium sp.,	300	100	100	200	200	200	400	100	300	200	0	400
Noctiluca sp.,	0	40	0	100	0	0	0	0	0	100	0	0
Protoperidinium sp.,	0	100	100	80	100	200	200	100	0	100	0	100
Dinophysis sp.,	0	100	100	100	0	100	0	0	0	100	0	0

Cochlodinium sp.,	0	0	0	40	0	0	100	200	300	0	300	100
Podolampas sp.,	0	200	100	60	0	100	0	100	0	200	0	0
Cyanobacteria	100	100	100	80	100	200	100	400	200	400	0	400
Chroococcus	0	0	0	0	0	0	0	0	0	0	200	0
Trichodesmium sp.,	600	400	1000	800	400	900	600	600	800	600	100	600
Total Abundance (No.L-1)	**3200**	**3300**	**6200**	**5360**	**4500**	**4900**	**4300**	**5600**	**4500**	**4900**	**4300**	**4700**

Table 3.10: Percent contribution of diatoms and dinoflagellates to the total phytoplankton abundance at the sampling stations in surface waters of the study region

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MOP1	MOP2
Diatoms	59.4	59.4	64.5	65.3	71.1	57.1	55.8	60.7	53.3	57.1	76.7	59.6
Dinoflagellate	18.8	25.5	17.7	18.3	17.8	20.4	27.9	21.4	24.4	22.4	16.3	19.1
Others	21.9	15.2	17.7	16.4	11.1	22.4	16.3	17.9	22.2	20.4	7.0	21.3

Table 3.11: Phytoplankton abundance (No./L) at the sampling stations in the bottom waters of the study region

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MOP1	MOP2
Diatoms												
Chaetoceros sp.,	200	100	200	100	100	200	100	200	100	200	200	200
Skeletonema sp.,	600	1600	600	400	100	400	100	300	1600	400	400	600
Rhizosolenia sp.,	400	400	0	200	200	200	400	200	200	600	200	0
Coscinodiscus sp.,	0	200	200	100	200	200	200	400	300	100	0	0
Cyclotella sp.,	200	300	300	400	400	400	600	100	400	400	400	200
Thalassiosira sp.,	200	100	100	0	600	200	100	200	400	0	300	0
Hemidiscus sp.,	0	0	200	200	0	0	0	0	0	0	0	200
Leptocylindrus sp.,	0	200	100	100	0	100	200	0	600	200	400	200
Pleurosigma sp.,	100	200	200	100	200	400	0	100	400	0	0	0
Pinnularia sp.,	0	0	0		0	0	200	100	0	100	200	0
Striatella sp.,	0	100	200	0	0	0	0		0	200	0	200
Nitschia sp.,	600	200	200	600	200	600	200	400	400	200	400	800
Synedra sp.,	0	0	0	100	0	200	200	200	200	100	0	0
Cymbella sp.,	200	0	0	0	0	100	0	100	0	0	200	100
Navicula sp.,	200	200	200	400	200	100	0	200	200	400	0	0
Thalassiothrix sp.,	0	800	400	100	0	0	400	300	100	200	200	100
Amphiprora sp.,	100	200	100	200	0	100	100	100	200	100	100	0
Dinoflagellate												
Prorocentrum sp.,	0	200	100	100	100	200	0	200	0	600	200	200
Ceratium sp.,	0	300	400	100	600	400	200	400	600	400	200	200
Peridinium sp.,	200	200	200	200	800	100	0	100	0	0	0	0
Gymnodinium sp.,	200	200	1000	200	600	200	800	200	600	200	200	400
Noctiluca sp.,	0	0	0	0	100	100	0	0	0	100	0	200
Protoperidinium sp.,	0	0	200	100	200	100	200	200	0	100	200	0
Dinophysis sp.,	0	100	0	0	0	100	0	100	0	100	300	100
Cochlodinium sp.,	400	200	0	200	200	200	0	0	0	0	0	0

Podolampas sp.,	0	200	0	100	100	0	100	0	0	100	200	100
Cyanobacteria	0	0	100	100	100	200	400	200	200	400	100	100
Chroococcus	0	0	0	0	0		0	100	100	200	100	0
Trichodesmium sp.,	600	1000	800	1600	1800	1200	600	900	600	800	200	200
Total Abundance (No.L-1)	**4200**	**7000**	**5800**	**5700**	**6800**	**6000**	**5100**	**5300**	**7200**	**6200**	**4700**	**4100**

Table 3.12: Percent contribution of diatoms and dinoflagellates to the total phytoplankton abundance at the sampling stations in bottom waters of the study region

	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**	**H10**	**MOP1**	**MOP2**
Diatoms	66.7	65.7	51.7	52.6	32.4	53.3	54.9	54.7	70.8	51.6	63.8	63.4
Dinoflagellate	19.0	20.0	32.8	17.5	39.7	23.3	25.5	22.6	16.7	25.8	27.7	29.3
Others	14.3	14.3	15.5	29.8	27.9	23.3	19.6	22.6	12.5	22.6	8.5	7.3

Table 3.13: Total zooplankton abundance (No./m^3) at the sampling stations in the surface waters of the study region

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MOP 1	MOP 2
Hydromedusae	0.7	0.1	0	0.2	0.3	0.1	0	1.1	1.7	1.8	0.2	0.4
Siphonophore	0.2	0.7	0.5	0.1	0.4	0.4	0.4	2.1	0	1.6	0.4	1.2
Ctenophora	0.3	0.7	0.1	1.7	0.4	0.4	0.8	1.7	1.3	1.6	0.4	0.6
Chaetognatha	7.5	20.4	18.3	12.9	9.1	6.6	9.16	2.5	35.41	8.3	28.7	4.2
Copepods	326	404	388	359	322	390	442	333	493	374	258	165
Cladocerans	4.2	6.12	0.8	1.6	1.4	0.4	0.8	0.7	0.1	0.4	3.2	4.1
Ostracods	0.2	0.3	0.7	0.1	0.4	0.6	0.9	0.6	0.2	0.3	0.1	0.8
Lucifers	1.3	8.6	1.3	1.7	1.3	2	3.4	1.9	1.6	1.6	3.2	1.4
Thaliacea	1.1	0.7	0.9	0.8	0.8	0.7	0.7	0.4	0.6	0.6	3.12	5.1
Appendicularians	11.2	2.1	1.9	16.6	7.5	2	12.5	4.6	4.3	9.1	0.6	4.1
Polychaete larvae	0.8	0	0.4	0	0.8	0.4	0	0	0	0	0	3.2
Decapod larvae	6.2	8.1	6.4	7.1	9.3	6.4	8.7	5.8	2	1.7	4.1	10.1
Bivalve larvae	5.8	0	4.2	0	6.4	1.2	0	8.5	0.8	0.8	2.3	3.1
Gastropod larvae	0.4	0	0	0.9	0	0	3.1	0	4.3	0	0	4.1
Fish Eggs	0.2	0.3	0.4	0.4	1.1	1.6	1.6	2.5	6.6	1.1	0.1	0.1
Fish larvae	0	1.3	0	0.6	0.8	0.7	0.1	0.3	0	0.4	0.1	0.2
Total (No./m^3)	**366**	**454**	**423**	**404**	**362**	**414**	**484**	**366**	**552**	**403**	**304**	**208**

Table 3.14: Percent contribution of various groups to the total zooplankton abundance at different sampling stations in the surface waters of the study region

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MOP 1	MOP 2
copepods	89	89	92	89	89	94	91	91	89	93	85	80
appendicularians	3.1	0.5	0.4	4.1	2.1	0.5	2.6	1.3	0.8	2.3	0.2	2.0
Decapod larvae	1.7	1.8	1.5	1.8	2.6	1.5	1.8	1.6	0.4	0.4	1.3	4.9
Bivalve larvae	1.6	0.0	1.0	0.0	1.8	0.3	0.0	2.3	0.1	0.2	0.8	1.5
Chaetognatha	2.0	4.5	4.3	3.2	2.5	1.6	1.9	0.7	6.4	2.1	9.4	2.0
Cladocerans	1.1	1.3	0.2	0.4	0.4	0.1	0.2	0.2	0.0	0.1	1.1	2.0
Thaliacea	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.0	2.5
Appendicularians	3.1	0.5	0.4	4.1	2.1	0.5	2.6	1.3	0.8	2.3	0.2	2.0

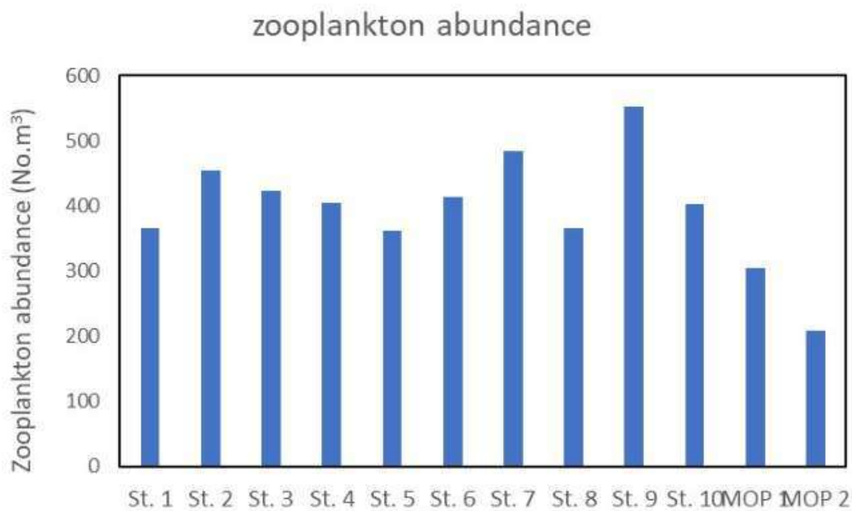


Fig. 3.8: Abundance (No/m^3) of zooplankton in surface waters of the study region

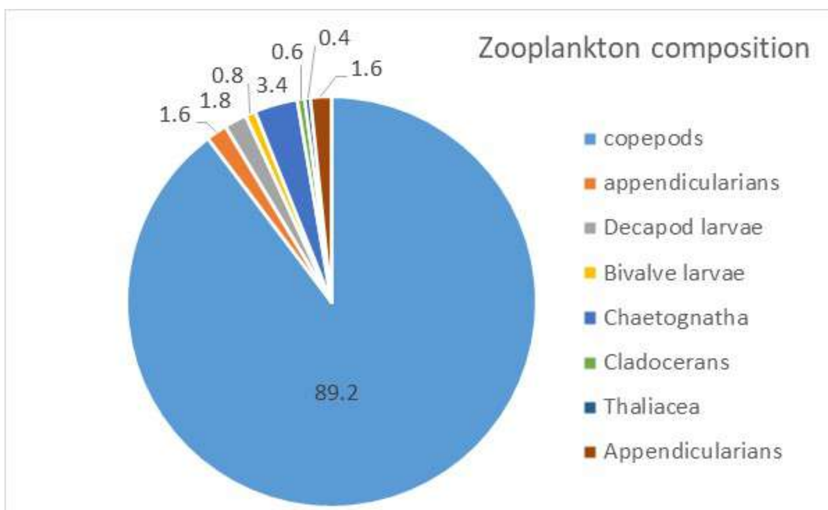


Fig. 3.9: Percent contribution of various groups to the total zooplankton abundance at different stations in the study region

3.2.3. Benthos

Benthos, the seafloor biota, contributes substantially to the secondary production of potential and sustainability of demersal or near bottom living fishable resources. The distribution of biomass production of benthos in the seas surrounding India is reported by

Parulekar et al (1982). A number of comparative studies on benthos of various ecosystems of the seas around India are available and a resume of published results on the standing crop and production of benthos from Bay of Bengal are given in Table 3.15.

Table 3.15: Reported standing crop and production of benthos in the Bay of Bengal

	REGION	BAY OF BENGAL
Biomass (g/m^2)	**Shelf**	<0.1-98.8 (4.9)
	Slope	0.1-60.2 (4.6)
	Deep	0.1-5.2. (2.3)
Productivity (gC/m^2/y)	Shelf	0.6-3.1 (1.2)
	Slope	0.1-2.4 (0.8)
	Deep	0.4-1.0 (0.8)

4.2.4.1. Macro and meiofauna:

Benthic macro fauna is basically comprised of sedentary and sessile organisms, dominated by polychaete worms and Arthropods. The macro faunal density of the study area ranged from 1950 to 3500 No./m^2 (Table 3.16; Fig. 3.10). The macrofaunal density range found in this study is slightly lower than those reported in a previous monitoring study conducted in this region in 2017 (900-4650 No./m^2), but higher than those reported in 2012 (400-2575 No./m^2) and comparable with those reported in 2014 (125-3325 No./m^2) from this region (Table 3.16). A total of 27 fauna were found in this study (Table 3.17). Contribution from various groups to the macrofaunal density ranged from 1.6% to 48.2% (Table 3.18). The fauna was dominated by families of polychaeta and their contribution was in the range of 16.1% - 48.2%, with a mean contribution of 30.6% to that of the total abundance (Figs. 3.11 and 3.12). Foraminifera is the second largest group that was contributed to total density of macrofauna and its contribution ranged from 17.9% to

37.7%, with a mean contribution of 24.1% (Fig. 3.12). Mollusca is the third largest group in the total macrofauna and it contributes 22.6% (range: 8.9% to 37.3%) to the total density of the macrofauna in the study region (Fig. 3.12).

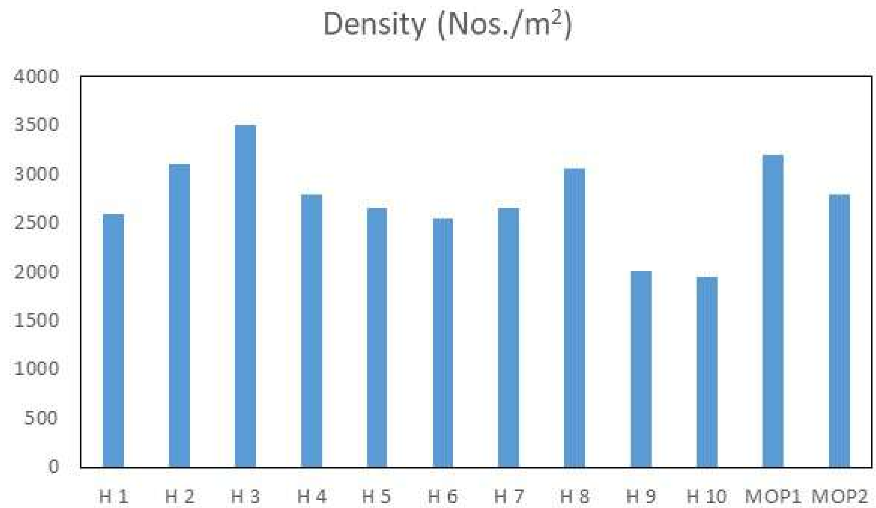


Fig. 3.10: Density of macrofauna in the surface sediments at different stations in the study region

The macro faunal density of the study area found in various previous monitoring studies was given in Table 3.16 and compared with the macro faunal density found in this study.

Table 3.16: Comparison of macrofaunal density in the study region during monitoring studies conducted in different years

Year of monitoring	Macrofaunal density (No./m^2)
2012	400 - 2575
2014	125 - 3325
2017	900 - 4650
2022 (This study)	1950 - 3500

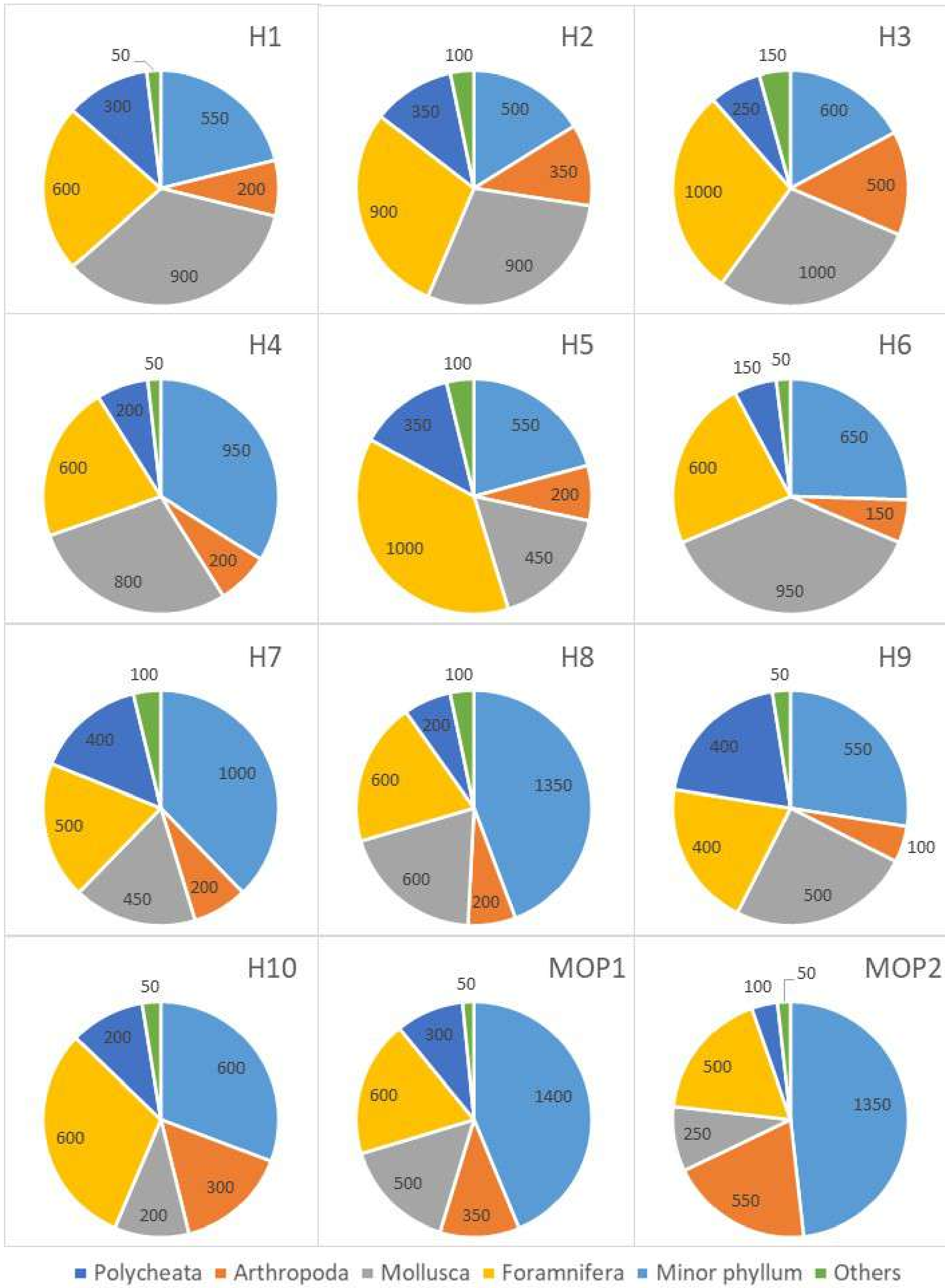


Fig. 3.11: Abundance of various groups (No./m^2) contributed to the total macrofaunal density in the surface sediments at different stations in the study region

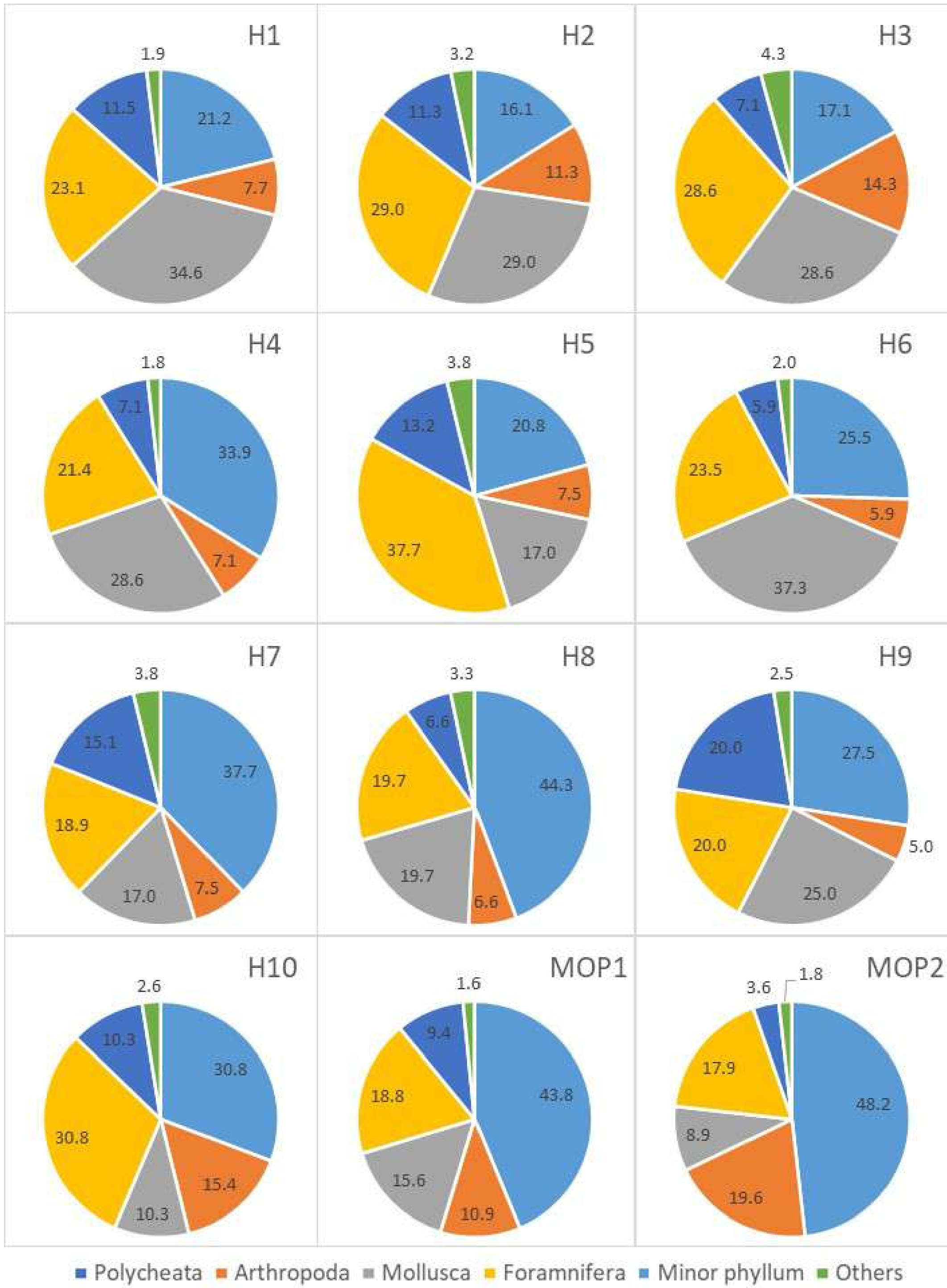


Fig. 3.12: Percent contribution of polychaeta, arthropoda, Mollusca, foraminifera, minor phylum and others to the total macrofaunal density in the surface sediments at different stations in the study region

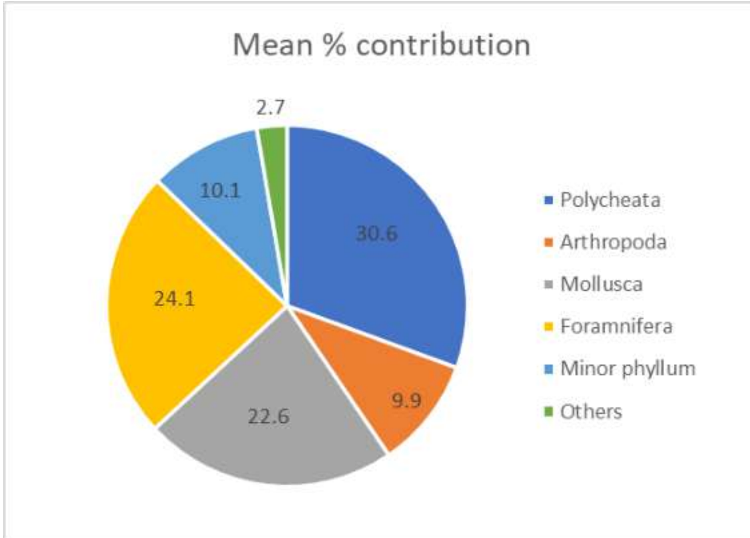


Fig. 3.13: Mean percent contribution of polychaeta, arthropoda, Mollusca, foraminifera, minor phylum and others to the total macrofaunal density in the surface sediments of the study region

The abundance of meio fauna varied from 346 No./10cm^2 to 870 No./10cm^2, with an average abundance of 539 No./10cm^2. Mean abundance of various meio faunal groups is shown in Fig. 3.14 and their percent contributions are shown in Fig. 3.15. The range of values of meio faunal density found in this study is slightly lower than those observed in a previous monitoring study conducted in this region in 2017 (416-1006 No./10cm^2) Abundance of Nematoda in this study varied from 100 to 291 No./10cm^2 (mean: 186.6 No./10cm^2) and this range is also comparatively lower than those reported in the 2017 monitoring study (311-710 No./10cm^2). Although, Nematoda are the major contributors to the total meio fauna abundance their contribution is lower in this study (34.6%) compared to the previous monitoring study (>80%), indicating increased biodiversity. Foraminiera is the second largest contributors with an average contribution of 16.6 % to the total meio faunal density. Turbellaria is the third largest contributor with a mean contribution of 8.1%. A total of 11 meio faunal groups were found in this study.

Fig. 3.14: Mean abundance of various groups of meio-fauna in the surface sediments of the study region

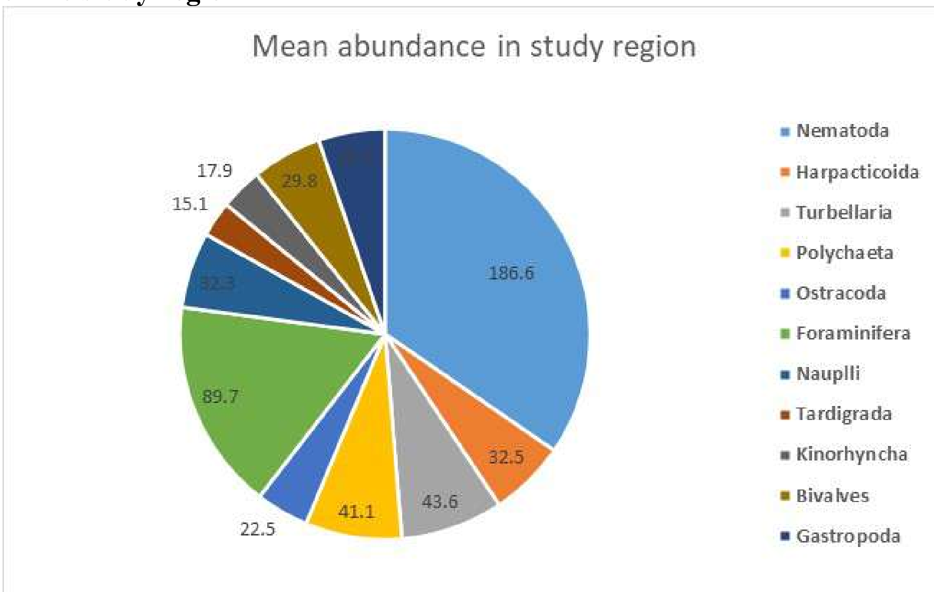


Fig. 3.15: Mean percent contribution of various groups to the total meio-faunal density in the surface sediments of the study region

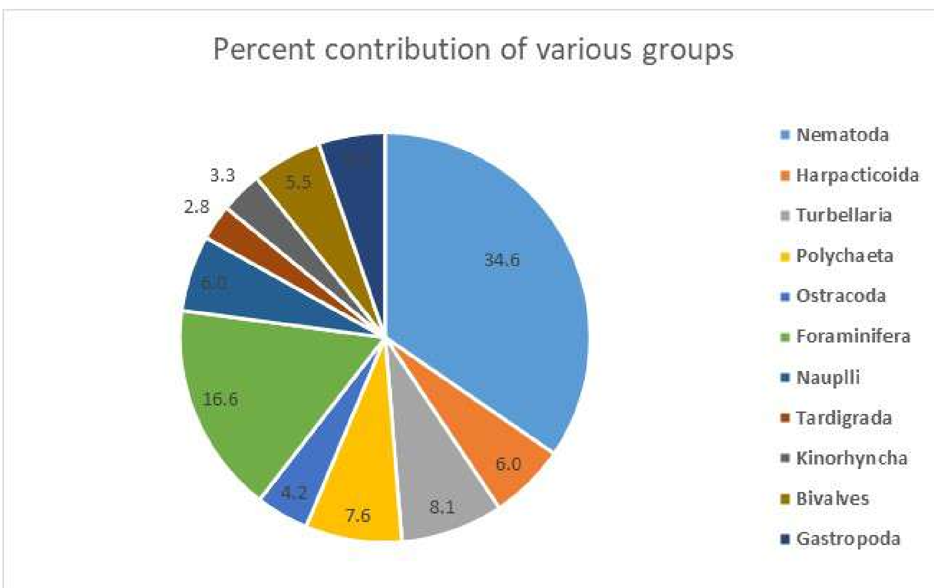


Table 3.17: Macrobenthos abundances (No/m^2) in surface sediments of the study region

SI.NO	Taxa	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H-MOP	H13
							Polychaeta						
1	Nephtyidae sp.	50	50	0	100	50	50	200	100	0	200	200	200
2	Orbinidae sp.	0	0	0	50	0	0	0	50	0	0	0	0
3	Spionidae sp.	50	50	50	100	0	50	100	100	50	100	0	100
4	Opheliidae sp.	0	50	0	100	0	0	100	100	100	0	0	0
5	Glyceridae sp.	50	0	100	0	100	50	50	50	50	50	400	400
6	Nereidae sp.	50	50	0	100	0	0	0	0	0	0	0	0
7	Pilardigae sp.	0	50	0	50	50	0	50	100	50	0	0	200
8	Aphroditidae sp.	100	0	0	0	0	100	0	200	0	0	0	0
9	Cossuridae sp.	0	0	0	0	0	100	100	0	50	50	100	0
10	Cirratulidae sp.	50	0	100	100	0	0	100	200	100	0	0	200
11	Terebellidae sp.	0	0	50	0	0	0	0	0	0	0	200	0
12	Syllidae sp.	50	50	0	50	100	0	100	50	50	0	0	0
13	Maldanidae sp.	0	0	0	0	0	50	50	0	50	50	0	0
14	Capitellidae sp.	0	0	50	0	0	50	0	0	0	0	200	100

15	Pisionidae sp.	50	50	0	200	200	50	0	100	0	0	0	0
16	Eunicidae sp.	50	50	50	0	0	0	0	0	0	100	0	50
17	Sabellidae sp.	0	0	0	0	0	50	50	200	50	0	200	0
18	Unidentified	50	100	200	100	50	100	100	100	0	50	100	100
	Arthropoda												
19	Amphipoda sp.	50	150	300	100	100	100	100	50	50	150	50	300
20	Tanaidacea	100	200	100	50	50	50	100	150	50	100	300	200
21	Isopoda sp.	50	0	50	0	50	0	0	0	0	50	0	50
22	Cumacean sp.	0	0	50	50	0	0	0	0	0	0	0	0
	Mollusca												
23	Gastropoda	500	400	600	200	250	450	250	200	200	100	300	100
24	Bivalvia	400	500	400	600	200	500	200	400	300	100	200	150
25	Foramnifera	600	900	1000	600	1000	600	500	600	400	600	600	500
	Minor phyllum												
25	Sipunculus	100	50	150	100	50	50	100	0	100	100	0	0
26	Nematoda	200	300	100	100	300	100	300	200	300	100	300	100
27	others	50	100	150	50	100	50	100	100	50	50	50	50
	Density no/m²	**2600**	**3100**	**3500**	**2800**	**2650**	**2550**	**2650**	**3050**	**2000**	**1950**	**3200**	**2800**

Table 3.18: Percent contribution of various groups to the total macrobenthos abundances (No/m^2) in surface sediments of the study region.

SI.NO	Taxa	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	HMOP	H13	Mean
1	Nephtyidae sp.	21.2	16.1	17.1	33.9	20.8	25.5	37.7	44.3	27.5	30.8	43.8	48.2	**30.6**
2	Orbinidae sp.	7.7	11.3	14.3	7.1	7.5	5.9	7.5	6.6	5.0	15.4	10.9	19.6	**9.9**
3	Spionidae sp.	34.6	29.0	28.6	28.6	17.0	37.3	17.0	19.7	25.0	10.3	15.6	8.9	**22.6**
4	Opheliidae sp.	23.1	29.0	28.6	21.4	37.7	23.5	18.9	19.7	20.0	30.8	18.8	17.9	**24.1**
5	Glyceridae sp.	11.5	11.3	7.1	7.1	13.2	5.9	15.1	6.6	20.0	10.3	9.4	3.6	**10.1**
6	Nereidae sp.	1.9	3.2	4.3	1.8	3.8	2.0	3.8	3.3	2.5	2.6	1.6	1.8	**2.7**

3.3 Microbiological parameters

Certain aquatic microbes serve as excellent indicators of pollution. Microbes, in particular, bacteria react quickly to changes in environmental conditions. An assessment of the microbial activity is possible by the determination of the microbial biomass (total viable count). Therefore, the total viable counts imply an indirect measure of *in situ* activity in contrast to several specific indicator microbes, and this has been used as one of the principal criteria of pollution in natural water. Besides the pollution indicator bacteria such as total coliforms (TC), *Escherichia coli* like organisms (ECLO) and *Enterococcus faecalis* like organisms (EFLO) occurring in the coastal waters have also been included. These indicator bacteria will presumably show that sewage discharge with human faecal matter is present, which also indicates the possible presence of pathogenic bacteria in the water samples. Apart from that some pathogenic bacteria such as *Vibro cholerae* like organisms (VLO) and *Vibro parahaemolyticus* like organisms (VPLO) abundance was also studied. Water samples from the surface and bottom were collected at each station with the help of a Niskin sampler. All the samples were stored in ice immediately after collection and transferred to the laboratory for the enumeration of different groups of bacteria. Standard microbiological methods were followed for dilution, spread plating and incubation.

Seawater samples collected from the study area were analyzed for the following microbiological parameters:

1. Total viable count (TVC) – R2A Agar seawater medium,
2. Total Coliform (TC) – Mac Conkey's Agar,
3. *Escherichia coli* like organisms (ECLO) – Hichrome Universal Agar,
4. *Enterococcus faecalis* like organisms (EFLO) – Hichrome Universal Agar,
5. *Vibro* like organisms (VLO) – TCBS Agar,

6. *Vibrio cholerae* like organisms (VCLO) – TCBS Agar,
7. *Vibrio parahaemolyticus* like organisms (VPLO) – TCBS Agar,

The counts of different groups of bacteria recorded in the water column are presented in Table 3.19. The values of TVC in the surface water were in the range of 2.9 to 24.6 x 10^3 CFU/ml. The values for the bottom water were 0.9 to 34.8 x 10^3 CFU/ml. These counts are comparable with those reported in the previous monitoring study conducted in this region in 2017 (5.6-13.6x10^3 CFU/ml and 3.2-33.0 x10^3 CFU/ml in surface and bottom waters, respectively). The total Coliform count was 1.4 to 8.4 x10^3 CFU/ml in surface water and 0.01 to 10.0 x10^3 CFU/ml in bottom water. The coliform count found in this study are considerably higher than those reported in the previous monitoring study conducted in this region in 2017 (0.3-0.8 x10^3 CFU/ml and 0.2-1.2 x10^3 CFU/ml in the surface and bottom waters, respectively). Similarly, the *Escherichia coli* like organism (ECLO) counts were NG to 3.2 x10^3 CFU/ml in surface water and NG to 3.1 x10^3 CFU/ml in bottom water. The range of ECLO found in this study is comparable with those found in the previous monitoring study conducted in this region in 2017 (1.5-3.7 x10^3 CFU/ml and 0.7-7.4 x10^3 CFU/ml in the surface and bottom waters, respectively). The *Enterococcus faecalis* like organism counts were NG to 22.9 x10^3 CFU/ml in surface water and NG to 1.6 x10^3 CFU/ml in bottom water. The *Vibrio* like organism (VLO) counts were NG to 3.0 x10^1 CFU/ml in surface water and NG to 1.0 x10^1 CFU/ml in bottom water. Similarly, the *Vibrio cholerae* like organism (VCLO) counts were NG to 3.0 x10^1 CFU/ml in surface water and NG to 1.0 x10^1 CFU/ml in bottom water. There is no growth of *Vibrio parahaemolyticus* like organism (VPLO) in both surface and bottom waters.

Wide variation in TVC is observed spatially both in surface and bottom waters. ECLO and EFLO counts were observed in most of the stations and were high in the few samples but a large variation was observed, which showed the influence of anthropogenic activities such as domestic and industrial discharge, recreational activities, open defecation in coastal (beach) regions (in villages), fisherman activities etc. The counts were higher than the reported from the coastal waters and as per standards of coastal recreational waters. VLO and VCLO counts were observed only in two stations out of the 12 stations sampled in the coastal waters off Rajayyapeta.

Table 3.19: Abundance (CFU/ml) of various bacterial populations in the water column of the study region

Station	Depth	TVC ($x10^3$)	TC ($x10^3$)	ECLO ($x10^3$)	EFLO ($x10^3$)	VLO ($x10^1$)	VCLO ($x10^1$)	VPLO ($x10^3$)
HET1	SUR	8.8 ^{3}	4.0	0.7	1.2	3.0	3.0	NG
	BOT	21.6	9.0	2.4	NG	NG	NG	NG
HET 2	SUR	15.2	5.6	1.6	0.2	NG	NG	NG
	BOT	5.6	6.2	NG	1.1	NG	NG	NG
HET 3	SUR	8.3	8.0	2.9	0.1	NG	NG	NG
	BOT	3.4	9.5	3.1	0.1	NG	NG	NG
HET 4	SUR	3.4	2.0	0.1	0.2	NG	NG	NG
	BOT	34.8	10.0	NG	0.2	NG	NG	NG
HET 5	SUR	11.8	7.2	NG	22.9	NG	NG	NG
	BOT	20.4	1.5	NG	0.1	NG	NG	NG
HET 6	SUR	12.2	6.0	1.5	0.5	NG	NG	NG
	BOT	18.0	9.0	NG	1.6	NG	NG	NG
HET7	SUR	15.6	7.5	1.9	0.3	NG	NG	NG
	BOT	3.1	0.4	NG	NG	1.0	1.0	NG
HET 8	SUR	4.8	5.7	1.8	NG	NG	NG	NG
	BOT	8.8	3.0	NG	0.1	NG	NG	NG
HET 9	SUR	2.9	8.4	3.2	8.4	NG	NG	NG
	BOT	0.9	1.7	0.4	NG	NG	NG	NG
HET 10	SUR	11.4	1.4	0.4	NG	NG	NG	NG
	BOT	5.1	1.1	0.1	0.1	NG	NG	NG
MOP1	SUR	18.6	6.9	1.2	0.6	NG	NG	NG
	BOT	3.1	0.01	NG	NG	NG	NG	NG
MOP2	SUR	24.6	3.0	0.8	0.1	NG	NG	NG
	BOT	4.0	1.5	0.3	0.1	NG	NG	NG

TVC	Total Viable Count
TC	Total Coliform Count
ECLO	*Escherichia coli* like organism Count
EFLO	*Enterococcus faecalis* like organism Count
VLO	*Vibrio* like organism Count
VCLO	*Vibrio cholerae* like organism Count
VPLO	*Vibrio parahaemolyticus* like organism Count
NG	No Growth

3.4.1 Eco-toxicity of treated effluent

The toxicity of the effluents can be evaluated by employing several tests. Bioassay is one of the important tests among them and it is used to test the sensitivity of the organisms on exposure to a toxicant. Bioassay is defined as the test in which a living tissue, organism or group of organisms are used as a reagent for the determination of the potency of any physiologically active substance of unknown activity. In this experiment, a test species either a larva or adult is exposed to different concentrations of toxicant in a given time in order to know the nature and degree of response. During acute toxicity experiments, the tolerance response of the organism is evaluated by exposing it to the specified toxicant for a short period of time. In general, the level of tolerance of any organism to the toxicant is observed for a period of 96 hrs. in acute toxicity experiments. Static bioassay is widely used as a short-term response experiment for acute toxicity experiments and this is one of the best methods to provide the results very fast and accurately. In this experiment, the response of a toxicant to the organism is measured in terms of mortality or lethality.

The physico chemical characteristics of the treated effluent collected from M/s Hetero Infrastructure SEZ Limited are given in Table 3.20. Test conditions and test acceptable criteria for whole effluent toxicity of treated effluent with pink zebra fish are presented in Table 3.21. Acute toxicity of treated effluent collected from the guard pond of M/s Hetero Infrastructure SEZ Limited with whole effluent toxicity test expressed in terms of median lethal concentrations (LC_{50}) was evaluated by subjecting the acclimatized pink zebrafish (*D. rerio*) exposed to different exposure periods (24 hrs; 48 hrs; 72 hrs. and 96 hrs.) with eight different concentrations (%, v/v) of treated effluent test solutions.

Table 3.20: **Physico-chemical characteristics of the treated effluent and dilution water used for preparing test solutions**

Parameter	Treated effluent	Dilution water
pH	7.4±0.1	7.06±0.4
Salinity (ppt)	0.8±0.2	0.6±0.1
Nitrite-Nitrogen (mg/L)		<0.03
Ammonium (mg/L)	32.1±0.7	<0.01
Nitrate-nitrogen (mg/L)	2.7±0.4	2.5±0.4
DO (mg/L)	6.48±0.2	7.01±0.1
BOD_5 (mg/L)	1.23 mg/L	0.2±0.1
TSM (mg/L)	20.7±1.2	1.5±0.1

Table 3.21: Summary of conditions and acceptance criteria for WET acute Toxicity Test with pink zebra fish as test species

Type	Comment
Test condition	Static non-renewal
Test duration	96 hrs.
Temperature	>28 °C
Photoperiod	12 hrs. light: 12 hrs. dark
Test chamber size	12 Litres
Length of test organisms	30±5 mm
No. fishes per test chamber	20 fishes
No. replicate chambers per Conc.	Three
Feeding	None
Test solution aeration	Yes, >6 mg l^{-1}
Dilution water	0 ± 1 ‰ salinity
Test concentrations	effluent conc. and a control
Dilution series	10%, 20%, 30%, 50%, 60%, 90% and 100% treated effluent
Endpoint	Mortality of fishes
Test acceptability criterion	90% survival in 100% effluent after 96 hours

Experiments were conducted under static conditions and all experimental tanks had a triplicate and each experimental set included a Control (0%). The test containers were inspected at regular intervals for recording mortality at different exposure periods of 12 hrs, 24 hrs, 36 hrs, 48 hrs, 60 hrs, 72 hrs and 96 hrs for calculating the LC_{50} values. The dead organisms were removed immediately from tanks in order to avoid any type of bacterial contamination. At the end of each test, the organisms were transferred to a clean tank for observing their recovery. The average percent mortality recorded at different test solutions in triplicate test containers during the four exposure periods was determined. The median lethal concentration (LC_{50}) values in the percentage of toxicant for zebra fish exposed to different concentrations of effluent were calculated based on the mortality rates. The average percent mortality recoded at different test solutions in triplicate test containers during the four exposure periods was determined.

The mortality of test organisms (pink zebra fishes) for effluent samples over different exposure periods are presented in Table 3.22. The mortality values of effluent water samples for different exposure periods (24 hrs, 48 hrs, 72 hrs and 96 hrs) were calculated following the method of log-probit transformation for time and dose-mortality curves suggested by Finney's method (1971) using LDP line software (http://embakr.tripod.com/ldpline).

Data on the average mortality of test animals (in %) recorded in different test concentrations of treated effluent from Hetero Infrastructure SEZ Limited over four exposure periods is presented in Table 3.23. The median lethal concentrations (LC_{50}) of treated effluent from Hetero Infrastructure SEZ Limited at different exposure periods are shown in Table 3.24.

Table 3.22: The survival rate of zebra fish exposed to different concentrations of treated effluent to different exposure periods

Exposure Time	Control 0%	Effluent Concentration 10%	20%	30%	50%	60%	90%	100%
1 hr.	100	100	100	100	100	100	100	100
6 hrs.	100	100	100	100	100	100	100	100
12 hrs.	100	100	100	100	100	100	100	95
24 hrs.	100	100	100	100	100	100	95	95
36 hrs.	100	100	100	100	100	100	95	95
48 hrs.	100	100	100	100	100	100	95	90
60 hrs.	100	100	100	100	100	95	95	90
72 hrs.	100	100	100	100	100	95	95	85
84 hrs.	100	100	100	100	95	95	90	75
96 hrs.	100	100	100	100	95	95	90	75

Table 3.23: Cumulative mortality of test (pink zebra) fish at different exposure periods in the 96-hour long experiment with treated effluent

Effluent conc. (% v/v)	Cumulative Mortality (%) of zebra fish during exposure periods 24 hrs	48 hrs	72 hrs	96 hrs
0%	0	0	0	0
10%	0	0	0	0
20%	0	0	0	0
30%	0	0	0	0
50%	0	0	0	5
60%	0	0	5	5
90%	5	5	5	10
100%	5	10	15	25

Table 3.24: Median Lethal concentrations (LC_{50}) of treated effluent from Hetero Infrastructure SEZ limited at different exposure periods

Exposure period (hrs.)	Median Lethal concentration (LC_{50}), %
24	-
48	-
72	326.7
96	187.6

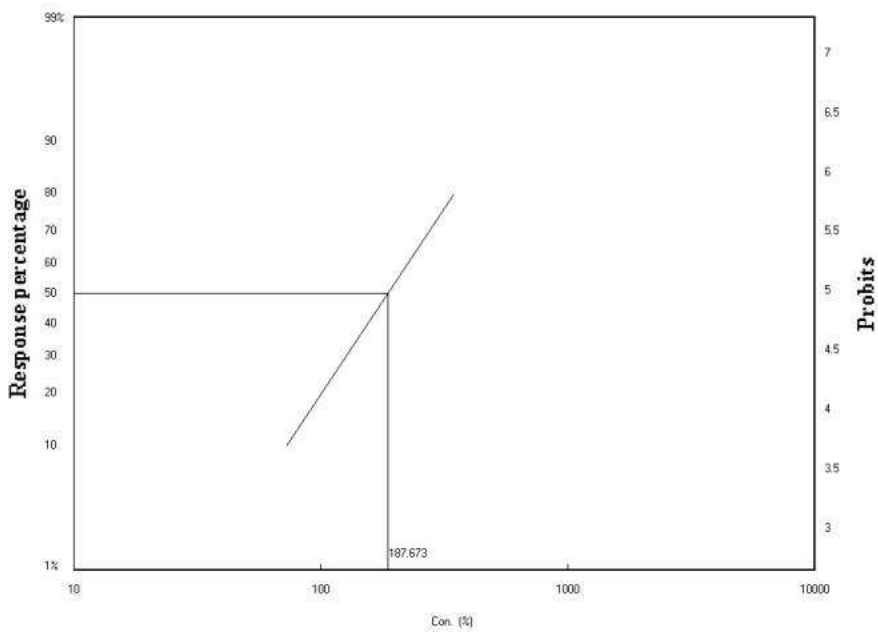
Experimental setup used for 96 hrs. LC_{50} of Hetero Infrastructure Limited effluent with pink zebra fish was shown Fig. 3.16. Dose-Mortality curves generated from the LDP Line software for median Lethal Concentrations (LC_{50}) during different exposure periods were shown in Fig. 3.17

During the 96 hrs. exposure period, no mortality was observed in control treatment. No mortality was found during the test time (96 hrs.) in the effluent concentrations of 10%, 20% and 30%. Effluent of 50% concentrations recorded 5% mortality during the last 24 hours. Whereas, 60% effluent recorded 5% mortality during the last 48 hours. The 90% effluent recorded 10% mortality while the 100% effluent recorded 25% mortality during the test time of 96 hours. These results indicate that the treated effluent collected from the guard pond of M/s Hetero Infrastructure SEZ Limited does not fulfill the test acceptability criterion. The results of this 4-day long bio-assay experiment revealed that the treated effluent of M/s Hetero Infrastructure SEZ Limited did not fulfil the CPCB norms for the bio-assay test, i.e. 90% of survival of zebra fish in 100% of treated effluent during the test time of 96 hours.

Fig. 3.16: Experimental set up for the bio-assay test

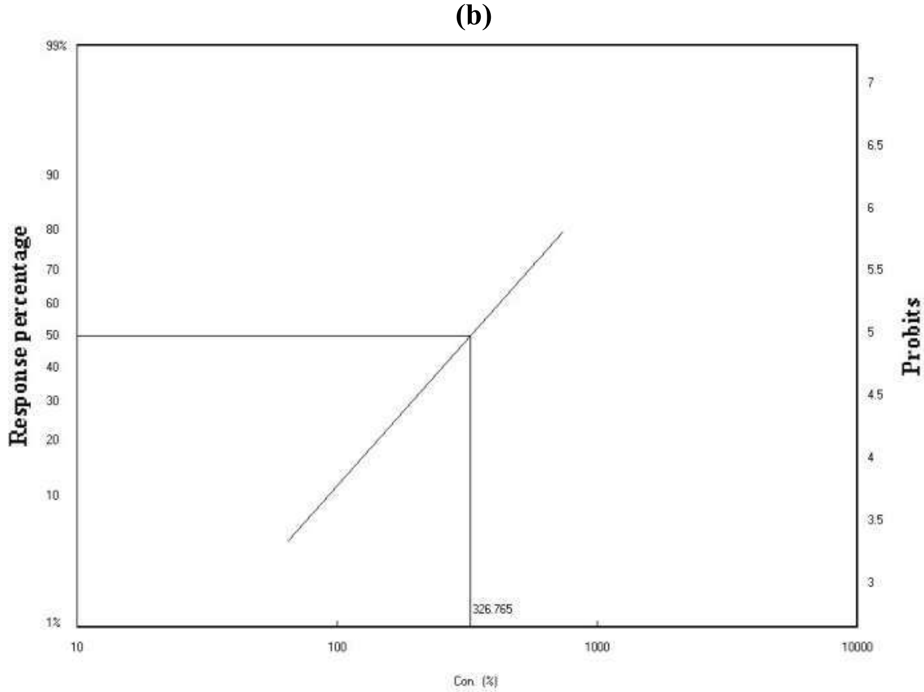
Fig. 3.17: Dose-Mortality curves generated from LDP Line software for median lethal concentration (LC_{50}) of zebra fish to the treated effluent during the exposure periods of (a) 72 hrs. and (b) 96 hrs.

(a)



72 Hrs.

(b)



96 Hrs.

Furthermore, an assessment of acute eco-toxicity of the treated effluent collected from M/s Hetero Infrastructure SEZ Limited was made in terms of Acute Toxicity Units (TUa). Recently, various industrial effluents that require discharge permits are assessed through the 'TUa' (TUa=100/LC_{50} %v/v). It is a specified criterion used for discharge monitoring permits routinely used by the US-EPA. For each test performed the toxicity unit was calculated as 100% (full-strength effluent expressed as percentage) divided by the LC_{50} values. Acute toxicity units (TUa) obtained for treated effluents from M/s Hetero Infrastructure SEZ Limited is 0.56 (range: 0.35 to 0.71) for zebra fish.

The following criteria (Table 3.25) used by Pool et al (2009) were used to assess the level of eco-toxicity of treated effluents for zebra fish.

Table 3.25: Acute Toxicity Grading of treated effluents based on Toxicity Units (TUa)

Toxicity Unit (TUa)	Category
< 1.0	**Limited/or not acutely toxic**
1 - 2	**Negligibly acute toxic**
2- 10	**Mildly acute toxic**
10 – 100	**Acutely toxic**
>100	**Highly acutely toxic**

Based on the above criterion, the treated effluent from M/s Hetero Infrastructure SEZ Limited is graded as **Limited Toxic**.

3.4.2. Trace metals in the treated effluent

Trace element concentrations in the treated effluent were determined by the ICP-MS analysis. Concentrations of all the elements measured in the treated effluent fulfil the norms of the Central Pollution Control Board (CPCB) (Table 3.26) set for treated effluent for sea discharge.

Table 3.26: Trace metal concentrations in the treated effluent collected from the guard pond

Element	Concentration (µg/L)	Standard Limit Max. (µg/L)
Al	162.8	-
V	8.6	200
Cr	13.9	2000
Mn	160.2	2000
Fe	274.3	3000
Co	3.5	-
Ni	11.5	2000
Cu	87.5	3000
Zn	494.7	5000
As	1.4	200
Se	9.7	50
Cd	2.7	50
Pb	29.5	100

Chapter 4
SUMMARY AND CONCLUSION

1. The quality of waters around the marine outfall point during the observational period is similar to that of a typical coastal environment. The results of the present study are comparable to those obtained in earlier monitoring studies conducted in 2012 and 2014 in the same region. Relatively high nutrients and less dissolved oxygen in the bottom waters than that of the surface are due to the consumption of nutrients by phytoplankton in the surface and the release of nutrients and consumption of oxygen during the heterotrophic decomposition of organic matter in the bottom waters.
2. The concentration ranges of all chemical constituents in the vicinity of marine outfall are well within the ambient levels of a healthy coastal environment and would not pose a threat to marine biota.
3. The normal range of microbial flora such as total viable bacterial counts (TVC), total coliform and *E. coli* like organisms (ECLO) in the surface waters (5.6 -13.6x10^3, 0.3-0.8x10^3 and 1.5-3.7x10^3 CFU/ mL respectively) and bottom waters (3.2-33.0x10^3, 0.2-1.2x10^3 and 0.7-7.4x10^3 CFU/ mL respectively) suggest that the marine environment the vicinity of the outfall location is healthy and no significant microbial contamination is evident in the region.
4. A total number of phytoplankton genera recorded in the surface water varied from 12-19 in the surface and 15-22 in the bottom waters. The majority of the phytoplankton taxa are diatoms. The important genera of phytoplankton in the region are *Cheatocerus, Nitzschia* sp., *Pseudo-nitzschia*, *Rhizosolenia* sp., *Skeletonema, Navicula Thalassionema Thalassiosira Thalassiothrix Coscinodisus and Guinarida*.

5. A total of 15 different taxa including larvae were recorded for zooplankton. The numerical counts of different taxa recorded in the study area varied between 500 and 3239 Nos/m^3 while the biomass was in the range of 0.03 - 0.41 mL /m^3. The most dominant taxa recorded was the copepod, with a contribution of 75.8 to 94.3% to the total abundance. The overall picture of the zooplankton in the study area suggests that the composition and biomass were moderately high and attributed to inter annual variations.
6. The population density of macrofauna ranged from 900 to 4650 Nos/m^2. The total wet weight of biomass was in the range of 1.22–8.99 g/m^2. Polychaetes are the major contributor to the wet weight of biomass.
7. The total count of meiofauna was in the range of 416-1006 No/10cm^2 with a mean value of 661$\pm$186/10cm^2. Nematodes were the most dominant group with numerical density of 311-710/10cm^2 and percent composition of >80% at all stations
8. A comparison of biological data of the present study with the results of previous monitoring studies conducted in 2012, 2014 and 2017 revealed that the abundance of both phytoplankton and zooplankton were relatively low in this study compared to those found in 2017 but comparable with those found in 2012 and 2014. Therefore, relatively low abundance of phyto- and zooplankton may be due to inter annual variability associated with inter annual variability in physical and biogeochemical processes
9. Bioassay tests conducted on treated effluent collected from the guard of M/s Hetero Infrastructure SEZ Limited using zebrafish revealed that the treated effluent did not fulfill the CPCB norms for bioassay test of treated effluent for sea discharge,,i.e., 90% survival in 100% effluent during the test time of 96 hours. Only 75% survival of zebra fish was found in the 100% effluent after 96 hours, suggesting that it is required to

improve the quality of effluent before releasing it into the sea. Extensive algal growth in the guard ponds, due to the availability of nutrients such as nitrate, phosphate and silicate, may be suppressed in eco-friendly manner.

Chapter 5
RECOMMENDATIONS

Based on in-situ observations and results on laboratory analysis of samples collected during the field work the following recommendation are given to improve the quality of treated effluent and to maintain the health of the ecosystem in the coastal waters of Nallamattipalem.

1. Due to the decrease in the abundance of phytoplankton and zooplankton in this study compared to the previous study conducted in 2017, it is recommended to monitor the marine environment continuously for the next three years during the pre-SW monsoon season of each year.
2. Sludge should be removed from the guard ponds on regular time intervals, at least quarterly time scales
3. Extensive algal growth found in the guard ponds caused by the availability of plenty of nutrients such as nitrate, phosphate and silicate, should be suppressed. Algal growth suppression should be achieved in eco-friendly manner, such as continuous mixing of effluent in the guard pond using air blowers.

References:

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Annexure-IX

DISPLAY BOARDS INSTALLED AT

THE CROSSING OF ROAD AND CREEK

ANNEXURE-X

Andhra Pradesh Coastal Zone Management Authority (APCZMA),
Andhra Pradesh
Ministry of Environment Forests & Climate Change Government of India
Paryavaran Bhavan, APIIC Colony Road, Gurunanak Colony,
Autonagar, Vijayawada-520007

सत्यमेव जयते

LiFE Lifestyle For Environment

Letter No. 382/CRZ/IND/2022- **Dated: 09.10.2023**

To
The Secretary,
Ministry of Environment and Forests and Climate Change,
Indira Paryavaran Bhavan,
Jorbagh Road,
New Delhi – 110 003.

Sir,

Sub: APCZMA - CRZ - M/s. Hetero Infrastructure SEZ Ltd. at N. Narasapuram (V), Ch. Lakshmipuram (V), Rajaihpeta (V), PedaTeernala (V), of Nakkapalli (M), Visakhapatnam District, Andhra Pradesh – Proposal for regularization of existing desalination plant in CRZ area - CRZ Clearance under the provisions of the CRZ Notification, 2011 - Recommendations of APCZMA – Communicated - Reg.

Ref:
1) Proposal received from M/s. Hetero Infrastructure SEZ Ltd, Visakhapatnam on 02.08.2022, 08.11.2022 & 09.12.2022.
2) APCZMA meeting held on 13.10.2022 at Vijayawada.
3) O.A. No. 23 of 2022 (SZ), the Hon'ble NGT, Chennai
4) T.O. letter dated: 09.11.2022.
5) Information received on 08.11.2022 & 09.12.2022.
6) APCZMA meeting held on 08.02.2023 at Vijayawada.
7) T.O. letter dated: 23.02.2023 addressed to the committee members and applicant for constitution of the Technical Committee.
8) Appeal No. 04 of 2023 (SZ) in OA No. 23 of 2022 the Hon'ble NGT, Chennai.
9) A mail was addressed to the Technical Committee on 09.03.2023 for inspection on 14.03.2023 & 15.03.2023.
10) T.O. letter dated: 24.04.2023 addressed to the project proponent and to the EE, RO: Visakhapatnam.
11) The applicant furnished information on 04.05.2023.
12) The Committee submitted report on 26.05.2023.
13) APCZMA meeting held on 17.08.2023 at Vijayawada.
14) APCZMA Letter dated: 20.09.2023.
15) EFS&T Dept., letter dated 29.09.2023.

***

1) M/s. Hetero Infrastructure SEZ Ltd., at N. Narasapuram (V), Ch. Lakshmipuram (V), Rajaihpeta (V), PedaTeernala (V), of Nakkapalli (M), Visakhapatnam District, Andhra Pradesh and submitted the proposal for regularization of existing

desalination plant in CRZ area. The applicant sought clearance under the provisions of CRZ Notification 2011.

2) Earlier, the project proposal was placed in the 52nd and 55th APCZMA meetings held on 13.10.2022 and 08.02.2023 at Vijayawada. A Technical Committee was constituted vide letter dt: 28.02.2023 to examine the following:

   - The report of Joint Committee constituted by the Hon'ble NGT regarding OA No. 23 of 2022;

   - The certified compliance report & other documents submitted by the project proponent and the consultant

   - Visit the area to assess the environmental damages caused by the construction of Desalination in CRZ area and shall give specific recommendation in respect of activities corresponding to the environmental or ecological damage assessed, to be taken up by the project proponent under Compensatory Conservation Plan (CCP) and Community Resource Augmentation Plan (CRAP), as per the MoEF&CC OM dated 19.02.2021 and OM F.No.19-125/2019-IA.III, dated: 05.03.2020.

3) The Committee inspected on 14.03.2023 and examined the issues and submitted a report on 26.05.2023.

4) The project proponent along with their consultant M/s. Indomer Coastal Hydraulics Pvt. Ltd., Chennai attended the meeting and explained about the proposal as follows:

   a) The proponent is ready to pay the compensation of Rs. 9.7 Crore proposed by the Committee constituted by the APCZMA.

   b) The Hon'ble NGT in OA. No. 23 of 2022 had constituted a Joint committee and one of the committee recommendations is as follows:
   "*M/s. Hetero Infrastructure SEZ Ltd., shall obtain approval from MoEF&CC for operation of desalination unit in CRZ area and also shall obtain necessary amendments for operation of the desalination plant in CFO of APPCB.*" The Committee report has already been submitted to the Hon'ble NGT. There are no further orders from the Hon'ble NGT.

   c) Appeal No. 04 of 2023 has also been filed in Hon'ble NGT against the industry. However, there are no orders of the Hon'ble NGT.

   d) The request for regularization of the desalination plant may be considered subject to the further orders of the Hon'ble NGT in OA No 23 of 2022 and Appeal No 04 of 2023.

5) The Authority noted the following observations:

a) The existing desalination plant is located in CRZ III (NDZ) area as per CRZ Notification, 2011. The approval taken earlier was for desalination plant in non-CRZ area; however, the desalination plant has been put up in CRZ III (NDZ) area. Hence, the proposal for regularization.

b) As per Para 8 (III) (A) (iii) (h) of CRZ Notification, 2011 - "Foreshore facilities for desalination plant and associated facilities" is a permissible activity in CRZ III (NDZ) area.

c) As per Para 5.3 (i) of CRZ Notification, 2019, "Desalination plants and associated facilities" is a permissible activity in CRZ III (NDZ) area as it is a permissible in CRZ IB area (5.1.2 (xviii))." However, CRZ Notification, 2019 is still to come in force in the State of AP .

d) There are sand dunes at a distance of 2.8 Km northeast of the desalination plant as per the EIA Report.

e) In OA No 23 of 2022, the Hon'ble NGT formed a committee. The committee has submitted its report to the Hon'ble NGT (***ANNEXURE-A***). In the committee report, there are observations of the committee, violations of CRZ, EC and CFO conditions. The Committee has also submitted its final recommendations along with the Environmental Compensation. The case is still pending in the Hon'ble NGT and there are no further orders.

f) Further, Appeal No. 04 of 2023 has been filed in the Hon'ble NGT after issue of CRZ orders by MoEF&CC vide dated 11th January, 2023. The case is pending in the Hon'ble NGT and no further interim / final orders have been issued by the Hon'ble NGT.

g) The proposal for linking of the desalination plant reject pipeline with the effluent marine discharge pipeline is absolutely against the marine discharge SOP of APPCB as no pipeline can be added after the guard ponds. Hence, the proposal for linking of the desalination plant reject pipeline cannot be considered.

h) The committee constituted by the APCZMA in the 55th APCZMA meeting has submitted a detailed report dt. 26.05.2023 (***ANNEXURE-B***), wherein the committee has recommended the regularization of desalination plant in NDZ area as the desalination plant does not create any major impact on the environment. However, the implementation of the Environmental Compensation will ensure prompt action and meet the goals of Sustainable development and socio economic progress of the region. The committee has made many observations and other recommendations in its report.

i) It was also presented that the condition of the desalination plant reject pipeline into the sea is not in good condition. The desalination plant needs to have independent intake pipeline and reject pipeline without any mixing with the effluent marine discharge pipeline. Hence, it is essential that the separate intake and reject pipeline of the desalination plant are duly verified for fitness and rectified if not in a fit condition.

j) There are number of other conditions recommended in the committee reports at ANNEXURE-A & ANNEXURE-B which need to be complied.

k) The Authority noted that the Para No 4 of the OM F.No. IA3-12/1/2022-IA.III, dated 26.04.2022 issued by the MoEF&CC, GoI, New Delhi reads as follows:

"In case, the CZMA desires to consider an activity which is not explicitly mentioned in the notification or not permissible, such recommendations shall be forwarded with detailed justification to the Ministry for consideration."

6) **Taking note of the above, after detailed discussions, the Authority decided to recommend the proposal of M/s. Hetero Infrastructure SEZ Ltd., at N. Narasapuram (V), Ch. Lakshmipuram (V), Rajaihpeta (V), PedaTeernala (V), of Nakkapalli (M), Visakhapatnam District, Andhra Pradesh to MoEF&CC, GoI, New Delhi to consider the proposal for regularization of existing desalination plant, duly taking into account the pending court cases and the above observations of the authority, with the following specific and general conditions, subject to orders in the Court cases:**

PART - A: Specific Conditions:

(i) *Compliance of all the conditions recommended by the committee constituted by the Hon'ble NGT, including the following, subject to the orders of the Hon'ble NGT:*

a) *M/s. Hetero Infrastructure SEZ Ltd., shall obtain approval from MoEF&CC for operation of desalination unit in CRZ area and also shall obtain necessary amendments for operation of the desalination plant in CFO of APPCB.*

b) *M/s. Hetero Infrastructure SEZ Ltd., & M/s. Hetero Labs Ltd, N-Narasapur Village, Nakkapalli Mandal, Visakhapatnam District shall pay the Environmental compensation of Rs.6,94,95,000/- for the failure to comply with the conditions of Environmental Clearance issued by MoEF&CC and Consent issued by APPCB and same shall be paid to APPCB.*

c) *M/s. Hetero Infrastructure SEZ Ltd., & M/s. Hetero Labs Ltd shall comply with the conditions issued by the MoEF&CC & APPCB.*

d) *The industry shall explore the possibility of recycling of treated wastewater and reducing the withdrawal of the sea water.*

e) *The industry shall make efforts to recycle and reuse the treated effluents so as to reduce the intake water quantity from the Sea.*

f) *The industry shall conduct long term Environmental Impact Assessment study to ascertain the impact of pollution on water, air, soil and agricultural crops within 5 Km radius of the industry through any reputed Institutes viz., NEERI, IIT, EPTRI.*

g) *The industry shall conduct impact assessment study on human health due to pollution of M/s. Hetero Infrastructure SEZ Ltd., & M/s. Hetero Labs Ltd if* *any through ICMR institute/any reputed Government institutions in 5 KMs radius in view of the apprehensions of the villagers on Health impacts due to operation of the industries.*

h) *The industry shall carry out an assessment study of the marine environment around the marine outfall point (MOP) of M/s. Hetero Infrastructure SEZ Ltd., including desalination rejects discharge point through NIO.*

i) *The industry close the excess raw water discharge pipeline (as observed in the report by the committee).*

(ii) *Compliance of all the conditions recommended by the committee constituted by the APCZMA, including the following:*

a) *The industry close down the existing excess seawater discharge pipeline.*

b) *The industry shall allocate the budget of Rs. 9.7 Crores (Compensatory Conservation Plan (CCP) - Rs.6.8 Crores & Community Resources Augmentation Plan (CRAP) - Rs.3.0 Crores) for implementing the activities under CCP & CRAP.*

c) *The industry increase the budget depending on the requirement under Compensatory Conservation Plan (CCP) and Community Resource Augmentation Plan(CRAP), as per the MoEF&CC OM dated 19.02.2021 and OM F.No.19-125/2019-IA.III, dated: 05.03.2020.*

(iii) *The proposal for linking of the desalination plant reject pipeline with the effluent marine discharge pipeline is absolutely against the marine discharge SOP of APPCB as no pipeline can be added after the guard ponds. Hence, the proposal for linking of the desalination plant reject pipeline cannot be considered. The desalination plant shall have its own separate intake and reject pipelines.*

(iv) *The separate intake and reject pipeline of the desalination plant shall be duly verified for fitness and rectified immediately.*

(v) *The proposed constructions shall conform to the norms prescribed in CRZ Notification issued by the Ministry of Environment and Forests, Government of India S. O. No.19(E), dated 06-01-2011 and shall not affect the coastal ecology of the area.*

(vi) *No activity on ground shall be undertaken without obtaining Environmental Clearance from the Ministry of Environment and Forests, Government of India as per S. O. No.19(E), dated 06-01-2011.*

(vii) *During accidental breakage of pipeline, the necessary mitigation measures like immediately attending the repair of pipeline has to be taken up. Necessary spares of pipeline segments with bends/tees and divers with experience in salvation operation irrespective of sea condition have to be kept ready always within the industrial unit.*

(viii) *A Continuous monitoring system should be put in place by the applicant to find* *out the impact on marine life/flora/fauna, due to discharge.*

(ix) *The applicant shall ensure that Continuous monitoring of all likely affected parameters including air/ water quality/ reject water discharges are monitored and monthly report is to be submitted to the APPCB.*

(x) *Priority to be given to the maintenance of storm water drains from the surrounding area to prevent possible flooding of the surrounding areas.*

(xi) *No solid waste shall be disposed in the Coastal Regulation Zone area. The solid waste shall be properly collected, segregated and disposed as per the provision of Solid Waste (Management and Handling) Rules, 2000 and amendment thereof.*

(xii) *The proponent shall implement all the mitigation measures as mentioned in the Marine EIA report.*

(xiii) *Once in a year around the discharge point, the biological fauna especially benthic organism status shall be studied and for that effect a report should be submitted to APCZMA.*

PART B: General Conditions:

(i) *A copy of the clearance letter shall also be displayed on the website of the AP Pollution Control Board. The Clearance letter shall also be displayed at the AP Pollution Control Board Regional Office, District Industries Centre and District Collector Office/ Mandal Revenue Office for 30 days.*

(ii) *The funds earmarked for environmental protection measures shall be kept in separate account and shall not be diverted for other purpose. Year-wise expenditure shall be reported to the Andhra Pradesh Coastal Zone Management Authority (APCZMA) and AP Pollution Control Board Regional Office.*

(iii) *Concealing factual data by the project proponent, any officer on behalf of the project proponent and consultants hired by the project proponent or submission of false/fabricated data and failure to comply with any of the conditions mentioned above may result in withdrawal of this clearance and attract action under the provisions of Environment (Protection) Act, 1986.*

(iv) *Consent for Establishment (CFE) and Consent for Operation (CFO), as may be applicable, shall be obtained from State Pollution Control Board under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.*

All waste (liquid and solid) arising from the proposed development shall be disposed of as per the norms prescribed by State Pollution Control Board. There shall not be any disposal of untreated effluent into the sea/coastal water bodies.

(v) *Full co-operation shall be extended to the officials from the APCZMA, APPCB and Regional Office of MoEF&CC, during monitoring of implementation of environmental safeguards stipulated. It shall be ensured that documents/data sought pertinent is made available to the monitoring team. A complete set of all the* *documents submitted to APCZMA shall be forwarded to the AP Pollution Control Board Regional Office.*

(vi) *In the case of any change(s) in the scope of the project, the project would require a fresh appraisal by the APCZMA.*

(vii) *The APCZMA reserves the right to add additional safeguard measures subsequently, if found necessary, and to take action including revoking of the CRZ clearance under the provisions of the Environmental (Protection) Act, 1986, to ensure effective implementation of the suggested safeguard measures in a time bound and satisfactory manner.*

(viii) *All other statutory clearances shall be obtained, as applicable by project proponents from the respective competent authorities.*

(ix) *The project proponent should advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded CRZ Clearance and copies of clearance letters are available with the AP Pollution Control Board and may also be seen on the website of APCZMA. The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the AP Pollution Control Board Regional Office.*

(x) *This Clearance is subject to any order passed by any Hon'ble Courts, as may be applicable to this project.*

(xi) *A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/ representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.*

(xii) *The proponent shall upload the status of compliance of the stipulated conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the AP Pollution Control Board Regional Office and the APPCB, Head Office.*

(xiii) *The Project Proponent shall ensure that there is no destruction of mangroves, if any, during the construction as well as the operation phase of the project.*

(xiv) *There shall be no dressing or alteration of the sand dunes and natural features, including landscape changes for beautification, recreation and other such purpose.*

(xv) *No permanent labour camp, machinery and material storage shall be allowed in CRZ area.*

(xvi) *There shall no ground water drawl within CRZ without prior approval of the State Ground Water Authority.*

(xvii) *Disposal of muck during construction phase should not create any adverse effect on the neighboring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved sites with the* *approval of competent authority.*

7) The MoEF&CC, GoI, New Delhi vide dt: 26.04.2022 issued Office Memorandum for the procedure for Clearance of Permissible Activities as per the CRZ Notification, 2011 and IPZ Notification, 2011 wherein, as per paragraph (5) stated that "*in case the Coastal Zone Management Authorities (CZMA) are not in existence due to delay in their reconstitution or any other reasons, then it shall be responsibility of the Dept. of Environment in the State Government or Union territory Administration, for providing comments and recommendation to the proposals in terms of the provisions of the said notification, to the concerned authority, as the case may be*".

8) The EFS&T Dept., Govt. of A. P., vide letter dated 29.09.2023, authorized the Member Secretary, APPCB to communicate the recommendations to the MoEF&CC, as per the approved minutes of the meeting held on 17.08.2023, as per the norms.

9) In view of the above, Recommendations of APCZMA on the proposal of M/s. Hetero Infrastructure SEZ Ltd., at N. Narasapuram (V), Ch. Lakshmipuram (V), Rajaihpeta (V), PedaTeernala (V), of Nakkapalli (M), Visakhapatnam District, Andhra Pradesh are communicated **to MoEF&CC, GoI, New Delhi to consider the proposal for regularization of existing desalination plant, duly taking into account the pending court cases and the above observations of the authority, with the following specific and general conditions, subject to orders in the Court cases**

Yours faithfully,

(2/2) **Member Secretary**
APPCB & APCZMA

Encl:
1. CRZ Form I;
2. EIA Report;
3. CRZ Report;
4. Copy of the Minutes of the APCZMA Meeting.

Copy to Sri. S. Kullayi Reddy, Associate Vice- President - EHS, M/s. Hetero Infrastructure SEZ Ltd., N. Narasapuram (V), Ch. Lakshmipuram (V), Rajaihpeta (V), Peda Teernala (V), Nakkapalli (M), Visakhapatnam District for information.

SV ENVIRO LABS & CONSULTANTS

(ENVIRONMENTAL ENGINEERS & CONSULTANTS IN POLLUTION CONTROL)

Corporate Office & Laboratory : Enviro House, B-1, Block B, IDA, Autonagar, Visakhapatnam - 530012

Hyderabad: Flat No. 202, [illegible] Residency, [illegible], Hyderabad-500038.

[illegible] 9440338155, +91 [illegible] [illegible] [illegible]

Recognized by Govt. of India MoEF & CC, New Delhi. Accredited by : NABL & NABET

Annexure-XI

Ref: SVELC/HH/23-11/01

Date: 20-11-2023

NAME AND ADDRESS : M/s. HETERO INFRASTRUCTURE SEZ LIMITED,
N.Narasapuram Village
Nakkapally Mandal
Visakhapatnam (Dt)

SAMPLE PARTICULARS : SOIL

SOURCE OF COLLECTION : 1. HETERO LABS UNIT [illegible]
2. HETERO LABS-IX
3. HETERO DRUGS UNIT IX

DATE OF COLLECTION : 11-11-2023

DATE OF RECEIPT : 11-11-2023

TEST REPORT

S.NO	PARAMETER	UNIT	1	2	3
1.	pH	-	7.45	7.62	7.26
2.	Conductivity	[illegible]	0.496	0.458	0.445
3.	Moisture	%	5.67	6.72	5.82
4.	Bulk density	g/cc	2.05	1.65	1.54
5.	Porosity	%	25	6	52
6.	Organic Matter	%	0.72	0.59	1.03
7.	Nitrogen as N	mg/100gm	0.31	0.38	0.41
8.	Phosphorus as P	mg/100gm	6.8	5.2	7.0
9.	Potassium as K	mg/100gm	3.5	4.5	[illegible]

CHECKED BY

SV ENVIRO LABS & CONSULTANTS

SV ENVIRO LABS & CONSULTANTS

(ENVIRONMENTAL ENGINEERS & CONSULTANTS IN POLLUTION CONTROL)

Corporate Office & Laboratory : [illegible]

Hyderabad : [illegible]

[illegible]

Recognized by Govt. of India-MoEF & CC, New Delhi. Accredited by : NABL & NABET

Ref: SVELC/H151/24-0401

Date: 29-04-2024

NAME AND ADDRESS : M/s. HETERO INFRASTRUCTURE SEZ LIMITED, N.Narasapuram Village, Nakkapally Mandal, Visakhapatnam (Dt).

SAMPLE PARTICULARS : WATER

SOURCE OF COLLECTION :
1. BOREWELL – 1 (Near STP)
2. BOREWELL – 2 (Near Labour Lake)
3. BOREWELL – 3 (Near Labour Shed)
4. BOREWELL – 4 (Near HLS-5)

DATE OF COLLECTION : 18-04-2024

TEST REPORT

S.No	Parameter	Unit	Results			
			1	2	3	4
1.	pH	-	7.68	6.79	8.08	7.74
2.	Total Dissolved Solids	mg/l	7220	24790	4730	[illegible]
3.	Total Alkalinity as $CaCO_3$	mg/l	472	360	426	540
4.	Total Hardness as $CaCO_3$	mg/l	840	7448	675	1600
5.	Calcium as Ca	mg/l	30.1	949	121	200
6.	Magnesium as Mg	mg/l	20	1392	85.4	267
7.	Chlorides as Cl	mg/l	3360	13972	2962	6640
8.	Copper as Cu	mg/l	<0.01	<0.01	<0.01	<0.01
9.	Manganese as Mn	mg/l	0.21	0.47	0.22	0.05
10.	Zinc as Zn	mg/l	0.35	0.44	0.39	0.28
11.	Aluminium as Al	mg/l	0.12	0.61	0.16	0.16
12.	Boron as B	mg/l	1.68	0.73	1.56	1.07
13.	Barium as Ba	mg/l	0.16	0.06	0.12	0.09
14.	Selenium as Se	mg/l	0.02	0.09	0.04	0.04
15.	Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01
16.	Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01
17.	Cyanide as CN	mg/l	<0.01	<0.01	<0.01	<0.01
18.	Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01
19.	Mercury as Hg	mg/l	<0.01	<0.01	<0.01	<0.01
20.	Nickel as Ni	mg/l	0.07	<0.01	<0.01	<0.01
21.	Total Arsenic as As	mg/l	0.03	0.12	0.04	0.02
22.	Total Chromium as Cr	mg/l	<0.01	<0.01	<0.01	<0.01
23.	Iron as Fe	mg/l	0.19	0.10	0.07	0.06

Note: All the above parameters are tested as per APHA methods, 24th Edition, 2023

CHECKED BY

SV ENVIRO LABS & CONSULTANTS

ANNEXURE-XII

भारत सरकार
Government of India
वाणिज्य और उद्योग मंत्रालय
Ministry of Commerce & Industry
पेट्रोलियम तथा विस्फोटक सुरक्षा संगठन (पैसो)
Petroleum & Explosives Safety Organisation (PESO)
पाँचवा तल, ए-ब्लाक, सी.जी.ओ.कॉम्प्लेक्स, सेमिनरी हिल्स
नागपुर- 440006
5th Floor, A-Block, CGO Complex, Seminary Hills,
Nagpur - 440006

E-mail : **explosives@explosives.gov.in**

Phone/Fax No : **0712 -2510248, Fax-2510577**

संख्या /No. : **P/HQ/AP/15/3852 (P250196)**

दिनांक /Dated : **23/12/2014**

सेवा में /To,

M/s. Hetero Drugs Limited (Unit IX),
Hetero Corporate, 7-2-A2,
Indl. Estate, Sanath Nagar,
Hyderabad,
District: HYDERABAD,
State: TELANGANA
PIN: 500018

विषय /Sub : **Plot No, Sy. No. 119/1A to 119/1F, 119/2A to 119/2F, 119/3 & 120/1, 120/2A to 120/2L, NA, N. Narasapuram (v), Nakkapally (m), District: VISAKHAPATNAM, State: Andhra Pradesh, PIN: 999999** में स्थित पेट्रोलियम वर्ग **A,B** अधिष्ठापन - पेट्रोलियम नियम 2002 के अंतर्गत प्ररूप XV में जारी अनुज्ञप्ति सं **P/HQ/AP/15/3852 (P250196)** – संशोधन के संदर्भ में ।

Existing Petroleum Class **A,B** Installation at **Plot No, Sy. No. 119/1A to 119/1F, 119/2A to 119/2F, 119/3 & 120/1, 120/2A to 120/2L, NA, N. Narasapuram (v), Nakkapally (m), District: VISAKHAPATNAM, State: Andhra Pradesh, PIN: 999999**- Licence No. **P/HQ/AP/15/3852 (P250196)** - granted in form XV under Petroleum Rules 2002 - Amendment regarding

महोदय /Sir (s),

कृपया आपके उपर्युक्त विषय से संबंधित पत्र संख्या **explo/petro/unit/02/2014-15** दिनांक **29/10/2014** का संदर्भ ग्रहण करें ।

Reference to your letter No. **explo/petro/unit/02/2014-15** dated **29/10/2014** on the above subject.

दिनांक **31/12/2024** तक वैध अनुज्ञप्ति संख्या **P/HQ/AP/15/3852 (P250196)** दिनांक **23/12/2014** निम्नलिखित वर्ग एवं मात्राओं में पेट्रोलियम भंडारण के लिए यथा संशोधित कर इस पत्र के साथ लौटाई जा रही है ।

Licence No. **P/HQ/AP/15/3852 (P250196)** dated **23/12/2014** valid upto **31/12/2024** is returned herewith duly amended with respect to Capacity Amendment,

पेट्रोलियम का विवरण /Description of Petroleum	किलोलीटरों में अनुज्ञप्ति क्षमता /Quantity licenced in KL
वर्ग क प्रपुंज पेट्रोलियम /Petroleum Class A, in bulk	**620.00 KL**
वर्ग क प्रपुंज पेट्रोलियम से भिन्न /Petroleum Class A, otherwise than in bulk	**NIL**
वर्ग ख प्रपुंज पेट्रोलियम /Petroleum Class B, in bulk	**124.00 KL**
वर्ग ख प्रपुंज पेट्रोलियम से भिन्न /Petroleum Class B, otherwise than in bulk	**NIL**
वर्ग ग प्रपुंज पेट्रोलियम /Petroleum Class C, in bulk	**NIL**
वर्ग ग प्रपुंज पेट्रोलियम से भिन्न /Petroleum Class C,otherwise than in bulk	**NIL**
कुल क्षमता /Total	**744.00 KL**

कृपया पावती दें।

Please acknowledge the receipt.

Note : Your ~~Balance Amount with the Organisation is Rs.[redacted], which will be used for processing of the same Licence in future.~~

भवदीय /Yours faithfully,

(आर.पी.सिंह)
(R.P.Singh)
उप मुख्य विस्फोटक नियंत्रक
Dy. Chief Controller of Explosives
कृते मुख्य विस्फोटक नियंत्रक
For Chief Controller of Explosives
नागपुर
Nagpur

Copy forwarded to :-
1. The The District Revenue Officer & Additional District Magistrate, Visakhapatnam , VISAKHAPATNAM(Andhra Pradesh) with reference to his NOC No 2897/2010/C6, Dated 20/05/2011
2. Jt. Chief Controller of Explosives, South Circle Office, CHENNAI. A Copy of the licence along with approved plan is enclosed.
3. Dy. Chief Controller of Explosives, Visakhapatanam, VISAKHAPATNAM. A Copy of the licence along with approved plan is enclosed.

For Chief Controller of Explosives
Nagpur

(अधिक जानकारी जैसे आवेदन की स्थिति, शुल्क तथा अन्य विवरण के लिए हमारी वेबसाइट : http://peso.gov.in देखें)

(For more information regarding status,fees and other details please visit our website: http://peso.gov.in)

1823

FORM XV
(see Article 6 of the First Schedule)

LICENCE TO IMPORT AND STORE PETROLEUM IN AN INSTALLATION

Licence No. : **P/HQ/AP/15/3852(P250196)** Fee Rs. **11660**/- per year

Licence is hereby granted to **M/s. Hetero Drugs Limited (Unit IX), Hetero Corporate, 7-2-A2, Indl. Estate, Sanath Nagar, Hyderabad, District: HYDERABAD, State: TELANGANA, PIN: 500018** valid only for the importation and storage of **744.00 KL** Petroleum of the class(es) and in quantities as herein specified and storage thereof in the place described below and shown on the approved plan No **P/HQ/AP/15/3852(P250196)** dated **20/07/2011** attached hereto subject to the provisions of the Petroleum Act, 1934 and the rule made thereunder and to the further conditions of this Licence.

The Licence shall remain in force till the 31st day of December **2024**

Description of Petroleum	Quantity licenced in KL
Petroleum Class A, in bulk	**620.00 KL**
Petroleum Class A, otherwise than in bulk	**NIL**
Petroleum Class B, in bulk	**124.00 KL**
Petroleum Class B, otherwise than in bulk	**NIL**
Petroleum Class C, in bulk	**NIL**
Petroleum Class C,otherwise than in bulk	**NIL**
Total	**744.00 KL**

July 20, 2011

Chief Controller of Explosives

1). Amendment dated - 16/02/2012
2). Amendment dated - 23/12/2014

DESCRIPTION AND LOCATION OF THE LICENSED PREMISES

The licensed premises, the layout , boundaries and other particulars of which are shown in the attached approved plan are situated at **Plot No: Sy. No. 119/1A to 119/1F, 119/2A to 119/2F, 119/3 & 120/1, 120/2A to 120/2L, NA, N. Narasapuram (v), Nakkapally (m), District: VISAKHAPATNAM, State: Andhra Pradesh, PIN: 999999** and consists of **Twenty aboveground Petroleum Class A & Four aboveground Petroleum Class B storage tanks together with connected facilities.** together with connected facilities.

Licence No. P/HQ/AP/15/3852 (P250196)

SPACE FOR ENDORSEMENT OF RENEWALS

This licence shall be renewable without any concession in fee for ten years in the absence of contravention of any provisions of the Petroleum Act, 1934 or of the rules framed thereunder or of any of the conditions of this licence.	Date of Renewal	Date of Expiry of license	Signature and office stamp of the licencing authority.
1).	16/02/2012	31/12/2015	Sd/- T R Thomas
2).	23/12/2014	31/12/2024	Sd/- R.P.Singh Dy. Chief Controller of Explosives For Chief Controller of Explosives Nagpur

This licence is liable to be cancelled if the licensed premises are not found conforming to the description given on the approved plan attached hereto and contravention of any of the rules and conditions under which this licence is granted and the holder of this licence is also punishable for the first offence with simple imprisonment which may be extend to one month, or with fine which may extend to one thousand rupees, or with both and for every subsequent offence with simple imprisonment which may extend to three months, or with fine which may extend to five thousand rupees or with both.

भारत सरकार
Government of India
वाणिज्य और उद्योग मंत्रालय
Ministry of Commerce & Industry
पेट्रोलियम तथा विस्फोटक सुरक्षा संगठन (पैसो)
Petroleum & Explosives Safety Organisation (PESO)
पाँचवा तल, ए-ब्लाक, सी.जी.ओ.कॉम्प्लेक्स, सेमिनरी हिल्स
नागपुर- 440006
5th Floor, A-Block, CGO Complex, Seminary Hills,
Nagpur - 440006

E-mail : explosives@explosives.gov.in
Phone/Fax No : 0712 -2510248, Fax-2510577

SPEED POST

संख्या /No. : P/HQ/AP/15/3853 (P250194)

दिनांक /Dated : 02/02/2015

4 FEB 2015

सेवा में /To,

M/s. M/s. Hetero Labs Ltd., (Unit IX),
Hetero Corporate, 7-2-A2,,
Indl. Estate, Sanath Nagar,
Hyderabad,
District: HYDERABAD,
State: TELANGANA
PIN: 500018

विषय /Sub : Plot No, Sy. No. 119/1A to 119/1F, 119/2A to 119/2F, 119/3 & 120/1, 120/2A to 120/2L, NA, N.Narasapuram (v), Nakkapally (m), Nakkapalle, Taluka: Nakkapalle, District: VISAKHAPATNAM, State: Andhra Pradesh, PIN: 999999 में स्थित पेट्रोलियम वर्ग A,B अधिष्ठापन - पेट्रोलियम नियम 2002 के अंतर्गत प्ररूप XV में जारी अनुज्ञप्ति सं P/HQ/AP/15/3853 (P250194) – संशोधन के संदर्भ में ।

Existing Petroleum Class A,B Installation at Plot No, Sy. No. 119/1A to 119/1F, 119/2A to 119/2F, 119/3 & 120/1, 120/2A to 120/2L, NA, N.Narasapuram (v), Nakkapally (m), Nakkapalle, Taluka: Nakkapalle, District: VISAKHAPATNAM, State: Andhra Pradesh, PIN: 999999- Licence No. P/HQ/AP/15/3853 (P250194) - granted in form XV under Petroleum Rules 2002 - Amendment regarding

महोदय /Sir (s),

कृपया आपके उपर्युक्त विषय से संबंधित पत्र संख्या Explo/Petro/Unit-IX/03/2014-15 दिनांक 26/12/2014 का संदर्भ ग्रहण करें ।
Reference to your letter No. Explo/Petro/Unit-IX/03/2014-15 dated 26/12/2014 on the above subject.

दिनांक 31/12/2024 तक वैध अनुज्ञप्ति संख्या P/HQ/AP/15/3853 (P250194) दिनांक 02/02/2015 निम्नलिखित वर्ग एवं मात्राओं में पेट्रोलियम भंडारण के लिए यथा संशोधित कर इस पत्र के साथ लौटाई जा रही है ।
Licence No. P/HQ/AP/15/3853 (P250194) dated 02/02/2015 valid upto 31/12/2024 is returned herewith duly amended with respect to Lay out Amendment,

पेट्रोलियम का विवरण /Description of Petroleum	किलोलीटरों में अनुज्ञप्ति क्षमता /Quantity licenced in KL
वर्ग क प्रपुंज पेट्रोलियम /Petroleum Class A, in bulk	328.00 KL
वर्ग क प्रपुंज पेट्रोलियम से भिन्न /Petroleum Class A, otherwise than in bulk	NIL
वर्ग ख प्रपुंज पेट्रोलियम /Petroleum Class B, in bulk	112.00 KL
वर्ग ख प्रपुंज पेट्रोलियम से भिन्न /Petroleum Class B, otherwise than in bulk	NIL
वर्ग ग प्रपुंज पेट्रोलियम /Petroleum Class C, in bulk	NIL
वर्ग ग प्रपुंज पेट्रोलियम से भिन्न /Petroleum Class C,otherwise than in bulk	NIL
कुल क्षमता /Total	440.00 KL

कृपया पावती दें।
Please acknowledge the receipt.

Note : Your Balance Amount with the Organisation is Rs.[redacted], which will be used for processing of the same Licence in future.

भवदीय /Yours faithfully,

(आर.पी.सिंह)
(R.P.Singh)
उप मुख्य विस्फोटक नियंत्रक
Dy. Chief Controller of Explosives
कृते मुख्य विस्फोटक नियंत्रक
For Chief Controller of Explosives
नागपुर
Nagpur

Copy forwarded to :-
1. The The District Revenue Officer & Additional District Magistrate, Visakhapatnam , VISAKHAPATNAM(Andhra Pradesh) with reference to his NOC No 2898/2010/C6 Dated 20/05/2011
2. Jt. Chief Controller of Explosives, South Circle Office, CHENNAI. A Copy of the licence along with approved plan is enclosed.
3. Dy. Chief Controller of Explosives, Visakhapatanam, VISAKHAPATNAM. A Copy of the licence along with approved plan is enclosed.

For Chief Controller of Explosives
Nagpur

69

FORM XV
(see Article 6 of the First Schedule)

LICENCE TO IMPORT AND STORE PETROLEUM IN AN INSTALLATION

Licence No. : **P/HQ/AP/15/3853(P250194)** Fee Rs. **7100**/- per year

Licence is hereby granted to **M/s. M/s. Hetero Labs Ltd., (Unit IX), Hetero Corporate, 7-2-A2,, Indl. Estate, Sanath Nagar, Hyderabad, District: HYDERABAD, State: TELANGANA, PIN: 500018** valid only for the importation and storage of **440.00 KL** Petroleum of the class(es) and in quantities as herein specified and storage thereof in the place described below and shown on the approved plan No **P/HQ/AP/15/3853(P250194)** dated **20/07/2011** attached hereto subject to the provisions of the Petroleum Act, 1934 and the rule made thereunder and to the further conditions of this Licence.

The Licence shall remain in force till the 31st day of December **2024**

Description of Petroleum	Quantity licenced in KL
Petroleum Class A, in bulk	**328.00 KL**
Petroleum Class A, otherwise than in bulk	**NIL**
Petroleum Class B, in bulk	**112.00 KL**
Petroleum Class B, otherwise than in bulk	**NIL**
Petroleum Class C, in bulk	**NIL**
Petroleum Class C,otherwise than in bulk	**NIL**
Total	**440.00 KL**

July 20, 2011

Chief Controller of Explosives

1). Amendment dated - 16/02/2012
2). Amendment dated - 02/02/2015

DESCRIPTION AND LOCATION OF THE LICENSED PREMISES

The licensed premises, the layout , boundaries and other particulars of which are shown in the attached approved plan are situated at **Plot No: Sy. No. 119/1A to 119/1F, 119/2A to 119/2F, 119/3 & 120/1, 120/2A to 120/2L, NA, N.Narasapuram (v), Nakkapally (m), Nakkapalle, Taluka: Nakkapalle, District: VISAKHAPATNAM, State: Andhra Pradesh, PIN: 999999** and consists of **Twenty Four aboveground Petroleum Class A & Two aboveground Petroleum Class B storage tanks together with connected facilities.** together with connected facilities.

Licence No. P/HQ/AP/15/3853 (P250194)

SPACE FOR ENDORSEMENT OF RENEWALS

This licence shall be renewable without any concession in fee for ten years in the absence of contravention of any provisions of the Petroleum Act, 1934 or of the rules framed thereunder or of any of the conditions of this licence.	Date of Renewal	Date of Expiry of license	Signature and office stamp of the licencing authority.
1).	16/02/2012	31/12/2017	Sd/- T R Thomas
2).	23/12/2014	31/12/2024	Sd/- R.P.Singh Dy. Chief Controller of Explosives For Chief Controller of Explosives Nagpur

This licence is liable to be cancelled if the licensed premises are not found conforming to the description given on the approved plan attached hereto and contravention of any of the rules and conditions under which this licence is granted and the holder of this licence is also punishable for the first offence with simple imprisonment which may be extend to one month, or with fine which may extend to one thousand rupees, or with both and for every subsequent offence with simple imprisonment which may extend to three months, or with fine which may extend to five thousand rupees or with both.

स्पीड पोस्ट

SPEED POST

26 OCT 2016

FORM XV

(See Article 1(b) of the First Schedule)

[illegible]

LICENCE TO IMPORT AND STORE PETROLEUM IN AN INSTALLATION

Licence No. : [illegible]

M/s. Honour Lab Limited - Unit - [illegible], H. No. [illegible], Erragadda, Hyderabad, District HYDERABAD, State: TELANGANA, PIN: [illegible] [illegible] 220.00 KL [illegible]

[illegible] is hereby granted to M/s. Honour Lab Limited - Unit - II, H. No. [illegible], Erragadda, Hyderabad, District HYDERABAD, State: TELANGANA, PIN: [illegible] [illegible] and storage of 220.00 KL [illegible] the approved plan No. [illegible] subject to the provisions of the Petroleum Act, 1934 and the rules made thereunder and to the further conditions of this licence.

[illegible] day of December 2025 [illegible]

The licence shall remain in force till the 31st day of December 2025

Description of Petroleum	Quantity licensed in KL
[illegible] Petroleum Class A in bulk	[illegible] KL
[illegible] Petroleum Class A, otherwise than in bulk	NIL
[illegible] Petroleum Class B in bulk	22.00 KL
[illegible] Petroleum Class B, otherwise than in bulk	NIL
[illegible] Petroleum Class C in bulk	NIL
[illegible] Petroleum Class C otherwise than in bulk	NIL
	220.00 KL

December [illegible], 2025

For Chief Controller of Explosives

HQ, Nagpur

DESCRIPTION AND LOCATION OF THE LICENSED PREMISES

[illegible] Survey No. 125 & 138, [illegible] SEZ Limited, [illegible], Taluka: [illegible], VISAKHAPATNAM, [illegible] Above Ground tank(s) for CLASS A [illegible] Above Ground tank(s) for CLASS B [illegible]

The licensed premises [illegible] are shown in the attached approved plan [illegible] Survey No. 125 & 138 [illegible] SEZ Limited, [illegible], Taluka: [illegible], VISAKHAPATNAM, State: Andhra Pradesh, PIN: [illegible] Above Ground tank(s) for CLASS A [illegible] Above Ground tank(s) for CLASS B, together with connected facilities.

Annexure-XIII

SV ENVIRO LABS & CONSULTANTS

Environmental Engineers & Consultants in Pollution Control
Enviro House B-1, Block - B, IDA,
Autonagar, Visakhapatnam
Phone: [illegible]
Email: [illegible]
(Recognized by GOI, Ministry of Environment & Forests)
(An ISO 9001 Certified and NABET Accredited for EIA)

Ref Code : SVELC/HISEZL/2024-04/008 Date : 28-04-2024

Name and Address : M/s. HETERO INFRASTRUCTURE SEZ LIMITED,
N. Narasapuram Village, Nakkapally Mandal,
Visakhapatnam (Dt).

Sample Particulars : NOISE LEVELS

Date of Collection : 18-04-2024

TEST REPORT

STACK DETAILS

S.No	Source of Collection	Noise Levels measured in dB(A)	
		Day	Night
1	Near Stores Area	65.6	58.5
2	Near DF Block Area	63.0	57.4
3	Near Solvent Area	66.4	60.6
4	Near Production Block	66.2	59.[illegible]
5	Near Solvent Area	51.7	55.6
6	Near Canteen Area	50.6	53.8
CPCB STANDARDS		75.0	70.0

SV ENVIRO LABS & CONSULTANTS

ANNEXURE-XIV

GOVERNMENT OF ANDHRA PRADESH
WATER RESOURCES DEPARTMENT

From,
Sri R Sreenivasa Rao, B.E
Executive Engineer, W R Dep.
Visakhapatnam Division
Visakhapatnam

To,
M/s Hetero Infrastructure SEZ Ltd.,
N. Narasapuram (V)
Nakkapalli (M)
Anakapalli District

Letter No.622M EE/DVSP DD/ATO /File No. 10-07-2023.

Gentlemen,

Sub: W R Dept - Nakkapalli (M) – Ch.Lakshmipuram (V) Representation received from M/s Hetero Infrastructure SEZ Ltd., Technical Suggestions for strengthening and permission for Draw of water from the Natural canal -Submission of detailed Report with recommendations for according permission -Regarding

Ref - 1) Hetero Infrastructure SEZ Ltd., Lr No H/SEL/Irrigation /2022-23/02
2) Dy EE YLM Sub – Division YLM Lr No 134E Dated 06/2023

-:o0o:-

In the reference 1st cited the M/s Hetero Infrastructure SEZ Ltd. of N. Narasapuram (V) of Nakkapalli (M) of Anakapalli District has put in a representation for draw of water from the Natural canal.

In the reference 2nd cited, the Dy Executive Engineer, Yellamanchili Sub Division Yellamanchili has reported that the site was inspected along with field staff. During the inspection it is observed that the natural canal is following adjacent to the company connecting to the Uppuveru Tank which is finally joins in Bay of Bengal through dondawaka jetty gates at Dondawaka (V) in Nakkapalli Mandal Anakapalli District duly following conditions as noted below.

1) Strengthening the existing canal should be done by the company as it is benefited by the company in and around the company. It should not be occupied by the company or its funds used for the sole benefit of the company. If any construction are already made on the canal it should not cause any obstruction to the free flow of water under any circumstances.

2) The rerouted canal formed should confirm supply of irrigation source continuity as feeder to uppuveru channel from upper reach water sources.

3) Necessary protection arrangements like canal lining are to be provided to the canal to will stand against the scouring action.

4) The suggestions does not confer any right to use the land other than which the suggestion is sought and should not encroach the channel in any way in what so ever manner or does not confirm any unauthorized occupation of Government land.

5) The canal maintenance such as jungle clearance and silt removal to be attended periodically with the presence of section officer of this department.

6. It is advised for drawing / collecting of water from the natural canal may not be permitted and it is advised to utilise the surface water available in your boundary premises, without disturbing the existing canal.

7. If any legal complications or objections arise from public in future, the applicant has to bear the sole responsibility as per final verdicts of the court.

8. This permission may be cancelled automatically when the above conditions are violated.

9. The Water resources department has got full rights to cancel the permission in full or some part of the permission without assigning any reasons or issue of any prior notice.

Yours Sincerely,

Executive Engineer, W.R.Dept.
Visakhapatnam Division, Visakhapatnam

ANNEXURE-XV

FEASIBILITY REPORT

ON

NEW EFFLUENT TREATMENT PLANT
(1.2 MLD CAPACITY)

AT

HETERO

M/S HETERO INFRASTRUCTURE SEZ LTD

N.Narasapuram Village, Nakkapalli Mandal
Visakhapatnam Dist -531081
Andhra Pradesh

PREPARED BY

GreenTek
ENVIRONMENTAL PRIVATE LIMITED
{A subsidiary of Eurotek Environmental Pvt. Ltd.}
An ISO 9001:2008 Certified

Flat No. 4K, B-Block, Jain Srikar Auroville,
Near 'N" Convention,Madhapur
Hyderabad – 500 081
Website: www.greentekindia.in, email: info@greentekindia.in

PREAMBLE

The Management of HETERO INFRASTRUCTURE SEZ Limited has assigned M/s Greentek Environmental Private Limited, Hyderabad to prepare Feasibility Report of the proposed 1.2 MLD new Effluent Treatment Plant.

The team of M/s Greentek Environmental Private Limited visited the site of M/s HETERO Infrastructure SEZ Limited and interacted with Mr. S. Kullayi Reddy, Associate Vice President EHS and his team to collect the data related to proposed Effluent Treatment Plant like Characteristics of Effluents (both inlet & outlet), technical details of Stripper/MEE/ATFD, Site Conditions etc.

This feasibility report consists of the operations of the various units of ETP, details of the mechanical equipments, Layout of the proposed ETP and the process flow diagram and has been prepared to meet the statutory requirements of M/s Hetero Infrastructure SEZ Ltd.

This Report is duly acknowledged by the AVP-EHS of M/s Hetero Infrastructure SEZ Ltd on 10th September 2022.

For Greentek Environmental Pvt. Ltd

G. Balarama Krishna
Director

TABLE OF CONTENTS

Chapter -1

INTRODUCTION

Hetero is a globally renowned vertically integrated pharmaceutical company engaged in research and development, manufacturing and marketing of high-quality chemical and biologic medicines across diverse therapeutic areas. Backed by 27+ years of expertise in the pharmaceutical industry, Hetero's strategic business areas spread across APIs, Global Generics, Biosimilars and Custom Pharmaceutical Services. The company is among the largest producers of Active Pharmaceutical Ingredients (APIs) in the world.

M/s Hetero, Hyderabad is operating the Industrial Estate (Both SEZ and Non-SEZ) exclusively for its own group of companies for manufacturing of Bulk Drugs (Active Pharmaceutical Ingredients) and its intermediates at Sy. No: 215,286/1, 286/2, 283/1 of Ch.Lakshmipuram village, 312/1 to 312/5, 312/10 to 312/12, 313/1 to 313/7 of Rajayyapeta village, 19(P) & 20 of Peda teenerla village, 117/1 to 117/3,119/1, 119/2, 120/1,120/2, 126, 129/1 to 129/9, 142, 150, 151 of N.Narasapuram Village of Nakkapalli Mandal Visakhapatnam District spread in an area of about 500 Acres. This facility is designed to meet the best global standards for an API facility and to meet the growing demands of Bulk Drugs worldwide.

The SEZ is surrounded by open lands in the south direction, open land in the east and north direction, and road connecting Upamaka with Rajayyapeta in the west direction. The NH5 is in the north direction at distance of 4 km. The nearest railway station is at Narsipatnam at a distance of 9 km in the north direction. The airport is located at a distance of 70 km in the northeast direction at Visakhapatnam. The Bay of Bengal is on the south-eastern side at 1.2 km. The area is drained by Varaha River at north in 13 km and by Tandava River at southwest in 14 km. At present the following units are in operation at the facility:

- M/s Hetero Labs Ltd., Unit-III (Non SEZ)
- M/s Hetero Labs Ltd., Unit-IX (SEZ)
- M/s Hetero Drugs Ltd., Unit-IX (SEZ)
- M/s Honour Lab Ltd., Unit-III (SEZ)
- M/s Hetero Infrastructure SEZ Ltd. (SEZ & Developer)

M/s Hetero has invested about Rs. 1500 Crores for setting up of industries and developed common infrastructure facilities like Water Treatment plants, Boilers, Effluent Treatment Plants, Sewage Treatment Plant, Hazardous waste storage area, Scrap yard, parking facilities, Roads & drains etc for meeting the requirement of the above-mentioned units in the premises of M/s Hetero Infrastructure SEZ Ltd.

At present, the Industry is having 550 KLD Effluent Treatment plant consisting of Pre-treatment, Strippers, Multiple Effect Evaporators, Dual stage Biological Treatment based on Activated Sludge process and Guard Ponds with Marine Disposal facility.

The Industry is going for Expansion of its unit M/s Hetero Labs Ltd, Unit-III due to market trends and hence proposed to install 1.2 MLD Effluent Treatment Plant for the treatment of effluents generated from the unit.

Chapter-2

DESIGN DETAILS OF THE EFFLUENT TREATMENT PLANT

Design Basis: The plant is designed based on the following characteristics of Effluent

Table-1
Characteristics of Raw Effluent (Inlet of Equalization Tanks)

S.No	Parameter	Unit	HTDS	LTDS
1	pH	--	4 - 6	7.0
2	Biochemical Oxygen Demand (BOD)	ppm	14000	2000
3	Chemical Oxygen Demand (COD)	ppm	25000	4000
4	Total Suspended Solids (TSS)	ppm	2500	< 1500
5	Total Dissolved Solids (TDS)	ppm	25000	< 6000
6	Oil & Grease	ppm	30	NIL
7	Ammonical Nitrogen	ppm	2000	<100
8	Flow	KLD	950	250

Note: Total effluent is proposed to treat in Stripper, MEE, ATFD followed by Biological Treatment & Disposal to Sea through Guard Ponds.

Table-2
Characteristics of MEE Condensate

S.No	Parameter	Unit	MEE Condensate
1	pH	--	7 – 7.5
2	Biochemical Oxygen Demand (BOD)	ppm	5000
3	Chemical Oxygen Demand (COD)	ppm	10000
4	Total Suspended Solids (TSS)	ppm	< 200
5	Total Dissolved Solids (TDS)	ppm	< 1000
6	Oil & Grease	ppm	<5
7	Ammonical Nitrogen	ppm	<500
8	Flow	KLD	950

Note: The Condensate of MEE, ATFD and LTDS effluent after pre-treatment is proposed to be mixed in the Intermediate Tank before subjected to Biological Treatment.

The Characteristics of effluents after mixing Condensate of MEE/ATFD and LTDS effluent after primary treatment which are considered for the design of the Biological Treatment are shown below:

Table-3

Characteristics of Inlet of Biological Treatment (MEE Condensate + LTDS)

S.No	Parameter	Unit	MEE Condensate + LTDS
1	pH	--	7 – 7.5
2	Biochemical Oxygen Demand (BOD)	ppm	4375
3	Chemical Oxygen Demand (COD)	ppm	8750
4	Total Suspended Solids (TSS)	ppm	< 275
5	Total Dissolved Solids (TDS)	ppm	< 2400
6	Oil & Grease	ppm	--
7	Ammonical Nitrogen	ppm	<850
8	Flow	KLD	1200

Table-4

Expected Treated Effluent Quality (After Biological Treatment)

S. No	Parameters	Unit	Values
1	pH	--	7 – 7.5
2	Biochemical Oxygen Demand (BOD)	ppm	<100
3	Chemical Oxygen Demand (COD)	ppm	<250
4	Total Suspended Solids (TSS)	ppm	< 300
5	Total Dissolved Solids (TDS)	ppm	< 2400
6	Ammonical Nitrogen	ppm	<20
7	Flow	KLD	1200

Note: The above quality of outlet of ETP is achieved subject to the following:

- Plant is strictly operated as per Operation Manual and Instructions
- The output quality is guaranteed subject to the influent quality being within + or – 5 %, of the values given.
- Close Monitoring of parameters of Effluents at different stages is required for getting desired results.

Chapter-3

Effluent Treatment Scheme

The proposed treatment scheme will have the following units:

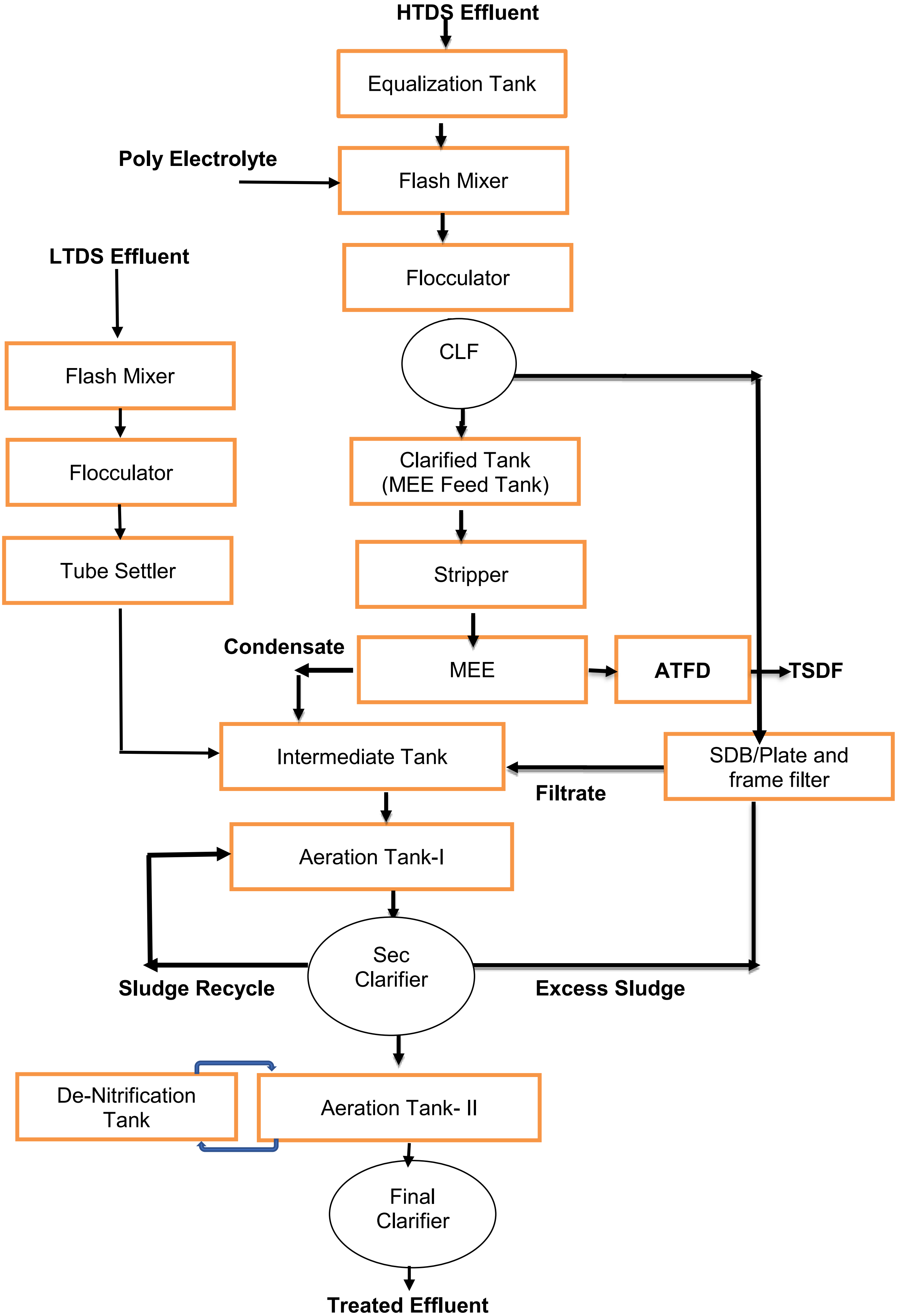
1. **Primary Treatment of Effluent**:
   - Grit Chamber
   - Oil & Grease Removal
   - Equalization Tank (04 nos each of one day storage capacity)
   - Flash Mixer
   - Flocculator
   - Clarifier/Tube Settler
   - Clarified effluent Tank

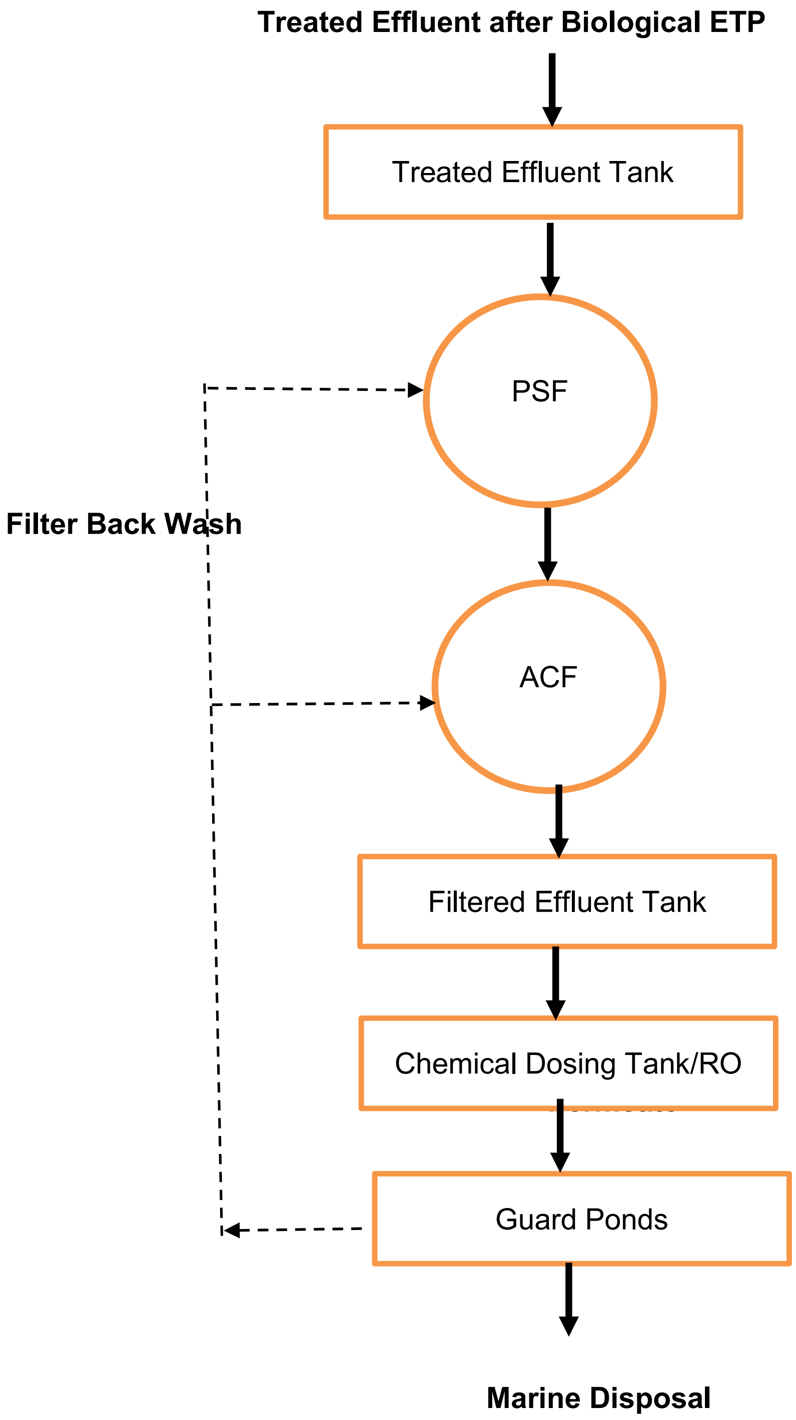
2. **Thermal Treatment**
   - Stripper (Steam operated)
   - Multiple Effect Evaporator (05 Effect)
   - Agitated Thin Film Drier

3. **Secondary Treatment (Biological Treatment)**
   - Intermediate Storage Tank
   - Aeration Tank -I
   - Secondary Clarifier
   - Aeration Tank -II
   - Final Clarifier
   - Sludge Handling Unit (SDB/Filter Press/Belt Press)
   - Treated effluent tank

4. **Final Treatment**
   - Pressure Sand Filter
   - Activated Carbon Filter
   - Filtered treated Effluent Tank
   - RO Plant (Optional and can be decided at later stage)
   - Guard Ponds
   - Marine Disposal System

Treatment Scheme is shown below:





Note: For reducing Phosphate's concentration in the treated effluent, the following treatment system is recommended:

- Lime treatment followed by neutralization or
- RO Plant

Chapter-4

Unit Operations

4.1 Screen Chamber:

Screening devise is used to remove the Coarse solids from the effluent. Coarse solids consist of rags, boards, and other large objects. The primary purpose of the screen is to protect the pumps and other mechanical equipments and to prevent the valves and other appurtenances in the onwards treatment units of effluent treatment plant.

4.2 Grit Chamber:

The effluent of the pharmaceutical industry contains some inorganic solids such as sand, pebbles, chemical sludges and metal fragments. The purpose of grit chamber is to remove these heavier objects from the effluent before entering the effluent into Fat trap. Most of the substances in the grit are abrasive in nature and will cause accelerated wear on pumps and sludge handling equipment with which it comes in contact in the onward treatment units. These solids deposit in the areas of low hydraulic shear in pipes, sumps and clarifiers may absorb grease and solidify. Additionally, these materials are not biodegradable and occupy valuable space in sludge digesters. It is therefore always desirable to separate them from the organic suspended solids.

4.3 Fat Trap/ Scum Removal:

The pharmaceutical/Bulk drug industry effluent contains lot of water immiscible solvents, oils and greases. Some of the chemicals in the wastewater mixes with these solvents and form scum (Floating layer) in the collection tanks of the effluent. The primary function of this chamber is to remove these solvents and oils from the effluent before entering into the Equalization tanks. These substances will cause hinderances in the onward treatment systems by way of improper coagulation & settling in the primary treatment and also causes smell nuisance in the equalization tanks. Also it will obstruct the oxygen transfer into the effluent in the biological treatment of effluent. Hence it is always essential to remove these floating solvents, oils and greases from the effluent for proper treatment in the onward units of ETP.

4.4 Equalization Tanks:

The primary purpose of the equalization tanks is to collect and hold the effluent after Screen, Grit and fat removal for specific time. The effluent of Bulk Drug/pharmaceutical industry is very typical in nature and one cannot assume effluent with uniform characteristics. Hence the effluents of different characteristics will be collected in the tank to equalize the properties of the effluent before sending for onward treatment. Also the effluent will be neutralized in these tanks by addition of either alkali or base depending on the characteristics of the effluent and proper mixing. By way of equalization and neutralization, one can ensure the effective coagulation and sedimentation in the primary treatment and to protect the equipment like stripper, MEE and ATFD.

4.5 Flash Mixer:

A flash mixer is a chamber that contains mechanical stirrer which is designed to ensure fast, thorough mixing of polyelectrolyte and other chemicals/ coagulants with the effluent for the purpose of creating floc. After Screen, Grit and fat removal and equalization & neutralization the effluent treatment really begins at the flash mixer chamber. Here the chemicals/polyelectrolytes are added to the effluent, primarily to aid in coagulation and flocculation. In the flash mixer, the wastewater is agitated violently for a short period of time before being released into the flocculation tank.

4.6 Flocculator:

Flocculator is the chamber where in the fine suspended solids in the effluent form flocs and will be removed from the effluent. The effluent after flash mixer enters the flocculation tank where the floc formation happens spontaneously in the presence of chemicals and gentle agitation. The primary purpose of the flocculator in the effluent treatment plant is to optimize particles coagulation and flocculation prior to settling in the primary clarifier.

The primary function of the flash mixer and flocculator is to remove suspended solids from the effluent to avoid frequent chocking of the equipments Stripper, MEE & ATFD and also to ensure the effective biological treatment.

4.7 Primary Clarifier:

Primary clarifier is the most important unit in the primary treatment of wastewater as the design of primary treatment of effluent is inadequate without primary clarifier. Primary clarifier is a unit operation primarily designed to concentrate and remove suspended solids from the effluent and clear supernatant flows into the MEE Feed tank. This will ensure the effective treatment in Stripper, Multiple effect evaporators and also to avoid frequent chocking of the thermal systems of effluent treatment plant.

4.8 Strippers

Steam stripping is used to remove various organic contaminants from plant wastewater to meet guidelines set by pollution controlling agency. The organics and steam from the top of the column are then condensed and separated using structural packing in the column. The condensed steam/solvent is refluxed to the top of the column. The system is used for treating the high TDS and high COD stream and the effluent is fed to the solvent stripper to minimizing low boiling solvents from the feed of the evaporator by maintaining temperature 90$\pm$5 degrees. The low boiling solvent vapor condensed by passing through condensers. Mixed solvent is collected separately in solvent collection vessel.

4.9 Multiple Effect Evaporator (MEE):

Multiple Effect Evaporators are used for the removal of total solids from the effluent to reduce toxicity & COD/BOD levels in the effluent. In MEE the effluent is concentrated from 2-4% solids to 35-40% solids and then the concentrate will be fed to ATFD for removal of solids from the effluent. The condensate of MEE can easily be treated in the Biological Treatment system to meet the required standards prescribed the Pollution Control Board.

A multiple-effect evaporator is an equipment for efficiently using heat from steam to evaporate water. In a multiple-effect evaporator, wastewater is boiled in a sequence of vessels, each held at a lower pressure than the last. Because the boiling temperature of water decreases as pressure decreases, the vapor boiled off in one vessel can be used to heat the next, and only the first vessel (at the highest pressure) requires an external source of heat and thus saves energy and overall operational cost.

4.10 Agitated Thin Film Drier (ATFD):

Agitated Thin Film Dryer is used to dry and collect baggable solids from high TDS effluent that comes out of Multi Effect Evaporator after evaporating the effluent from 2-4% solids to 35-40% solids. The condensate of ATFD will be subjected to Biological Treatment along with MEE Condensate to meet the standards prescribed by SPCB.

A typical Agitated Thin Film Drier (ATFD) consists of a tubular heat transfer area with an external heating jacket and a fast-revolving, inner rotor with flexible or rigid wiper elements. The feed product is evenly distributed by the rotor and its wipers over the heating surface, forming a thin liquid film of uniform thickness. This assures excellent heat transfer combined with constant renewal of the product film and provides an even heating and short residence time of the product.

4.11 Intermediate Tank:

The main purpose of the intermediate tank to make the feed to Biological Treatment with uniform characteristics and flow to get optimum results from the Biological Treatment. In this tank the LTDS effluent after primary treatment, MEE Condensate and ATFD condensate are mixed and then fed to biological treatment system. Also the effluent will be cooled by providing air grid in the tank to meet the requirements of biological Treatment as the condensate of MEE&ATFD will be on higher side.

4.12 Aeration Tank-I:

Aeration Tank-I is the first step of a Conventional Activated Sludge (CAS) system and is used to remove BOD from the Effluent. The effluent from intermediate tank will be pumped to the aeration tank-I and in the aeration tank, the wastewater is mixed with air to activate micro-organisms. While digesting the wastewater, the organisms collide with each other, forming larger particles called flocs, which have a larger capacity to degrade the biological components of the wastewater.

The rate at which oxygen is consumed by the microorganisms in the biological reactor is called the oxygen utilization rate. For the activated sludge process, the oxygen utilization rate will always exceed the rate of natural replenishment, thus some artificial means of adding oxygen must be used. Oxygen is supplied by aerating the mixed liquor in the aeration tank. Aeration techniques will be used to inject compressed air into the aeration tank using mechanical mixers to stir the contents violently enough to entrain and distribute air through the liquid.

4.13 Secondary Clarifier:

The aeration basin is followed by a secondary clarifier or settling tank. During this step, the mixed liquor from the aeration tank -1 flows into the clarifier and micro-organisms with their adsorbed organic material settle at the bottom of clarifier and the clear supernatant liquid flows into the onward treatment units for further purification.

The surplus micro-organisms can easily be channeled to any of sludge treatment solutions and another part of the micro-organisms is fed back into the aeration tank to keep the load of micro-organisms at a sufficient level for the biological degrading processes to continue.

4.14 Aeration Tank -II (Extended Aeration Tank):

This unit works on the same principle of Aeration tank-I and this tank is mainly used to reduce left over BOD from the effluent after conventional aeration & secondary clarification system. This system helps in meeting the discharge standards of effluent prescribed by the State Pollution Control Board/MoEF&CC/CPCB.

Normally effluent after secondary clarifier with low BOD is fed to Aeration tank- II and this system works under endogenic respiration principle. Higher MLSS concentration will be maintained in the aeration tank as compared to the Aeration tank-I.Oxygen is supplied by aerating the mixed liquor in the aeration tank. Aeration techniques will be used to inject compressed air into the aeration tank using mechanical mixers to stir the contents violently enough to entrain and distribute air through the liquid.

4.15 Final Clarifier:

The aeration tank-II is followed by a final clarifier or settling tank. During this step, the mixed liquor from the aeration tank -II flows into the clarifier and micro-organisms with their adsorbed organic material settle at the bottom of clarifier and the clear supernatant liquid flows into the onward treatment units for further purification.

The surplus micro-organisms can easily be channeled to any of sludge treatment solutions and another part of the micro-organisms is fed back into the aeration tank-II to keep the load of micro-organisms at a sufficient level for the biological degrading processes to continue.

4.16 De-Nitrification Tank:

Excessive usage of nitrogen compounds in various industries, e.g., agricultural, pharmaceutical, dairy or food, contribute to nitrogen pollution. A common method of treating N-pollution is nitrification, followed by denitrification. Biological denitrification enables transformation of oxidized nitrogen compounds by a wide spectrum of heterotrophic bacteria into harmless nitrogen gas with accompanying carbon removal. The liquid from the aeration tank-II is fed to De-nitrification tank where anoxic conditions will be created to convert the ammonical nitrogen into Nitrates & Nitrites to Nitrogen gas. During this process, the bacteria derive their oxygen from the oxygen contained in the nitrate. The nitrogen gas produced is in the form of nitric oxide (NO), nitrous oxide (N_2O) or nitrogen gas (N_2). The net removal of nitrogen is accomplished by stripping the nitrogen gas formed during denitrification out of the wastewater in a subsequent aeration process. The optimum pH range for de-nitrification is 7-8.5 and the DO level to be maintained in the Denitrification process is 0.3 mg/l (Anoxic Conditions).

The process of De-nitrification would enable the industry to meet the standards prescribed by the Board and also to avoid oxygen depletion in the receiving body, reducing the toxicity levels in the treated effluent, eutrophication and methemoglobinemia in the receiving body.

4.17 Treated effluent Tank:

The clear supernatant from the final clarifier flows into the treated effluent tank. The main purpose of this tank is to collect and store the treated effluent for further treatment in Tertiary treatment units.

4.18 Pressure Sand Filter:

The treated effluent from the treated effluent tank is pumped to Pressure sand filter to remove turbidity and suspended particles present in the treated effluent with minimum pressure drop. The Pressure Sand Filter consists of a multiple layer of sand with a variety in size and specific gravity.

In a Pressure Sand Filter, treated effluent is passed through multi layers of filter media consisting graded sand, pebbles and gravels layers. The contaminants in the effluent are captured in the media bed and filtered water passes into the discharge manifold at the bottom of the tanks. The next and last step is backwashing, a process of effectively removal of captured contaminants from the media bed. After backwashing the filter is rinsed with raw water and after the required quality of water is achieved the filter is put back into service.

4.19 Activated Carbon Filter:

The effluent from the pressure sand filter outlet is then passed through the activated Carbon filter. Activated Carbon Filter is used to adsorb chlorine, organics, tri-halo methane (THM), taste, odour, and colour from treated effluent. Activated carbon is a charcoal that has been treated with oxygen to open up millions of tiny pores between the carbon atoms. Activated carbon filtration is an adsorptive process in which the contaminant is attracted to and adsorbed onto the surface of the carbon particles. The efficiency of the adsorption process is influenced by carbon characteristics (particle and pore size, surface area, density and hardness) and the contaminant characteristics.

4.20 Guard Ponds:

The treated effluent after Activated Carbon filter/RO plant will be pumped to the Guard ponds. The main purpose of these tanks is to collect and store the treated effluent before discharging into the Sea. Marine disposal pumping station is connected to the Guard ponds for pumping the treated effluent into the Sea.

4.21 Sludge Blender and Sludge Thickener:

Sludge Blending and thickening is the primary step in sludge treatment. It allows the solids and excess water to separate properly from the sludge. The main purpose of this stage is to reduce the moisture content in the sludge. The sludge contains a high amount of moisture content; therefore it becomes really necessary to reduce the amount of water content in sludge and thicken and condense it.

Sludge thickening is done by gravity in the thickener. Rotating scraper mechanism is provided to separate the settled sludge and liquid. The settled sludge is then pumped to either Filter Press or Belt press for further dewatering of sludge and drying.

Chapter -5

SIZES AND SPECIFICATIONS OF UNITS

UNIT	SCREEN CHAMBER
Duty	To remove larger particles which are in suspension (if any) from the effluent
Number of Units	02 (01 working and 01 standby)
Size of the unit	2.15m x 1m x 2.4m
MOC	Reinforced Cement Concrete (RCC) with acid proof lining
Provision	Screens with removable arrangement for cleaning purpose.

UNIT	GRIT CHAMBER
Duty	To remove heavy suspended particles from the effluent
Number of Units	02 (01 working and 01 standby)
Size of the unit	2.15m x 5.3m x 2.4m
MOC	Reinforced Cement Concrete (RCC) with acid proof lining
Provision	Drain valve and inlet valve arrangement for cleaning and controlling the flow respectively

UNIT	FAT TRAP
Duty	To remove oil & grease from the effluent. This would also help in removing water immiscible solvents from the effluent
Number of Units	01
Size of each tank	2.15m x 4m x 2.4m
MOC	Reinforced Cement Concrete (RCC) with Acid proof lining
Provision	Fine bubble diffuser for carrying oil & grease to the top of tank and scraper arrangement for removal of accumulated fat on the top of liquid surface

UNIT	EQUALISATION TANK
Duty	➢ For equalizing the effluents of different characteristics and for neutralization. ➢ To avoid shock loading in the subsequent units i.e Pre-treatment & Secondary treatment
Number of Units	04 (02 working and 02 for collection of effluents)
Size of each tank	21.6 m x 15m x 3.5 m SWD + 0.5m FB (1050 KL x 4 Nos)
MOC	Reinforced Cement Concrete (RCC) with Acid proof lining
Provision	➢ Air Grid with blower for Equalizing the Effluents ➢ Hoods and scrubbers for controlling the smell in and around ETP ➢ Flow control arrangement

UNIT	FLASH MIXER (HTDS)
Duty	To mix the effluent & catalyst (Polyelectrolyte) thoroughly for floc formation
Number of Units	02
Size of each tank	1.12m X 1.12m X 2.6m
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Agitator with gear box for thorough mixing ➢ Chemical Dosing system (tanks & dosing pumps) for addition of polyelectrolyte

UNIT	FLOCCULATOR (HTDS)
Duty	To mix effluent to form flocs for separation of suspended matter from the effluent in the subsequent clarification unit
Number of Units	02
Size of each tank	2.3m x 2.3m x 2.4m SWD + 0.9FB
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Agitator with gear box for gentle mixing ➢ Removal of floating matter

UNIT	PRIMARY CLARIFIER
Duty	For separation of suspended matter from the effluent to have clear liquid for subsequent units
Number of Units	02
Size of each tank	8 m dia x 3.5m SWD
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Scraper Mechanism for collection of settled suspended solids to the centre of clarifier. ➢ Sludge pumps for removal of settled sludge from the clarifier. ➢ Feed well and outer well for avoiding foam entry into launder

UNIT	FLASH MIXER (LTDS)
Duty	To mix the effluent & catalyst (Polyelectrolyte) thoroughly for floc formation
Number of Units	02
Size of each tank	1.35m x 1.1m x 2.0m SWD + 0.6FB
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Agitator with gear box for thorough mixing ➢ Chemical Dosing system (tanks & dosing pumps) for addition of polyelectrolyte

UNIT	FLOCCULATOR (LTDS)
Duty	To mix effluent to form flocs for separation of suspended matter from the effluent in the subsequent clarification unit
Number of Units	02
Size of each tank	2.9m x 2.6m x 2.5m SWD + 0.9FB
MOC	Reinforced Cement Concrete (RCC)
Provision	Agitator with gear box for gentle mixing

UNIT	TUBE SETTLER
Duty	For separation of suspended matter from the effluent to have clear liquid for subsequent units
Number of Units	01
Size of each tank	2.85m x 2.4m x 4m
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ UV Stabilized PVC media for settling of solids. ➢ Sludge pumps for removal of settled sludge from the clarifier. ➢ Overflow launder for collection of supernatant Liquid

UNIT	MEE Feed Tank
Duty	For collection and storage of clear effluent from the primary clarifier and to have uniform feed to stripper and MEE.
Number of Units	01
Size of each tank	13.5m x 8m x 3 m SWD + 0.5m FB
MOC	Reinforced Cement Concrete (RCC)
Provision	MEE Feed pumps with necessary flow control arrangement

UNIT	STRIPPER
Duty	For removal of low boiling organics/Solvents from the effluent to reduce COD.
Number of Units	02
Size & Capacity of stripper	1.5m dia X 14 meter Column height Total Height of Stripper -24 m 600 KLD or 30 KL/hour feed each
MOC	Duplex steel or SS-316L
Provision	➢ Reboiler with thermosiphon system with steam line ➢ Structural packing inside the column and ➢ condensate collection and pumping arrangement.

UNIT	MULTIPLE EFFECT EVAPORATOR (MEE)
Duty	For concentration of effluent to the required level in multistage effect evaporator (5 effect or 6 effect)
Number of Units	02
Capacity of MEE	600 KLD or 30 KL/hour feed each
MOC	➢ All contact parts are of SS Ti grade ➢ Shell is of either Duplex steel or SS-316L ➢ Piping in SS-316 L
Provision	➢ Steam and cooling water ➢ Condensate collection and pumping arrangement

UNIT	AGITATED THIN FILM DRIER (ATFD)
Duty	For separation of salts from the concentrated effluent by drying and to make the salts suitable for disposal.
Number of Units	06
Size of unit	30 m^2 area each Feed Rate : 2000 – 2500 Litres/hour
MOC	Either Duplex steel or SS-316L
Provision	➢ Steam and cooling water ➢ Condensate collection and pumping arrangement and ➢ Salt collection

UNIT	INTERMEDIATE TANK
Duty	For collection, mixing of MEE Condensate & LTDS effluent and cooling of the effluent to make it suitable for treatment in biological system.
Number of Units	01
Size of each tank	13.5m x 8m x 3.5m Volume: 380 KL
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Air Grid or Coarse Bubble diffusers with air blower for thorough mixing and cooling of effluent ➢ Pumping arrangement of effluent

UNIT	AERATION TANK – I
Duty	To enable degradation of organic matter through biochemical oxidation of the wastewater in presence of atmospheric air.
Number of Units	02
Size	55m x 40m x 6.0 m SWD+ 0,5m FB Volume:13000 KL
MOC	RCC Tank with baffle wall in the tank
Provision	Provision shall be made for installation of triton aerators & working platforms.

UNIT	SECONDARY CLARIFIER
Duty	To enable solid liquid separation
No. of units	02
Size	8 m dia x 3.5 m SWD
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Hopper bottom shall be provided for collecting sludge ➢ Provision shall be made for fixing of Scraper mechanism and overflow launder and ➢ Sludge recirculation pumps

UNIT	DENITRIFICATION TANK
Duty	For removal of Nitrates by way of oxidization of N-compounds
No. of units	01
Size	11.4 m x 11.4m x 5.0 m SWD + 0.5 FB
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Agitators/mixers for mixing of effluents ➢ Provision shall be made for dosing of chemicals for increasing pH. ➢ Pumps for transferring effluent from De-nitrification tank to Aeration Tank-2

UNIT	AERATION TANK – II
Duty	To enable degradation of left over organic matter through biochemical oxidation of the wastewater in presence of atmospheric air after conventional treatment in Aeration Tank-I and secondary Clarifier.
Number of Units	01
Size	63m x 15m x 4.5mSWD + 0.5m FB Volume : 4250 KL
MOC	RCC Tank with baffle wall in the tank
Provision	Provision shall be made for installation of triton aerators & working platforms.

UNIT	FINAL CLARIFIER
Duty	To enable solid liquid separation
No. of units	01
Size	10m x 3m SWD
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Hopper bottom shall be provided for collecting sludge ➢ Provision shall be made for fixing of Scraper mechanism and overflow launder and ➢ Sludge recirculation pumps

UNIT	TREATED EFFLUENT TANK
Duty	To Collect and temporarily store the treated effluent before pumping to filtration
No. of units	01
Size	10m x 15m x 4m SWD+0.5 m FB Volume: 400 KL
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Air grid to keep the treated effluent in aerobic condition. ➢ Pumping arrangement for pumping treated effluent to Filters.

UNIT	SLUDGE BLENDER
Duty	To blend the excess sludge from Primary and secondary clarifiers for dewatering purpose.
No. of units	01
Size	5.5 m x 6 m x 4m SWD + 0.5FB
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Agitator with gear box for gentle mixing ➢ Provision for chemical/polyelectrolyte dosing ➢ Drain provision. ➢ Hydraulic lifting arrangement for Scraper

UNIT	SLUDGE THICKENER
Duty	For separation of Solid and Liquid for thickening of sludge and to remove moisture from the sludge.
No. of units	01
Size	10m dia x 4m SWD
MOC	Reinforced Cement Concrete (RCC)
Provision	➢ Scraper arrangement for separation of solids with hydraulic lifting arrangement ➢ Screw pumps for pumping the settled sludge to filter press or Belt press ➢ Drain provision with pumping arrangement

UNIT	FILTER PRESS or BELT PRESS
Duty	For dewatering and drying of sludge.
Number of Units	04 nos filter press or 02 Nos of Belt Press
Size	Filter press with 32 Plates or Belt press unit
MOC	PP plates with filter cloth for filter press or SS with belt for belt press.
Provision	➢ Provision shall be made for leachate collection and its recycling back to Equalization Tank. ➢ Sludge drying platform for further removal of moisture from the sludge.

UNIT	PRESSURE SAND FILTER
Duty	To remove turbidity and suspended particles present in the treated effluent with minimum pressure drop
Number of Units	02 Nos
Size	03 m Dia and 4-meter height
MOC	MSRL or Stainless Steel.
Provision	➢ Provision shall be made for backwash of the filter ➢ Air provision for backwash

UNIT	ACTIVATED CARBON FILTER
Duty	To adsorb chlorine, organics, tri-halo methane (THM), taste, odour, and colour from treated effluent
Number of Units	02 Nos
Size	2.6 m Dia and 4-meter height
MOC	MSRL or Stainless Steel.
Provision	➢ Provision shall be made for backwash of the filter ➢ Air provision for backwash

UNIT	FILTERED EFFLUENT TANK
Duty	To collect and store treated filtered effluent for further treatment (if required)
Number of Units	01 Nos
Size	8m x 12m
MOC	Reinforced Cement Concrete
Provision	➢ Provision shall be made for air grid or agitator ➢ Pumping arrangement for pumping the effluent to onward treatment units or Guard Ponds

UNIT	GUARD PONDS
Duty	To collect and store treated filtered effluent before discharging into the Sea
Number of Units	04 Nos
Size	Guard Pond-1 : 1920 KL (Existing Pond) Guard Pond-2 : 2400 KL (Existing Pond) Guard Pond-3 : 3000 KL (25m x 30m x 4 m SWD) Guard Pond-4 : 3000 KL (25m x 36m x 4 m SWD)
MOC	Reinforced Cement Concrete
Provision	➢ Provision shall be made for air grid or agitator. ➢ Pumping arrangement for pumping the effluent to Sea. ➢ Provision for connecting the effluent line to online effluent monitoring system. ➢ Locking arrangement for Effluent pipes.

UNIT	RO PLANT or CHEMICAL TREATMENT
Duty	To remove phosphates from the treated effluent
Number of Units	01 Nos
Size	As per the requirement
RO plant (optional)	50 m^3/hour feed rate
Accessories	All required equipments for the operation of the RO plant

UNIT	INTERCONNECTING PATHWAYS, FOUNDATIONS AND MISC. WORKS
Duty and specifications	To connect the various units of Effluent Treatment Plant, foundations for equipment and other miscellaneous works as required for proper and safe operation of the ETP shall be provided. All walkways and foundations shall be made of RCC. The minimum width of walkway shall be 1.0 m to 1.2 m and railing shall be provided to all the walkways for safety of operating personnel.

UNIT	CONTROL PANELS
Duty and specifications	PCC panel shall be provided for main supply for the plant and 03 Nos of MCC panels shall be provided for safe and easy operation and for the isolation of power during any breakdowns without interrupting other operations. One panel will be provided for primary treatment, one will be for Stripper/MEE/ATFD and one will be provided for Biological Treatment. Isolated MCC panels will also reduce the cost of cables & cable trays.

Chapter-6

STRIPPER/MEE/ATFD

Capacity of Unit : 600 KLD
Operating Hours : 20 hours
No. of Systems : 02 Nos

Detail of the system are as below:

Equipment	Technical Details	Remarks
STRIPPER -01 No		
Stripper		
Dia of Stripper Column	1500 mm	Effluent feed rate: **31200** KL/hour Solvent Recovery rate : 1610 Lt/hour **MOC:** Shell : SA 240 GR 316 Packings : SA 240 GR 316 Internals : SA 240 GR 316
Height of stripper Column	18 meter	
No. of Packed beds	04	
Packing height/ section	02 meter	
Packing details	SS 316L pal rings and structural packing	
Reboiler Effective heat transfer area	90 m^2	**MOC:** Tubes :SA 213 TP 316Ti Tube sheet :SA 240 GR 316 Main shell :SA 240 GR 304 Top & Bottom Dish : SA 240 GR 316
Surface Condenser Effective heat transfer area	80 m^2	**MOC:** Tubes : SA 213 TP 316 Tube sheet : SA 240 TP 316 Shell : SA 240 TP 304 Side Dish : SA 240 TP 304
Tanks & Vessels Stripper Feed Tank Stripper Bottom Vessel Reflux Drum(Solvent Holding)	 01 No 01 No 01 No	**MOC** SA 240 GR 316
Ancillary Units	• Stripper feed pumps • Circulation pumps • Piping & pipe fittings	Pumps of suitable make & capacity and piping connections as required.
MULTIPLE EFFECT EVAPORATOR – 01 No (5 effect or 6 effect)		
Total Heat transfer area of Calendria (Approx)	2500 m^2 (Approx)	**MOC** Tubes : Ti Gr2 Tubesheet :SA240GR 316+Ti Bonding Main Shell : SA 240 GR 316 Top & Bottom Covers : SS 316 L
Preheaters – 04 or 05 Nos		
Vapour Separators	As required	**MOC** : SS316 L
Vapour Ducts	As required	**MOC:** Main Duct : SA 312 TP 316 Fittings : SA 403 GR 316 Flanges : SA 182 F 316
Process pipes & fittings	As required	
Condensate & non-condensate piping	As required	
Surface Condensers	01 Nos (250 M^2)	**MOC** Tubes : SA 213 GR 316 Tube Sheet : SA 240 GR 316

		Main shell, TOP & Bottom Cover: SS304
Ancillary Units	Recirculation pumps	As per the requirement for plant operation
	Vacuum pumps	
	Concentrate Pumps	
	Condensate pumps	
	Temperature Gauges	
	Vacuum Gauges	
	Pressure Gauges	
AGITATED THIN FILM DRIER (ATFD)– 03 NO		
Capacity of each ATFD	30 m^2	**MOC:** Inner Vessel : SA 240 GR 316 Shell : SA 240 GR 316
Surface Condensers	03 Nos	As per the requirement **MOC:** Tubes : SA 213 TP 316 Tube sheet : SA 240 TP 316 Shell : SA 240 TP 304 Side Dish : SA 240 TP 304
Balance Tanks	As per the requirement	MOC : SS 316
Ancillary Units	Pumps with Motors • Feed Pumps • Condensate Pumps • Gear Box with Motor	As per the requirement
	Cyclone Separator	Duplex Steel
	Vapour Ducts • Pipes • Fittings • Flanges	 SA 312 TP 316 SA 403 GR 316 SA 182 F 316
	Blower with Motor	
	Vacuum Gauge	
	Temperature Gauge	
ADDITIONAL REQUIREMENTS		
Electrical Panels (As per the requirement)		
Automation & instrumentation for operation of the plant with all accessories. PLC with SCADA arrangement		
Electrical Cables (preferably Copper Cables)		
Cable Trays (GRP Cable Trays)		
Gratings (GRP Gratings)		
Structural Steel (Hetero will make foundations upto first floor)		

Technical Proposal with complete details of equipments Submitted by M/s Chemin Enviro Systems and Certified by Technical Consultant Mr. Narasimham is enclosed

Chapter – 7

Details of Mechanical Equipments

Details : 1 MLD New Effluent Treatment Plant

S.NO	Name of the Unit	Equipment	Quantity	Technical Details
1	Flash Mixer (Size of tank: 1.2X1.2X2m)	Mixer mechanism with Agitator, Gear Box, Motor and Structural supports	03 Nos	**Gear Box:** Make : Elecon Gear Ratio : 10:1 **Motor:** Make : ABB/CG
		Dosing Tanks	06 Nos	MOC : PP/FRP Capacity : 1000 Litres
		Dosing Pump	06 Nos	Make : Sandur Flow : 50 l/hr Pr : 3.5 Bar **Motor:** Make : ABB/CG
		Agitator with necessary gear box & Motor for dosing tank	06 Nos	**Gear Box:** Make : Elecon Gear Ratio : 10:1 **Motor:** Make : ABB/CG
2	Flocculator (Size of tank: 2.5X2.5X2.5m)	Mixer mechanism with Agitator, Gear Box, Motor and Structural supports	03 Nos	**Gear Box:** Make : Elecon Gear Ratio : 20:1 **Motor:** Make : ABB/CG
3	Clarifiers (8.0m dia x 3.5m SWD)	Clarifier Mechanism	02 Nos	**Gear Box:** Make : Elecon Gear Ratio : 128:1 **Motor:** Make : ABB/CG
		Sludge pumps	04 Nos	Flow : 20 m^3/hr Head : 30 mtr MOC : SS316 Make : NAGA, KSB, Wilo, Jhonson **Motor:** Make : ABB/CG
		Valves, Piping & Pipe fittings	Lot	**PIPE HDPE 16KG/CM2** 2" (63MM): 700mtrs 3" (90MM): 60mtrs 6" (160MM): 36mtrs 8" (200MM): 300mtrs 10" (250MM): 100mtrs **BALL VALVE PP 3PC F/E** 2": 58 No 3": 15 No 6": 10 No 8": 2 No **KNIFE EDGED GATE VALVE** SS316 W/F 8"-10 No

				BALL VALVE MOC SS316 3PC F/E 1”: 68 No 2”: 54 No 3”: 18 No **PIPE SS316 SMLS A 312 SCH40** 1": 60 m 2”: 250 m 3”: 50 m 4”: 60 m 6”: 12 m And other related Fittings as per pumps Suction & Delivery Sizes
4	Tube Deck (Size of tank: 3mX3mX3.2m)	Tube Deck Media	15 m^3	PVC UV Stabilized tube deck Specification: Media FS 41.50, Colour: Black, Vertical Height: 1200mm, Angle:60 Deg, Thickness: 1mm MOC: HDPE **Make:** MM Aqua
		Sludge Pumps	02 Nos	Flow : 20 m^3/Hr Head : 30 Mtrs MOC : SS 316 Make : NAGA, KSB, Wilo, Jhonson **Motor:** Make : ABB/CG
5	Sludge Handling	Filter Press/Belt Press	02 Nos	---
6	Electrical Works	MCC Panel	1 No	To Be Designed with circuit breakers, Feeders, Energy meters, MCB, MCCB and protection devices, etc.
		Cables	Lot	XLPE Armor FRLS Copper 4 Core Cables: 2.5 sqmm: 5000 m 1.5 sqmm: 5500 m 6 sqmm : 1000 m 300sqmm: 700 m
		Cable Trays	Lot	GRP Cable Trays 600mm : 500 m 450mm : 200 m 300mm : 200 m 200mm : 200 m 100mm : 600 m and Required fittings as per the requirement
7	Fat Trap	Scraper for fat removal	02 Nos	**Gear Box:** Make : Elecon Gear Ratio : 30:1

			With Mechanisum **Motor:** Make : ABB/CG
8	Oil and Grease transfer pumps with motors	8 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 20 m^3/hr Head: 30 m MOC: SS **Motor:** Make : ABB/CG
9	Lye transfer pump with motors	2 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 20 m^3/hr Head: 30 m MOC: SS **Motor:** Make : ABB/CG
10	Sulphuric Acid transfer pumps with motors	2 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 20 m^3/Hr Head: 20 Mtrs MOC: MS **Motor:** Make : ABB/CG
11	Effluent transfer pumps with motors	8 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 50 m^3/Hr Head: 30 m MOC: CI with PP lining **Motor:** Make : ABB/CG
12	Equalization tank mix up blower with motors	3 Nos	Make: Everest Flow: 900 m^3/Hr MOC: CI **Motor:** Make : ABB/CG
13	LTDS TANK Transfer Pumps with Motor	2 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 20 m^3/hr Head: 30 Mtrs MOC: SS **Motor:** Make : ABB/CG
14	Intermediate Tank Transfer Pumps with Motor	2 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 50 m^3/hr Head: 30 m MOC: SS **Motor:** Make : ABB/CG
15	MEE Feed Pumps with Motor	4 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 30 m^3/hr Head: 30 m MOC: SS

				Motor: Make : ABB/CG
16	Intermediate tank mix up blower with motors		3 Nos	Make: Everest Flow: 450 m^3/Hr MOC: CI **Motor:** Make : ABB/CG
17	Stripper Condensate transfer pumps with motors		2 Nos	Make : NAGA, KSB, Wilo, Jhonson Flow: 10 m^3/hr Head: 20 Mtrs MOC: SS **Motor:** Make : ABB/CG
18	Effluent transfer pumps from Intermediate tank to Aeration Tank-1		2 Nos	**Make** : KSB, Wilo, Jhonson **MOC** : SS304 Flow: 50 m^3/hr Head: 30 m **Motor:** Make : ABB/CG
19	Aeration Tank-1	Aerators	12 Nos	Make : Triton (Eurotek) HP : 60 HP **Motor:** Make : ABB/CG
20	Secondary Clarifiers (8m dia)	Clarifier Mechanism	02 Nos	**Gear Box:** Make : Elecon Gear Ratio : 128:1 **Motor:** Make : ABB/CG
		Sludge pumps	04 Nos	Flow : 20m^3/hr Head : 30 mtr MOC : SS316 Make : NAGA, KSB, Wilo, Jhonson **Motor:** Make : ABB/CG
		Valves, Piping & Pipe fittings	Lot	**PIPE HDPE 16KG/CM2** 3" (90MM): 100mtrs Piping for Pump Headers **BALL VALVE PP 3PC F/E** 3": 15 No 6": 6 No **PIPE SS316 SMLS A 312 SCH40** 8”: 60 mtrs And other Fittings as per pumps Suction & Delivery Sizes
21	Denitrification Tank	Agitators/Mixers	02 Nos	Make : Triton (Eurotek) HP : 20 HP **Motor:** Make : ABB/CG
22	Aeration Tank -2	Aerators	06 Nos	Make : Triton (Eurotek) HP : 60 HP

				Motor: Make : ABB/CG
23	Final Clarifier (10m dia)	Clarifier Mechanism	01 Nos	**Gear Box:** Make : Elecon Gear Ratio : 128:1 **Motor:** Make : ABB/CG
		Sludge pumps	02 Nos	Flow : $20m^3/hr$ Head : 30 mtr MOC : SS316 Make : NAGA, KSB, Wilo, Jhonson **Motor:** Make : ABB/CG
		Valves, Piping & Pipe fittings	Lot	**PIPE HDPE 16KG/CM2** 3" (90MM): 100mtrs Piping for Pump Headers **BALL VALVE PP 3PC F/E** 3": 15 No 6": 6 No **PIPE SS316 SMLS A 312 SCH40** 8”: 60 mtrs Other Fittings as per pumps Suction & Delivery Sizes
24	Treated Effluent Tank	Pumps	02 Nos	Flow : $50\ m^3/hr$ Head : 50 mtr MOC : SS304 Make : KSB, Wilo, Jhonson **Motor:** Make : ABB/CG
		Air Grid	Lot	HDPE pipes, Supports and Valves & fittings as required
25	Sludge Blender	Mixer mechanism with Agitator, Gear Box, Motor and Structural supports	01 Nos	**Gear Box:** Make : Elecon Gear Ratio : 20:1 **Motor:** Make : ABB/CG
26	Sludge Thickener	Scraper Mechanism with Hydraulic lifting provision	01 Nos	**Gear Box:** Make : Elecon Gear Ratio : 128:1 **Motor:** Make : ABB/CG
		Sludge pumps	02 Nos	Flow : $10m^3/hr$ Head : 30 mtr MOC : SS316 Make : Screw pumps **Motor:** Make : ABB/CG
		Valves, Piping & Pipe fittings	Lot	Pipes, Valves & fittings as per the requirement
27	Guard Ponds	Pumps	02 Nos	Flow : $650\ m^3/hr$ Head : 50 mtr

				MOC : SS304 Make : KSB, Wilo, Jhonson **Motor:** Make : ABB/CG
		Piping	Lot	SS 2”: 100 m SS 6”: 200 m **Valves & Fittings**: As per Requirement
28	Miscellaneous items		All bought out items as per the requirement during execution of the project.	

N. Narasimham
M.Tech
Consultant

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20th September 2022

S. Kutayi Reddy
Associate Vice President - EHS
Hetero Infrastructure SEZ Ltd
Nakkapalli
Anakapalli Dist

Dear Sir,

Sub : Technical Evaluation of Proposed Stripper, MEE and ATFD - Regarding

Ref : **Purchase Order No: 4900212839 dated 30/07/2022**

This is to inform you that, I have technically verified all the specifications of Stripper, Multiple Effect Evaporator and ATFD in the final proposal submitted by M/s Chemin Enviro Systems Pvt Ltd dated 20/09/2022 for your upcoming Effluent Treatment Plant.

This is to certify that, M/s Chemin Enviro Systems Pvt Ltd have incorporated all the changes which I have suggested in the initial proposal for the better performance of the system in the final proposal and now the design parameters are as per the requirement.

You can go ahead with the system for your proposed new Effluent Treatment Plant.

Thanking you,

Yours faithfully,

M.Narasimham
Technical Consultant

Ref : CES/HD/922(F)/2022

Date :20.09.2022

To

Mr.S.Kullayi Reddy,

Sr.General Manager –EHS,

Hetero Drugs

Dear Sir,

Subject: 600 KLD- Zero Liquid Discharge Systems.

As per the discussions had with you, we have mentioned below technical & commercial details of above mentioned ZLD system based on the revised URS Sheet dated on 05.09.2022.

Reject Concentration & ZLDS

Design Considerations

TDS for our Design	:	25000-40000mg/l
Total Suspended Solid	:	500-1000mg/l
Salt Present	:	Mixed Salt
Total Hardness	:	3000-6000mg/l
COD	:	40000-80000mg/l
BOD	:	20000-50000mg/l
pH	:	7-8

System Offered – Reject Concentration:

- ✓ **Stripper Column and its accessories**
- ✓ **Six Stage Evaporator, to raise concentration from 4.22% to 35%.**
- ✓ **Three Sets of Agitated Thin Film Dryer System, to recover the mixed salt.**

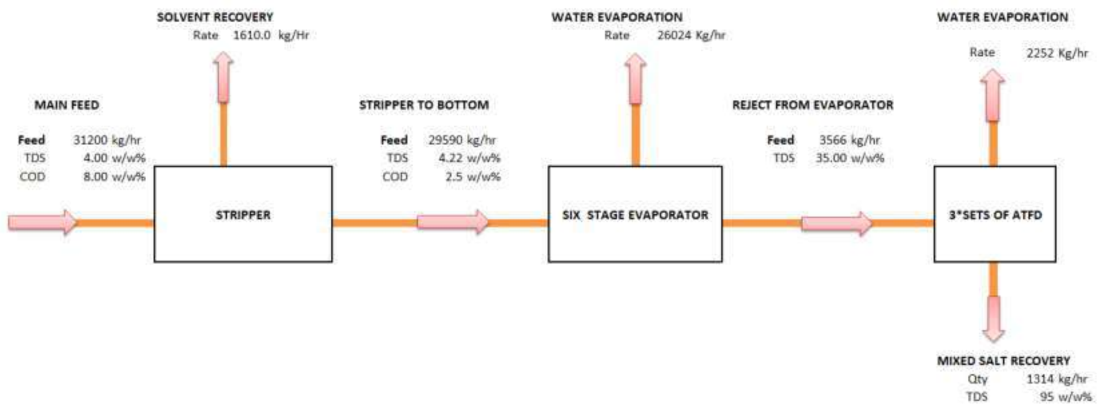
Please find enclosed here with following data

- Basis of Design
- Equipment details which includes Technical Specifications, Material of Construction & Scope of supply
- Battery limits and exclusion
- Terms & Conditions

We wish that our proposal is lined up with your requisite. We now would like to invite your good office to visit our work place and looking forward for encouraging consideration from your side. For further information or clarification, please do not hesitate to contact us.

I. Basis of Design

Mass balance chart for 600KLD ZLDS @ 40000 PPM



Recovered Water Quality:

Parameters	MEE Condensate Quality	ATFD Condensate Quality
TDS	<500 PPM	<1000 PPM
pH	7.5 to 8.5	7.5 to 8.5
COD	Based on Volatile COD Present in the Feed	

II.Equipment Details

1. Stripper Column

[a].Operating Parameters:

Sl. No.	Particulars	Unit	Technical Details
1.	Solvent Recovery Rate	Kg/hr	1610
2.	Product Feed Rate	Kg/hr	31200
3.	Outlet Rate	Kg/hr	29590
4.	Total Solids in Product Feed	Weight %	4%
5.	Total Solids in Outlet	Weight %	4.22%
6.	Initial COD	Weight %	8%
7.	Cooling Water Inlet Temp.	ºC	32
8.	Cooling Water Outlet Temp.	ºC	38
9.	Cooling Water Recirculation Rate	m^3 / hr	118
10.	Motive Steam Pressure	Kgf / cm^2 (g)	3-4
11.	**Motive Steam Consumption**	**Kg/hr**	**3936**
12.	Plant Power Requirement	Kwh	11.25
13.	Vacuum Pump Power	Kwh	3.75
14.	Cooling Tower Pump Power with Fan	Kwh	18.75
15.	**Total Power Installed**	**Kwh**	**33.75**
16.	Electricity Supply Required	415V, 3Ph, 50Hz, AC	
17.	Operating hours	Hrs / Day	20

[b]. Material of Construction with Qty

Scope of Supply – Stripper & its accessories		
Stripper Column		
Qty	:	1 No
Flow,m3/hr	:	30
Dia/Column, mm	:	1500
Height of the Stripper Column, mtrs	:	18
Packing Details	:	Packing Bed - 2" SS316L Pall rings & structure packings
MOC of the Shell (Column)	:	SA 240 GR 316L(6mm Thick)
MOC of Internals	:	SA 240 GR 316L
MOC of Packings	:	SA 240 GR 316L
Reboiler		
Qty	:	1 No
Effective heat Transfer Area , Sq.M.	:	90
MOC of the Tubes	:	SA 213 TP 316Ti(Seamless)(1.2mm Thick)
MOC of Tube Sheet	:	SA 240 GR 316L (20mm Thick)
MOC of Main Shell	:	SA 240 GR 304 (5mm Thick)
MOC of Top & Bottom Cover	:	SA 240 GR 316L (5mm Thick)
Tube Details	:	OD-31.75, Height-2mtrs, Total no.of Tubes -450 Nos
Surface Condenser		
Qty	:	1No
Effective heat Transfer Area , Sq.M.	:	80
MOC of the Tubes	:	SA 213 TP 316L(ERW) (1.2mm Thick)

MOC of Tube Sheet	:	SA 240 GR 316L (20mm Thick)
MOC of Main Shell	:	SA 240 GR 304 (5mm Thick)
MOC of Top & Bottom Cover	:	SA 240 GR 304 (6mm Thick)
Tube Details	:	OD-19.05, Height-3mtrs, Total no.of Tubes -446 Nos
Stripper Bottom Vessel		
Qty	:	01 No
MOC of the Shell	:	SA 240 GR 316L
Thickness of the Shell	:	5mm Thick
Volume, KL	:	6.25
Reflux Drum (Solvent Holding)		
Qty	:	01 No
MOC of the Shell	:	SA 240 GR 316L
Thickness of the Shell	:	5mm Thick
Volume, KL	:	0.5
Pumps With Motors		
Feed Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	30
Head,mtrs	:	15
Power in HP/Kwh	:	5/3.75
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole

Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Reflux Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	6.5
Head,mtrs	:	20
Power in HP/Kwh	:	5/3.75
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Circulation/Outlet Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	30

Head,mtrs	:	20
Power in HP/Kwh	:	5/3.75
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Cooling Tower Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	118
Head,mtrs	:	25
Power in HP/Kwh	:	15/11.25
Motor RPM	:	1450
Motor Efficiency	:	IE3
No.of Poles	:	4 Pole
Seal Type	:	Single Mechanical Seal
Seal Mechanism	:	Silicon Carbide (SiC)
Pump Make	:	Johnson
Motor Make	:	BB/CG
Vacuum Pump		
Qty	:	1 W+1FSB

Pump Type	:	Water Ring Liquid
MOC	:	CI+CF8
Flow,m3/hr	:	81
Power in HP/Kwh	:	5/3.75
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Pump Make	:	PPI
Motor Make	:	BB/CG
Pipelines & Fittings		
Process Pipelines		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipe	:	Sch 10
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Vapour Duct		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Thickness of Pipe	:	5 mm Thick
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L(Chemin Std)
Solvent Outlet Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipe	:	Sch 10

MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
PHE for Stripper		
Qty	:	1 No
Make	:	Alfalaval/Sondex/Trantor

2. Six Stage Evaporator

[a].Operating Parameters:

Sl. No.	Particulars	Unit	Technical Details
1.	Water Evaporation Capacity	Kg/hr	26024
2.	Product Feed Rate	Kg/hr	29590
3.	Concentrate Outlet Rate	Kg/hr	3566
4.	Total Solids in Product Feed	Weight %	4.22%
5.	Total Solids in Concentrate Outlet	Weight %	35%
6.	Concentrate Outlet Temp.	Around °C	48
7.	Cooling Water Inlet Temp.	°C	32
8.	Cooling Water Outlet Temp.	°C	38
9.	Cooling Water Recirculation Rate	m^3 / hr	380
10.	Motive Steam Pressure	Kgf / cm^2	3-4
11.	**Motive Steam Consumption**	**Kg/hr**	**5200**
12.	Plant Power Requirement	Kwh	309.375
13.	Vacuum Pump Power	Kwh	45
14.	Cooling Tower Pump Power with Fan	Kwh	60
15.	**Total Power Installed**	**Kwh**	**414.375**

16.	Electricity Supply Required	415V, 3Ph, 50Hz, AC	
17.	Operating Hours	hrs / day	20

[b]. Material of Construction with Qty

Scope of Supply – Six Stage Evaporators		
Calandria		
Qty	:	6 Nos
Type	:	Forced Circulation
Tube MOC	:	TiGrII Seamless (1 – 1.2mm Thick)
Tube Dia, mm	:	38.1
Tube Height, mtrs	:	9
MOC of the Tube Sheet	:	SA 240 GR 316 with Ti Bonding (25mm Thick)
MOC of Shell	:	SA 240 GR 316L (6mm Thick)
MOC of Top & Bottom Cover	:	SA 240 GR 316L (8mm Thick)
No.of Tubes		Cal-I : 554Nos Cal-II : 536Nos Cal-III : 464Nos Cal-IV : 332Nos Cal-V : 217Nos Cal-VI : 217Nos
Effective Heat Transfer Area,Sq.m		
Calandria-I	:	597Sq.m
Calandria-II	:	577Sq.m

Calandria-III	:	500Sq.m
Calandria-IV	:	358Sq.m
Calandria-V	:	234Sq.m
Calandria-VI	:	234Sq.m
Total Heat Transfer Area	:	**2500Sq.m**
Preheater		
Qty	:	6 Nos
Type	:	Straight Tube type
Tube MOC	:	TiGrII Seamless (1 – 1.2mm Thick)
Tube Dia, mm	:	31.75
Tube Height, mtrs	:	8.85
MOC of the Tube Sheet	:	SA 240 GR 316 with Ti Bonding (16mm Thick)
MOC of Shell	:	SA 240 GR 316L (Sch 10 Pipe)
MOC of Top & Bottom Cover	:	SA 240 GR 316L (Sch 10 Pipe)
No.of Tubes	:	PHE-I : 12Nos PHE-II : 12Nos PHE-III : 12Nos PHE-IV : 12Nos PHE-V : 12Nos PHE-VI : 12Nos
Effective Heat Transfer Area,Sq.m		
Preheater-I	:	10.5Sq.m
Preheater-II	:	10.5Sq.m

Preheater-III	:	10.5Sq.m
Preheater-IV	:	10.5Sq.m
Preheater-V	:	10.5Sq.m
Preheater-VI	:	10.5Sq.m
Total Heat Transfer Area	:	**63Sq.m**
Vapour Separator		
Qty	:	6 Nos
Type	:	Cylindrical Vertical arrangement
MOC of the Shell	:	SA 240 GR 316L
Thickness of the Shell	:	6mm Thick
Capacity for each Vapour separator , CuM except the duct		
Vapour Separator-I	:	$14m^3$
Vapour Separator-II	:	$14m^3$
Vapour Separator-III	:	$14m^3$
Vapour Separator-IV	:	$14m^3$
Vapour Separator-V	:	$14m^3$
Vapour Separator-VI	:	$14m^3$
Surface Condenser		
Qty	:	1 No
Type	:	Surface Type (Shell &Tube)
Tube MOC	:	SA 213 TP 316L (1.2mm Thick)
Tube Dia, mm	:	19.05
Tube Height, mtrs	:	9
MOC of the Tube Sheet	:	SA 240 GR 316L(20mm Thick)
MOC of Shell	:	SA 240 GR 316L (5mm Thick)

MOC of Top & Bottom Cover	:	SA 240 GR 316L (8mm Thick)
Heat Transfer Area,Sq.m	:	250
No.of Tubes	:	464Nos
Balance Tank		
Qty	:	1 No
MOC	:	SA 240 GR 316L
Thickness of Shell,mm	:	5
Volume,KL	:	1.5
Pumps With Motors		
Feed Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	40
Head,mtrs	:	30
Power in HP/Kwh	:	15/11.25
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Condensate Pump		
Qty	:	1 W+1FSB

Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	40
Head,mtrs	:	20
Power in HP/Kwh	:	10/7.5
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Recirculation Pump- I		
Qty	:	1 No
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	1000
Head,mtrs	:	9-10
No.Of passes	:	5
Power in HP/Kwh	:	60/45
Motor RPM	:	960
Motor Efficiency	:	IE3
No.of Poles	:	6 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC)

		Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Recirculation Pump- II		
Qty	:	1 No
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	1000
Head,mtrs	:	9-10
No.Of passes	:	5
Power in HP/Kwh	:	60/45
Motor RPM	:	960
Motor Efficiency	:	IE3
No.of Poles	:	6 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Recirculation Pump- III		
Qty	:	1 No
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	1000
Head,mtrs	:	9-10
No.Of passes	:	5

Power in HP/Kwh	:	60/45
Motor RPM	:	960
Motor Efficiency	:	IE3
No.of Poles	:	6 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Recirculation Pump- IV		
Qty	:	1 No
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	1000
Head,mtrs	:	9-10
No.Of passes	:	3
Power in HP/Kwh	:	60/45
Motor RPM	:	960
Motor Efficiency	:	IE3
No.of Poles	:	6 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Common Store Standby Pump only for Recirculation	:	1 No

I to IV		
Recirculation Pump- V		
Qty	:	1 No
Pump Type	:	Axial
MOC	:	CF8M (SS316)
Flow,m3/hr	:	1500-1600
Head,mtrs	:	5
No.Of passes	:	1
Power in HP/Kwh	:	60/45
Motor RPM	:	900
Motor Efficiency	:	IE3
No.of Poles	:	6 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Propeller/JEC
Motor Make	:	BB/CG
Recirculation Pump- VI		
Qty	:	1 No
Pump Type	:	Axial
MOC	:	CF8M (SS316)
Flow,m3/hr	:	1500-1600
Head,mtrs	:	5
No.Of passes	:	1
Power in HP/Kwh	:	60/45
Motor RPM	:	900

Motor Efficiency	:	IE3
No.of Poles	:	6 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Propeller/JEC
Motor Make	:	BB/CG
Common Store Standby Pump only for Recirculation V& VI	:	1 No
Concentrate Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	40
Head,mtrs	:	20
Power in HP/Kwh	:	10/7.5
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
ML Pump		

Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	30
Head,mtrs	:	25
Power in HP/Kwh	:	7.5/5.625
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Seal Water Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	30
Head,mtrs	:	30
Power in HP/Kwh	:	10/7.5
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC)

		Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Cooling Tower Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	348
Head,mtrs	:	25
Power in HP/Kwh	:	50/37.5
Motor RPM	:	1450
Motor Efficiency	:	IE3
No.of Poles	:	4 Pole
Seal Type	:	Single Mechanical Seal
Seal Mechanism	:	Silicon Carbide (SiC)
Pump Make	:	Johnson
Motor Make	:	BB/CG
Vacuum Pump		
Qty	:	1 W+1FSB
Pump Type	:	Water Ring Liquid
MOC	:	CI+CF8
Flow,m3/hr	:	1700
Power in HP/Kwh	:	60/45
Motor RPM	:	725
Motor Efficiency	:	IE3
No.of Poles	:	6 Pole

Pump Make	:	PPI
Motor Make	:	BB/CG
Pipelines & Fittings		
Process Pipelines		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipe	:	Sch 10
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Vapour Duct		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Thickness of Pipe	:	5mm Thick
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Condensate Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipe	:	Sch 10
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Non Condensate Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipe	:	Sch 10
MOC of Fittings	:	SA 403 GR 316L

MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Cooling Tower Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	IS2062
Schedule of Pipe	:	C Class
MOC of Fittings	:	IS2062
MOC of Flanges	:	IS2062 (Chemin Std)
Vacuum Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	IS2062
Schedule of Pipe	:	C Class
MOC of Fittings	:	IS2062
MOC of Flanges	:	IS2062 (Chemin Std)
PHE for Vacuum		
Qty	:	1 No
Make	:	Alfalaval/Sondex/Trantor
Seal Water Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes & Fittings	:	UPVC
Schedule of Pipe	:	Sch 40
PHE for Seal Water		
Qty	:	1 No
Make	:	Alfalaval/Sondex/Trantor

3. Agitated Thin Film Dryer (ATFD)

[a]. Operating Parameters:

Sl. No.	Particulars	Unit	Tech. details
1.	Water Evaporation Capacity	Kg/hr	2252
2.	Product Feed Rate	Kg/hr	3566
3.	Mixed Salt Recovery Rate	Kg/hr	1314 max
4.	Weight percentage of Product Feed	Wt %	35%
5.	Weight Percentage of Concentrate Outlet	Wt %	95%
6.	Salt Outlet Temp.	Around oC	55
7.	Cooling Water Inlet Temp.	oC	32
8.	Cooling Water Outlet Temp.	oC	38
9.	Cooling Water Recirculation Rate	m^3/ hr	223
10.	**Motive Steam Consumption**	**Kg/ hr**	**3031**
11.	Motive Steam Pressure	Kgf / cm^2	3-4
12.	Process Power Required	Kwh	72.75
13.	Cooling Tower Pump Power	Kwh	30
14.	Blower Power	Kwh	16.875
15.	**Total Power Installed**	**Kwh**	**119.625**
16.	Operating Hours	hrs / day	20
17.	Duty	-	Continuous

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[b]. Material of Construction with Qty

Scope of Supply – Agitated Thin Flim Dryer		
ATFD		
Qty	:	3 Nos
Type	:	Scrapper Mechanism
Contact Parts MOC	:	Inner Drum: SA 240 GR 316L (6mm Thick) Main Shell : SA 240 GR 316L (8mm Thick)
Jacket MOC	:	SA 240 GR 304 (8mm Thick)
Heat Transfer Area,Sq.m	:	30Sq.m*3 Nos
Cyclone Separator		
Qty	:	3 Nos
Type	:	Conical
MOC of the Shell	:	SA 240 GR 316L
Thickness of the Shell	:	5 mm Thick
Surface Condenser		
Qty	:	3 Nos
Type	:	Surface Type (Shell &Tube)
Tube MOC	:	SA 213 TP 316L (1.2mm Thick)
Tube Dia, mm	:	19.05
Tube Height, mtrs	:	6
MOC of the Tube Sheet	:	SA 240 GR 316L (20mm Thick)
MOC of Shell	:	SA 240 GR 304 (5mm Thick)
MOC of Top & Bottom Cover	:	SA 240 GR 304 (8mm Thick)

Heat Transfer Area, Sq.m	:	51.6 /each
No.of Tubes	:	96Nos/Each
Balance Tank		
Qty	:	1 No
MOC	:	SA 240 GR 316L
Thickness of Shell, mm	:	5
Volume, KL	:	1.5
Pumps With Motors		
Feed Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	8
Head,mtrs	:	15
Power in HP/Kwh	:	3/2.25
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Condensate Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal

MOC	:	CF8M (SS316)
Flow,m3/hr	:	8
Head,mtrs	:	15
Power in HP/Kwh	:	2/1.5
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Seal Type	:	Double Mechanical Seal
Seal Mechanism	:	Inboard –Silicon Carbide (SiC) Outboard –Carbon Silicon Carbide
Pump Make	:	Johnson
Motor Make	:	BB/CG
Cooling Tower Pump		
Qty	:	1 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8M (SS316)
Flow,m3/hr	:	223
Head,mtrs	:	25
Power in HP/Kwh	:	20/15
Motor RPM	:	1450
Motor Efficiency	:	IE3
No.of Poles	:	4 Pole
Seal Type	:	Single Mechanical Seal
Seal Mechanism	:	Silicon Carbide (SiC)
Pump Make	:	Johnson
Motor Make	:	BB/CG

Blower		
Qty	:	3 W+1FSB
Pump Type	:	Centrifugal
MOC	:	CF8
Power in HP/Kwh	:	7.5/5.625 (Each)
Motor RPM	:	2900
Motor Efficiency	:	IE3
No.of Poles	:	2 Pole
Pump Make	:	Nadi
Motor Make	:	BB/CG
Gear Box -ATFD		
Qty	:	3 Nos
MOC	:	Std
Power in HP/Kwh	:	30/22.5 (Each)
Motor RPM	:	1450
Gear Box Make	:	Bonfiglioli
Motor Make	:	BB/CG
Gear Box -BT		
Qty	:	1 No
MOC	:	Std
Power in HP/Kwh	:	2/1.5
Motor RPM	:	1450
Gear Box Make	:	Bonfiglioli
Motor Make	:	BB/CG
Pipelines & Fittings		
Process Pipelines		

Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipes	:	Sch 10
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Vapour Duct		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Thickness of Pipe	:	5 mm Thick
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Condensate Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	SA 312 TP 316L
Schedule of Pipes	:	Sch 10
MOC of Fittings	:	SA 403 GR 316L
MOC of Flanges	:	SA 182 F 316L (Chemin Std)
Cooling Tower Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	IS2062
Schedule of Pipes	:	C Class
MOC of Fittings	:	IS2062
MOC of Flanges	:	IS2062 (Chemin Std)
Blower Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes	:	IS2062

Schedule of Pipes	:	C Class
MOC of Fittings	:	IS2062
MOC of Flanges	:	IS2062 (Chemin Std)
Seal Water Pipes & Fittings		
Qty	:	1 Lot
MOC of Pipes & Fittings	:	UPVC
Schedule of Pipes	:	Sch 40

Note: All gear box assembly and its construction in IS 2062, Big flanges bottom and top support are in IS 2062.

III. List of our Standard Make:

Sl. No	Description	Make
1.	Electrical Accessories	Siemens
2.	Process Pump	Johnson
3.	Vacuum Pump	PPI
4.	Motors	BB/CG
5.	Steel (SS)	Jindal
6.	MS Structure (Main Column-H Section)	Vizag/Sail
7.	Instruments	E&H/ Forbes/Krohne Marshall
a.	Vacuum transmitter	E&H/ Forbes/Krohne Marshall
b.	Temperature transmitter	E&H/ Forbes/Krohne Marshall
c.	Pressure transmitter	E&H/ Forbes/Krohne Marshall
d.	Feed flow meter	E&H/ Forbes/Krohne Marshall
e.	Condensate flow meter	E&H/ Forbes/Krohne Marshall
f.	Pneumatic valve	Aira/Uflow
g.	TDS transmitter	E&H/ Forbes/Krohne Marshall

h.	Rotameter	Forbes/Krohne Marshall
i.	Level transmitter	E&H/ Forbes/Krohne Marshall
j.	Steam Control Valve	Technik/ Forbes Marshall
k.	Steam Flow meter	E&H/Forbes Marshall
7.	Blower	Nadi
8.	Gear Box	Bonfiglioli
9.	VFD	Yaskawa/Siemens

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IV. Scope of Supply - Electrical & Instrument Parts:

Sl.No.	Specification	Quantity
1.	Control Panel with a. Power & Motor Control System b. PLC Control System c. Energy meter	1 Unit
2.	Field Instruments a. Vacuum transmitter-6 Nos b. Temperature transmitter-6 Nos c. Pressure transmitter-3 Nos d. Feed flow meter-1 No e. Condensate flow meter-1 No f. Mass Flow Meter-1 No g. Pneumatic valve-4 Nos h. TDS transmitter-1 No i. Rotameter-2 Nos j. Level transmitter-6 Nos k. Steam Control Valve-2 Nos l. Steam Flow meter-2 Nos	1 Lot
3.	Software a. PLC With SCADA Programming	1 Lot

V. Scope of Supply –Other accessories:

A) Cooling Tower-TR	:	1500
Qty	:	1 Lot
Water Flow Rate,CMH/Cell	:	286.67/Cell*3 Nos
Total Flow Rate,CMH	:	860.01
Total Fan Motor HP,Kw		60/45
Fan Motor RPM	:	477
B) MS Structural for Equipments		
Material Qty,Tons	:	150
Gratings Qty,Nos	:	85
GRP Coating area,Sq.mtr	:	3000 (GRP Coatings for all columns and Tie beams)
C) Electricals		
Type	:	Non Compartment
Fixing Type	:	Non-Draw Out Type
	:	Floor Mounted
MOC	:	MS with Powder Coated
Protection	:	IP-30
Cable Entry	:	Bottom Cable Entry, Single Front
Paint Shade	:	RAL7035 (Siemens Grey)
Base Frame	:	75 x 38 mm ISMC
Input Supply	:	415 ± 10 VAC, 3 Phase, 50 Hz, 4 Wire

Switchgears & Accessories Make	:	Siemens
Electrical Cable Make	:	Polycab/Hawells
Cable MOC	:	Copper Armoured
Cable Tray MOC	:	GRP
D) Insulation		
75mm Rockwool with 26SWG Aluminium Cladding for all units where live steam is applied (Stripper,Calandira-I & ATFD) and 50mm Thick & 26SWG aluminium Cladding for remaining units.		

VI. Utility Details:

1. **Steam Consumption:**

For Stripper	-3936Kg/hr@3-4Kgf / cm^2
For Evaporator	-5200Kg/hr@3-4Kgf / cm^2
For ATFD	-3031Kg/hr@3-4Kgf / cm^2
Total Steam	**- 12167Kg/hr**

2. **Power Consumption:**

For Stripper	-33.75Kwh
For Evaporator	-414.375Kwh
For ATFD	-119.625Kwh
Total Installed Power	**-567.75Kwh**

3. **Cooling Tower Circulation Rate:**

For Stripper	-118m^3/hr @1-2 Kgf / cm^2

For Evaporator	-380m^3/hr @1-2 Kgf / cm^2
For ATFD	-223m^3/hr @1-2 Kgf / cm^2

4. **Fresh Water Required for Makeup:**

For Cooling Tower & Seal Water	-7500Ltr/hr (Continuous)
Fresh Water Quality	**- RO Permeate or Equivalent Quality**

VII. Battery Limits and Exclusions

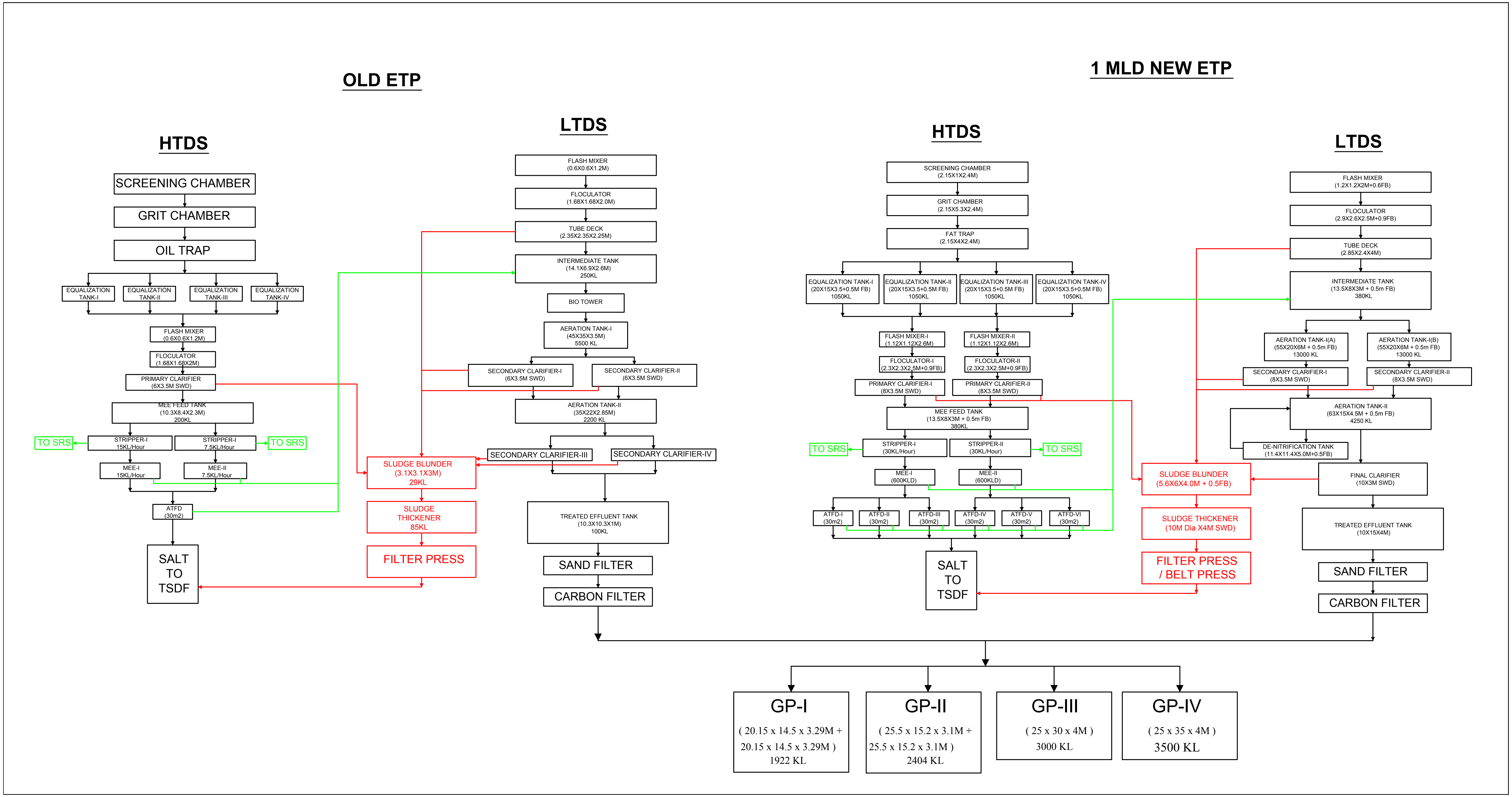
Battery Limits:

Feed	:	At the inlet of the Stripper, Evaporator / ATFD Balance Tank
Steam	:	At that inlet of the Stripper, ATFD/Evaporator Equipment inlet nozzle
Product outlet	:	At that outlet of the ATFD
Solvent outlet	:	At that outlet of the Solvent Collections
Process condensate	:	At the outlet of the Condensate Pump of Evaporator/ATFD
Sealing water	:	At the inlet of the Seal water Tank
Raw water	:	At the inlet of the both Balance Tank, Cooling Tower & Seal water Tank
Drain	:	At individual Equipment & Piping
Power/Earthing	:	At the panel (MCC) incoming at individual motors

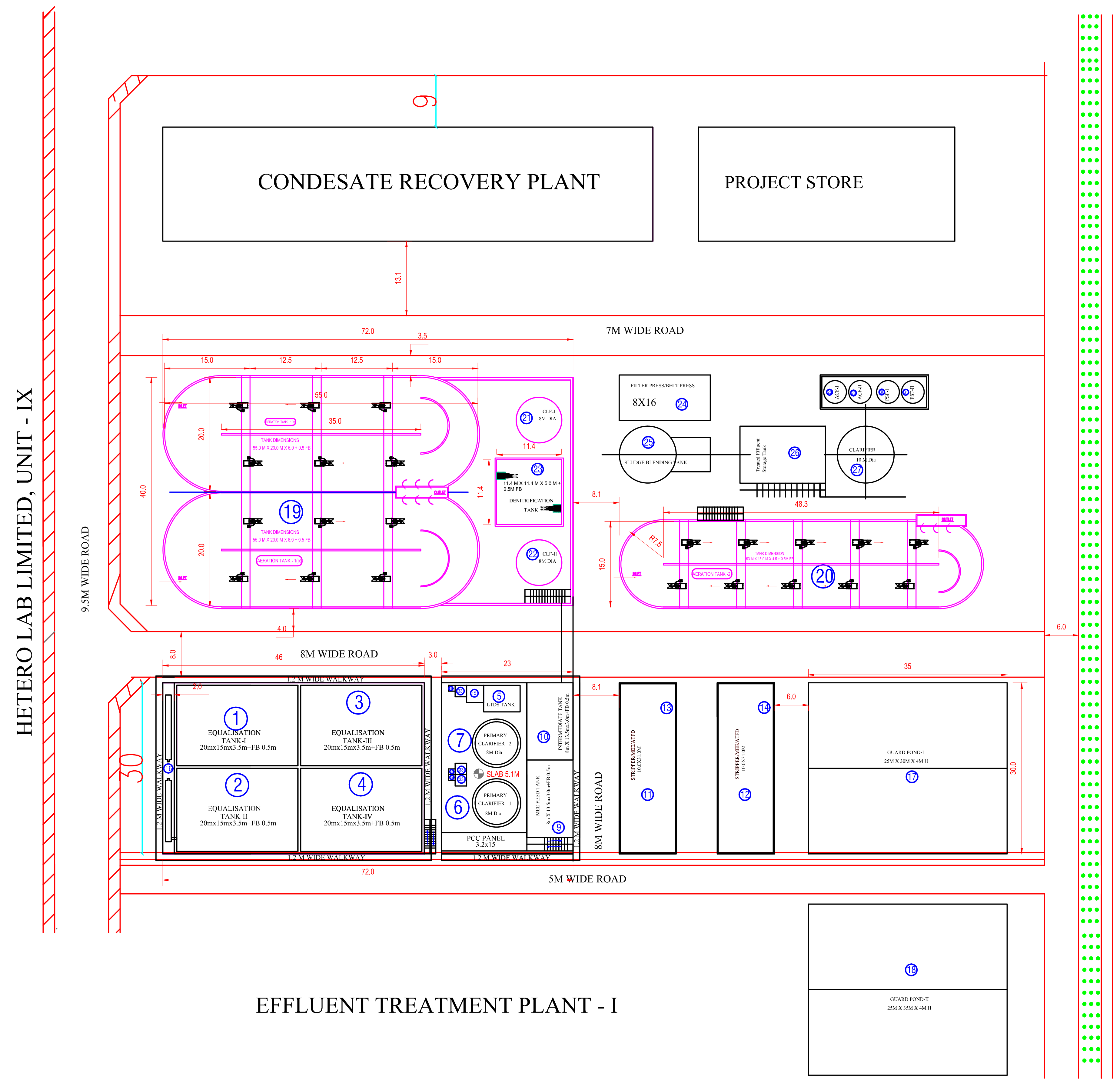
Scope of Supply Details:

Sl. No	DESCRIPTION	Scope Details
1.	All Equipment Supply as Per above Scope of Supply.	Chemin
2.	All civil works related with System, such as foundation of column, equipment and pumps, Necessary storage tank, if other civil works not mentioned and related to the system.	Client
3.	All statutory, legal and government formalities and permission for the erection and operation of the plant (Electrical/PCB activities).	Client
4.	Unloading, storing of the equipment and safety at site.	Client
5.	Steam boiler, Pipeline and Valves upto the system.	Client
6.	All Input and output Pipelines.	Client
7.	Cooling Tower, Pump & its Pipelines.	Chemin
8.	Foundation Bolt, Nut and its accessories	Client
9.	Supply of Electrical Cables, Tray and its accessories	Chemin
10.	MS Structure and its accessories.	Optional
11.	Motor Cover and its Painting work	Chemin
12.	Lubrications of the Rotating Equipments.	Client
13.	Painting Work at site	Client
14.	Roof shed & its accessories.	Client
15.	Insulation of the Equipments and pipelines	Chemin
16.	Instrument and its Automation Work.	Chemin

17.	Food, Travelling & Accommodation of Our Engineers and Labours at the time of Erection Supervision.	Chemin
18.	Crane Charges for Erection at Site.	Client
19.	Erection & Fabrication at site	Chemin
20.	Supervision of Commissioning at site.	Chemin
21.	Necessary Electrical power supply and water supply for the equipment erection and fabrication at site.	Client
22.	Necessary chemical and tools for trail run and commissioning of the system.	Client
23.	If any other thing not mentioned other than the offer.	Client


OLD ETP
1 MLD NEW ETP
HTDS
SCREENING CHAMBER
GRIT CHAMBER
OIL TRAP
EQUALIZATION TANK-I
EQUALIZATION TANK-II
EQUALIZATION TANK-III
EQUALIZATION TANK-IV
FLASH MIXER (0.6X0.6X1.2M)
FLOCULATOR (1.68X1.68X2M)
PRIMARY CLARIFIER (6X3.5M SWD)
MEE FEED TANK (10.3X8.4X2.3M) 200KL
TO SRS
STRIPPER-I 15KL/Hour
STRIPPER-I 7.5KL/Hour
TO SRS
MEE-I 15KL/Hour
MEE-II 7.5KL/Hour
ATFD (30m2)
SALT TO TSDF
LTDS
FLASH MIXER (0.6X0.6X1.2M)
FLOCULATOR (1.68X1.68X2.0M)
TUBE DECK (2.35X2.35X2.25M)
INTERMEDIATE TANK (14.1X6.9X2.6M) 250KL
BIO TOWER
AERATION TANK-I (45X35X3.5M) 5500 KL
SECONDARY CLARIFIER-I (6X3.5M SWD)
SECONDARY CLARIFIER-II (6X3.5M SWD)
AERATION TANK-II (35X22X2.85M) 2200 KL
SECONDARY CLARIFIER-III
SECONDARY CLARIFIER-IV
SLUDGE BLUNDER (3.1X3.1X3M) 29KL
SLUDGE THICKENER 85KL
FILTER PRESS
TREATED EFFLUENT TANK (10.3X10.3X1M) 100KL
SAND FILTER
CARBON FILTER
HTDS
SCREENING CHAMBER (2.15X1X2.4M)
GRIT CHAMBER (2.15X5.3X2.4M)
FAT TRAP (2.15X4X2.4M)
EQUALIZATION TANK-I (20X15X3.5+0.5M FB) 1050KL
EQUALIZATION TANK-II (20X15X3.5+0.5M FB) 1050KL
EQUALIZATION TANK-III (20X15X3.5+0.5M FB) 1050KL
EQUALIZATION TANK-IV (20X15X3.5+0.5M FB) 1050KL
FLASH MIXER-I (1.12X1.12X2.6M)
FLASH MIXER-II (1.12X1.12X2.6M)
FLOCULATOR-I (2.3X2.3X2.5M+0.9FB)
FLOCULATOR-II (2.3X2.3X2.5M+0.9FB)
PRIMARY CLARIFIER-I (8X3.5M SWD)
PRIMARY CLARIFIER-II (8X3.5M SWD)
MEE FEED TANK (13.5X8X3M + 0.5m FB) 380KL
TO SRS
STRIPPER-I (30KL/Hour)
STRIPPER-II (30KL/Hour)
TO SRS
MEE-I (600KLD)
MEE-II (600KLD)
ATFD-I (30m2)
ATFD-II (30m2)
ATFD-III (30m2)
ATFD-IV (30m2)
ATFD-V (30m2)
ATFD-VI (30m2)
SALT TO TSDF
SLUDGE BLUNDER (5.6X6X4.0M + 0.5FB)
SLUDGE THICKENER (10M Dia X4M SWD)
FILTER PRESS / BELT PRESS
LTDS
FLASH MIXER (1.2X1.2X2M+0.6FB)
FLOCULATOR (2.9X2.6X2.5M+0.9FB)
TUBE DECK (2.85X2.4X4M)
INTERMEDIATE TANK (13.5X8X3M + 0.5m FB) 380KL
AERATION TANK-I(A) (55X20X6M + 0.5m FB) 13000 KL
AERATION TANK-I(B) (55X20X6M + 0.5m FB) 13000 KL
SECONDARY CLARIFIER-I (8X3.5M SWD)
SECONDARY CLARIFIER-II (8X3.5M SWD)
AERATION TANK-II (63X15X4.5M + 0.5m FB) 4250 KL
DE-NITRIFICATION TANK (11.4X11.4X5.0M+0.5FB)
FINAL CLARIFIER (10X3M SWD)
TREATED EFFLUENT TANK (10X15X4M)
SAND FILTER
CARBON FILTER
GP-I (20.15 x 14.5 x 3.29M + 20.15 x 14.5 x 3.29M) 1922 KL
GP-II (25.5 x 15.2 x 3.1M + 25.5 x 15.2 x 3.1M) 2404 KL
GP-III (25 x 30 x 4M) 3000 KL
GP-IV (25 x 35 x 4M) 3500 KL

1 MLD EFFLUENT TREATMENT PLANT SITE LAYOUT



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COMPONENTS OF ETP:

1. EQUALISATION TANK - I	: 1 NO - 20mx15mx3.5m+FB 0.5m
2. EQUALISATION TANK - II	: 1 NO - 20mx15mx3.5m+FB 0.5m
3. EQUALISATION TANK - III	: 1 NO - 20mx15mx3.5m+FB 0.5m
4. EQUALISATION TANK - IV	: 1 NO - 20mx15mx3.5m+FB 0.5m
5. LTDS TANK	: 1 NO - 4.5mX4.2mx3.5m+FB 0.5m
6. PRIMARY CLARIFIER-1	: 1 NO - Dia8mx3.5mSWD
7. PRIMARY CLARIFIER-2	: 1 NO - Dia8mx3.5mSWD
8. MCC ROOM	: 1 NO - 8m X 23mX4.5m+FB 0.5m
9. MEE FEED TANK	: 1 NO - 8m X 13.5mx3.0m+FB 0.5m
10. INTERMEDIATE TANK	: 1 NO - 8m X 13.5mx3.0m+FB 0.5m
11. STRIPPER/MEE/ATFD-1	: 1 NO - 10.0mX31.0m
12. STRIPPER/MEE/ATFD-2	: 1 NO - 10.0mX31.0m
13. COOLING TOWER-1	: 1 NO - 10m X 6m x3m+FB 0.5m
14. COOLING TOWER-2	: 1 NO - 10m X 6m x3m+FB 0.5m
15. TUBE SETTLER	: 1 NO - 2.85m X 2.4m X 4m
16. GRIT CHAMBER	: 1 NO - 2.15m X 5.3m X 2.4m
17. GUARD POND-I	: 25M X 30M X 4M H
18. GUARD POND-II	: 25M X 35M X 4M H
19. AERATION TANK-I	: 55.0 M X 20.0 M X 6.0 + 0.5 FB
20. AERATION TANK-II	: 63mX15mX4.5m+FB 0.5m
21. CLARIFIER - 1	: 1 NO - 8M DIAx3.5mSWD
22. CLARIFIER - 2	: 1 NO - 8M DIAx3.5mSWD
23. DE-NITRIFICATION TANK	: 1 NO - 11.4M X 11.4M X 5.0M+0.5M FB
24. FILTER PRESS/BELT PRESS	: 1 NO - 8m X 16m
25. SLUDGE BLENDING TANK	: DIA 5.6mX6mX4.0M+0.5FB
26. Treated Effluent STORAGE TANK	: 1 NO - 10m X 15m X 4m
27. CLARIFIER	: 1 NO - 10M DIAx3.0mSWD
28. ACTIVATED CARBON FILTER-1	: 1 NO - DIA 2.8m
29. ACTIVATED CARBON FILTER-2	: 1 NO - DIA 2.8m
30. PRESSURE SAND FILTER -1	: 1 NO - DIA 2.1m
31. PRESSURE SAND FILTER -2	: 1 NO - DIA 2.1m
32. FLASH MIXER	: 3 NO - 1.2m X 1.2m X 2m + 0.6FB
33. FLOCULATOR	: 3 NO - 2.9m X 2.6m X 2.5m + 0.9FB

ALL DIMENSIONS ARE IN METERS

HETERO

HETERO INFRASTRUCTURE SEZ LIMITED
N.NARSAPURAM, NAKKAPALLI MANDAL
VISAKHAPATNAM – 531081

TITLE

1 MLD ETP LAYOUT

	NAME	DATE	SIGNATURE
DRAWN	SUNEEL	20.02.21	
CHECKED	SK REDDY	20.02.21	
APPROVED	SK REDDY	20.02.21	

SCALE: 1:1000 | SHEET-1/1 | REV-0

Drg no:- HLL-III/ETP/01-2021

VERMI COMPOST PLANT

Design Parameters:

Plant is designed to treat 100 Kgs of wet Garbage Per Day

HAZARDOUS WASTE AND MODE OF DISPOSAL

Hazardous wastes are being disposed as per the conditions stipulated by APPCB in the CTO.
Minimum stocks are being maintained in the Hazardous waste storage yard.
Hazardous waste and mode of disposal specified by the APPCB in CTO is mentioned below:

S.No	Details of waste	Mode of Disposal
1	Process Solid waste	To TSDF, Parawada, Anakapalli Dist. For secured Land filling
2	MEE/ Forced Evaporation Salt	
3	Incineration Ash	
4	ETP Sludge	
5	Solvent Residue/Organic Residue	Shall be incinerated to sent to Cement industries for Co-incineration/Coprocessing/ Pre-processing units
6	Spent Carbon	
7	Damage or Rejected APIs/products	
8	Damaged or Expired Raw materials	
9	Used PPEs	Shall be incinerated in in-house incinerator or sent to Cement industries for incineration
10	Used Oils	To Re-processing units authorized by APPCB
11	Used Batteries	Shall be sent to suppliers on buy back basis
12	e-Waste/ electrical waste	Sent to Authorized Recyclers approved by APPCB/CPCB.
13	Empty Drums/ Containers/ Liners contaminated with Hazardous chemicals/waste	To outside agencies after complete detoxification.
14	Empty barrels / containers / liners contaminated with hazardous chemicals / wastes	
15	LDPE Paper	To authorized Recyclers/ outside agencies
16	Coal Ash from Boilers	To Brick manufacturing units
17	Spent Solvents	Shall be recycled within the units of Hetero Infrastructure SEZ Ltd or sold to outside agencies
18	Recovered Solvents	

Annexure-XVIII

HETERO INFRATSRUCTURE SEZ LTD

Photographs of Diesel Generator sets in the plant

ANNEXURE-XIX

HETERO INFRASTRUCTUE SEZ LTD
Green Belt Photos

HETERO INFRASTRUCTUE SEZ LTD
Green Belt Photos

HETERO INFRASTRUCTUE SEZ LTD
Green Belt Photos

SV ENVIRO LABS & CONSULTANTS

ENVIRONMENTAL ENGINEERS & CONSULTANTS IN POLLUTION CONTROL

Corporate Office & Laboratory: [illegible]

Hyderabad: [illegible]

[illegible]

Recognised by Govt. of India-MoEF & CC, New Delhi, Accredited by NABL & NABET

Annexure-XX

Ref: SVELC/HISL/24-04/01

Date: 29-04-2024

NAME AND ADDRESS : M/s. HETERO INFRASTRUCTURE SEZ LIMITED,
N.Narasapuram Village, Nakkapally Mandal,
Visakhapatnam (Dt).

SAMPLE PARTICULARS : WATER

SOURCE OF COLLECTION :
1. BOREWELL – 1 (Near ETP)
2. BOREWELL – 2 (Near Hetero Labs)
3. BOREWELL – 3 (Near Labour Shed)
4. BOREWELL – 4 (Near [illegible])

DATE OF COLLECTION : 18-04-2024

TEST REPORT

S.No	Parameter	Unit	Results			
			1	2	3	4
1.	pH	-	7.68	6.78	8.08	7.72
2.	Total Dissolved Solids	mg/l	7220	24790	4730	1152[illegible]
3.	Total Alkalinity as $CaCO_3$	mg/l	475	380	426	530
4	Total Hardness as $CaCO_3$	mg/l	840	7440	672	1606
5.	Calcium as Ca	mg/l	56[illegible]	848	121	206
6	Magnesium as Mg	mg/l	170	1292	89.[illegible]	267
7.	Chlorides as Cl^-	mg/l	3960	13972	2962	6640
8.	Copper as Cu	mg/l	<0.01	<0.01	<0.01	<0.01
9.	Manganese as Mn	mg/l	0.71	3.87	0.32	0.95
10.	Zinc as Zn	mg/l	0.35	0.44	0.18	0.25
11.	Aluminium as Al	mg/l	0.12	0.61	0.14	0.16
12.	Boron as B	mg/l	1.58	0.78	1.56	[illegible].07
13.	Barium as Ba	mg/l	0.15	0.06	0.12	0.09
14.	Selenium as Se	mg/l	0.01	0.09	0.04	0.04
15.	Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01
16.	Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01
17	Cyanide as CN	mg/l	<0.01	<0.01	<0.01	<0.01
18.	Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01
19.	Mercury as Hg	mg/l	<0.01	<0.01	<0.01	<0.01
20.	Nickel as Ni	mg/l	0.07	<0.01	<0.01	<0.01
21	Total Arsenic as As	mg/l	0.03	0.12	0.05	0.02
22.	Total Chromium as Cr	mg/l	<0.01	<0.01	<0.01	<0.01
23.	Iron as Fe	mg/l	0.19	0.13	0.07	0.0[illegible]

Note: All the above parameters are tested as per APHA methods 24th Edition, 2023

CHECKED BY

SV ENVIRO LABS & CONSULTANTS VISAKHAPATNAM

SV ENVIRO LABS & CONSULTANTS

SV ENVIRO LABS & CONSULTANTS

(ENVIRONMENTAL ENGINEERS & CONSULTANTS IN POLLUTION CONTROL)
Corporate Office & Laboratory : [illegible], Visakhapatnam-530012
Hyderabad. Flat No. 302, [illegible], Hyderabad-500038
[illegible]
Recognized by Govt. of India-MoEF & CC, New Delhi. Accredited by : NABL & NABET

Ref: SVELC/[illegible]/24-[illegible]

Dated: 29-04-2024

NAME AND ADDRESS : M/s. HETERO INFRASTRUCTURE SEZ LIMITED,
N.Narasapuram Village, Nakkapally Mandal,
Visakhapatnam (Dt).

SAMPLE PARTICULARS : WATER

SOURCE OF COLLECTION :
1. BOREWELL – 1 (Nallimarripalem)
2. BOREWELL – 2 (Lakshmi Puram Village)
3. BOREWELL – 3 (Ayyannapalem Village)
4. BOREWELL – 4 ([illegible] gate)

DATE OF COLLECTION : 18-0[illegible]-2024

TEST REPORT

S.No	Parameter	Unit	Results			
			1	2	3	4
1.	pH	-	7.16	7.18	8.15	7.68
2.	Total Dissolved Solids	mg/l	380	[illegible]	[illegible]	7641
3.	Total Alkalinity as $CaCO_3$	mg/l	105	480	332	[illegible]
4.	Total Hardness as $CaCO_3$	mg/l	90.0	350	195	840
5.	Calcium as Ca	mg/l	31.2	54.1	22.0	[illegible]
6.	Magnesium as Mg	mg/l	2.91	52.2	34.0	190
7.	Chlorides as Cl	mg/l	[illegible]	1150	726	3120
8.	Copper as Cu	mg/l	<0.01	<0.01	<0.01	<0.01
9.	Manganese as Mn	mg/l	0.12	1.15	0.45	0.22
10.	Zinc as Zn	mg/l	0.44	0.47	0.57	0.33
11.	Aluminium as Al	mg/l	0.26	0.28	0.08	0.15
12.	Boron as B	mg/l	1.58	1.36	1.62	1.78
13.	Barium as Ba	mg/l	0.18	0.05	0.05	0.09
14.	Selenium as Se	mg/l	0.03	0.07	0.02	0.05
15.	Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01
16.	Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01
17.	Cyanide as CN	mg/l	<0.01	<0.01	<0.01	<0.01
18	Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01
19.	Mercury as Hg	mg/l	<0.01	<0.01	<0.01	<0.01
20.	Nickel as Ni	mg/l	0.09	<0.01	<0.01	<0.01
21.	Total Arsenic as As	mg/l	0.04	0.11	0.09	0.05
22.	Total Chromium as Cr	mg/l	<0.01	<0.01	<0.01	<0.01
23.	Iron as Fe	mg/l	0.72	0.14	0.12	0.08

Note: All the above parameters are tested as per APHA methods, 24th Edition, 2023

CHECKED BY

SV ENVIRO LABS & CONSULTANTS

SV ENVIRO LABS & CONSULTANTS VISAKHAPATNAM

Confidential

Final Report

Annexure-XXI

Detailed Energy Audit
At
Hetero Labs Limited
(Unit-III, Unit-IX), HDL-IX & Honour Lab

Submitted to

Hetero Labs Limited

(Hetero Group of Companies.)

Narasapuram Village, Nakkapalli,

Visakhapatnam – 530001(A.P.)

By

National Productivity Council,

10th Eastern Wing, Gagan-vihar Complex,

M.J. Road, Nampally, Hyderabad – 500 001

PH: 040 – 24733473, FAX: 040 – 24606981

Email: npc.ap@nic.in, Website: www.npcindia.gov.in

(November 2017)

ACKNOWLEDGEMENT

National Productivity Council (NPC), Hyderabad wishes to place on record its deep gratitude to the progressive management of Hetero Group, Hyderabad, for vesting its confidence in National Productivity Council to carry out the ***Detailed Energy Audit of Hetero Labs Limited (Unit-III, Unit-IX),Hetero Drugs Limited –IX & Honour Labs.***

Our special thanks are due to Shri Dr.C.Mohan Reddy Director & Shri Dr.J.Sambi Reddy, Director for his valuable guidance and encouragement throughout the study.

The study team is thankful to Shri MSN Reddy Vice President(Operations),Shri Raghu Kavuru, Plant Head (HLL-09) , Shri Goli Srinivas Reddy, Plant Head (HLL-03), Shri Ramana Reddy Yerraguntla, GM(Central Engg), Shri Bhaskar Amuluru, VP(Projects & TSD), Shri D.Prasad Rao,AVP(Engg), Shri Kamalakar Reddy Kalli, GM(HR), Shri Dora Reddy, GM(Honour Lab), Shri K.Srinivas Reddy,GM(HDL-09), Shri J.Kondala Rao,Sr GM (Engg-HLL-09), Shri Ramakrishna Reddy, GM(Engg HLL-03), Shri V.Subba Reddy, GM (Elec), Shri D.Venu Prakash,GM(CPP), Shri S.Kulai Reddy,GM(EHS),Shri Konda Ram Reddy,AGM(Elec), Shri R.Appa Rao,Sr Manager(CPP), Shri Chiranjeevi, Engg Head (HDL-09), Shri S.Harsha Vardhan Reddy, Engg Head (Honour Lab) & Shri.T.Sampath, Dy.Manager-Engg for there valuable help and co-operation during the conduct of the study.

We are thankful to all the executives, non-executives and other staff, who have rendered co-operation and assistance to NPC team during the entire period of the study at Hetero Labs Limited (Unit-III & Unit-IX), Hetero Drugs Limited-IX ,Honour Lab & CPP.

Energy Audit Team

National Productivity Council

NPC STUDY TEAM

Project Advisor

Shri R.Virendra, Deputy Director General, NPC

Project Director

Shri.Dr.B.Hemant Kumar Rao, Regional Director, NPC Hyderabad

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Shri Pavan Kumar Ryali, Dy. Director, NPC Hyderabad,
Shri Vijay Raju, Dy. Director, NPC Chennai
Shri J.P.Varun, Asst.Director. NPC-Chennai
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Shri P.R.Rajkamal, Asst.Director, NPC Hyderabad

Table of Contents

Annexure-XXI

List of Tables

List of Figures

SUMMARY OF SAVINGS

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
HLL-03						
Service Block-01						
1	Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-1/RFS 001/+5ºC/173TR.	0.56		3.4	0	0
2	Optimization of chiller Evaporator temperature by adjusting the existing set point of 400TR chiller with reference US-1/RFS 006/+5ºC/400TR	0.56		3.4	0	0
3	Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-1/RFS 002/-5º**C/120TR**	0.65		3.9	0	0
4	Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-1/RFS 004/-15ºC/186TR	1.60		9.66	0	0
5	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0
6	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 001/+5º**C/173TR**		180.10	5.4	9	1.7

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
7	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 006/+5°**C/400TR**		170.07	5.1	9	1.76
8	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 002/-5°C/120TR		75.96	2.3	9	3.94
9	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 004/-15°**C/186TR**		158.7	4.8	9	1.89
10	Energy Savings by replacement of primary pumps +5 ^{0}C 173TR with new energy efficient pump	0.24		1.44	0.8	0.6
11	Energy Savings by replacement of primary pumps +5 ^{0}C 400TR with new energy efficient pump	0.34		2.04	1.4	0.7
12	Energy Savings by replacement of primary pumps -5 ^{0}C 120TR with new energy efficient pump	0.28		1.68	0.55	0.32
13	Energy Savings by replacement of Secondary pumps -5 ^{0}C 120TR with new energy efficient pump	0.28		1.68	0.55	0.32
Service Block-02						

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
14	Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 001/+5°C/173TR	0.78		4.70	0	0.00
15	Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 002/+5°C/173TR	0.67		4.05	0	0.00
16	Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-2/RFS 009/-15°C/186TR	1.85		11.10	0	0.00
17	Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-2/RFS 003/-20°C/120TR	0.84		5.08	0	0.00
18	Stop running of primary pumps when chiller is in OFF condition	2.98		17.87	0	0.00
19	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0.00
20	Energy Savings by changing operating compressor pressure settings	0.2		1.20	0	0.00
21	Energy Savings by installing -5°C chiller in the place of -15oC chiller	5.5		33.00	37.2	1.12

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
22	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 007/+5°**C/173TR**		115.88	3.5	9	2.59
23	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 003/-20°**C/120TR**		37.62	1.1	9	7.97
24	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 009/-15°**C/186TR**		151.80	4.6	9	1.98
25	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 002/+5°C/173TR		90.47	2.7	9	3.3
26	Energy Savings by replacement of primary pumps -15 ^{0}C 186TR with new energy efficient pump	0.2		1.2	0.6	0.5
27	Energy Savings by replacement of primary pumps -40^{0}C 50TR with new energy efficient pump	0.23		1.38	0.3	0.21
	Service Block-04					
28	Operating Two skids instead One skid to attain set point for the chiller	3.09		18.54	0	0.00

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
29	Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 002/+5oC/395TR	0.68		4.08	0	0.00
30	Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 001/+5oC/395TR	0.68		4.08	0	0.00
31	Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 003/-15oC/450TR	0.86		5.16	0	0.00
32	Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 004/-20oC/450TR	0.54		3.24	0	0.00
33	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0.00
34	Energy Savings by changing operating compressor pressure settings	0.3		1.8	0	0.00
35	Energy Savings by replacement of primary pumps of RFS001/+50^{0}C 395TR with new energy efficient pump	0.72		4.32	2	0.46
36	Energy Savings by replacement of primary pumps of RFS002/+50^{0}C 395TR with new energy efficient pump	0.76		4.56	2	0.43

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
37	Energy Savings by replacement of primary pumps -15^{0}C 450TR with new energy efficient pump	1.01		6.06	2.7	0.44
38	Energy Savings by replacement of primary pumps -20^{0}C 450TR with new energy efficient pump	0.79		4.74	2.7	0.56
	Sub-Total	**40.60**	**980.61**	**273.14**	**122.8**	**0.45**

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
HLL-09						
Service Block-01						
1	Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-08/+5 oC/395TR	1.69		10.14	0	0
2	Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference SB-04/-15 oC/158TR	0.73		4.38	0	0
3	Optimization of chiller Evaporator temperature by adjusting the existing set point of 52TR chiller with reference SB005/-40oC/52TR	1.56		9.36	0	0
4	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0
5	Energy Savings by changing operating breathing air compressor pressure settings	0.2		1.2	0	0
6	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-04/-15 oC/158TR		151.68	4.6	9	1.98
Service Block-02						
7	Optimization of chiller Evaporator temperature by adjusting the existing set point of 362TR chiller with reference SB-2/+5oC/362TR	0.56		3.36	0	0

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
8	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0
9	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-2/+5oC/362TR		147.45	4.4	9	2.03
10	Energy Savings by changing operating air compressor pressure settings	0.5		3	0	0.00
Service Block-03						
11	Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 oC/395TR/Comp-01	0.74		4.44	0	0
12	Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 oC/395TR/Comp-02	1.49		8.94	0	0
13	Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-03/-15 oC/Comp-04/450TR	3.47		20.82	0	0
14	Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB03/-40oC/150TR	1.86		11.16	0	0
15	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0
16	Energy Savings by changing operating air compressor pressure settings	0.3		1.8	0	0
17	Energy Savings by replacement of primary pumps -40^{0}C	0.35		2.1	2.2	

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
	150TR with new energy efficient pump					1.05
Service Block-04						
18	Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-001/-15 oC/450TR	3.45		20.7	0	0
19	Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-002/-15oC/450TR	2.48		14.88	0	0
20	Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB04/comp-003/-40oC/150TR	1.58		9.48	0	0
21	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0
22	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-4/AM Comp-001/-15oC/450TR		204.3	6.1	9	1.47
23	Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-4/AM Comp-002/-15oC/450TR		144.42	4.3	9	2.08
24	Energy Savings by replacement of primary pumps -40^{0}C 150TR with new energy efficient pump	0.82		4.92	1.67	0.33
Service Block-05						
25	Energy Savings by changing operating air compressor pressure settings	0.1		0.6	0	0

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
26	Energy Savings by replacement of Cooling Water Pumps of VAM002 of +5^{0}C 300TR with new energy efficient pump	0.74		4.44	3.35	0.75
27	Energy Savings by replacement of Cooling Water Pumps of VAM001 of +5^{0}C 300TR with new energy efficient pump	0.66		3.96	3.35	0.85
Service Block-06						
28	Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-001/+5 oC/350TR	1.14		6.84	0	0
29	Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-002/+5 oC/350TR	1.61		9.66	0	0
30	Energy Savings by changing operating air compressor pressure settings	0.3		1.8	0	0
31	Energy Savings by replacement of primary pumps +5^{0}C SB-6/FN Comp-01 350TR with new energy efficient pump	0.69		4.14	2.7	0.65
32	Energy Savings by replacement of primary pumps +5^{0}C SB-6/FN Comp-02 350TR with new energy efficient pump	0.54		3.24	2.7	0.83
	Sub-Total	**45.4**	**647.86**	**291.8**	**51.97**	**0.17**

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
			HDL-09			
1	Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference US-HDL-09/-15oC/158TR	1.4		8.4	0	0
2	Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers	4.46		26.76	0	0
3	Energy Savings by changing operating breathing air compressor pressure settings	0.04		0.24	0	0
4	Energy Savings by replacing existing +5oC old inefficient chiller with new energy efficient chiller	62.28		373.68	34.6	0.09
5	Energy Savings by replacement of primary pumps +5^{0}C 173TR with new energy efficient pump	0.39		2.34	0.4	0.18
	Sub-Total	**68.57**	**0**	**35.4**	**35**	**0.98**

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
Honour Lab						
1	Energy Savings by changing operating breathing air compressor pressure settings	0.06		0.36	0	0
2	Energy Savings by changing operating instrument air compressor pressure settings	0.01		0.06	0	0
3	Energy Savings by changing operating process air compressor pressure settings	0.15		0.9	0	0
4	Energy Savings by recovering condensate in Honour Lab otherwise sent to ETP and gardening		13.5	18.5	3	0.16
	Sub-Total	**0.22**	**13.5**	**19.82**	**3**	**0.15**

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Tonnes Per Annum)(TPA)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
Captive Power Plant						
1	Energy Savings by arresting Air Leakage in APH tube leakage		5360	160.8	30	0.19
2	Energy Savings by reducing load on ID fan by arresting air preheater leakage	5.31		31.86	0	0.00
3	Energy Savings by Reducing Loss due to unburnt in ash in coal		5520	165.6	0	0.00
4	Energy Savings by Reducing Loss due to Moisture in coal		560	16.8	0	0.00
5	Monetary Savings by by increasing power output from captive power plant (CPP)	88.74		1060.46	462	0.44
	Sub-Total	**94.05**	**11440**	**1435.52**	**492**	**0.34**

S.No	Name of the Encon Option	Annual Savings (In Lakh kWh)	Coal Savings (Kg/Hr)	Annual Monetory Savings (Rs In Lakh)	Investment (In Lakhs)	Simple Payback Period (In Years)
Process Equipment						
1	Energy Savings by utilizing RT water in the place of Chilled water in HLL-03(The basis of calculation is 100TR)	7.6	0	45.6	0	0
2.	Energy Wastage by Idle running of Circulating Water Pump in Production Block-D	0.44	0	2.69	0	0
SRS & Lighting						
2	Waste Heat Recovery from SRS vapours by preheating RO makeup water to boiler		648	19.44	30	1.54
3	Energy Savings by replacing all sodium vapour street lights with LED Street Lights in HLL-03	2.30		13.80	15	1.08
4	Energy Savings by replacing all sodium vapour street lights with LED Street Lights in HLL-09	0.55		3.31	3.6	1.08
	Sub-Total	**10.45**	**648**	**82.15**	**48.60**	**0.59**

1.0 INTRODUCTION

1.1 About Hetero Drugs Limited

Hetero Drugs Limited was founded in 1993 and is based in Hyderabad, India.Hetero was founded by the visionary scientist Dr. BPS Reddy. Under his leadership, Hetero has risen to become the largest closely held pharmaceutical company in India and a world leader in the production of anti-retroviral drugs.

Hetero Drugs Limited, a global leader in anti-retroviral drugs (ARV),markets active pharmaceutical ingredients (APIs)& Formulations, with proven capabilities in development, manufacturing and marketing of Intermediates, Bulk Drugs and Finished Formulations of Chemical & Biologic Drugs. It offers cytotoxics to the pharmaceutical companies that manufacture formulations and other products, generic formulations, biologics, and biosimilars, including monoclonal antibodies.

The company also develops formulations, novel drug delivery systems, new chemical entities, etc. In addition, it provides research and manufacturing services for various pharmaceutical companies and franchises its operations. It offers its products in various therapeutic categories, such as HIV/AIDS, oncology, cardiovascular, neurology, hepatitis etc.

The company exports its products to South Asia, Middle East, Europe, America, and internationally. It has marketing offices in India, the United States, Russia, Spain, China, Thailand, the United Arab Emirates, Egypt, Singapore, Colombia, Ukraine, Mexico, and South Africa.

1.2 About National Productivity Council (NPC)

NPC is a tripartite autonomous not-for-profit organization under Ministry of Commerce & Industry, Govt. of India and is a pioneer national level organization promoting productivity culture in the country.

NPC as an apex body has been providing consultancy and training in various fields including Energy Management, over the past five decades and has undertaken research in the areas of productivity, besides implementing the productivity promotion programs of the Government of India and also for the Tokyo based Asian Productivity Organization (APO).

Amongst the NPC's renowned clients are UNIDO, EU, UNICEF, World Bank, USAID, GTZ etc. NPC has presence all across the country with 14 regional offices in most of the major capital cities

The Management of Hetero has initiated many energy conservation options like

- Installation of Highest no. of ANFD's (276 Nos)
- Invertor type and Five Star Rated Air Conditioners
- World class Screw or Centrifugal Chillers with Evaporative Condensers
- Highest Population of Dry screw Vacuum Pumps
- High efficient Agitator in Process Vessels
- Sea Water Desalination Plant with Turbo/ERI/I Save
- Renewable Energy – Wind Power Generation

In addition to in-house efforts on energy conservation in their facilities M/s Hetero Drugs Limited requested National Productivity Council, under Ministry of Commerce and Industry, GoI, to conduct a comprehensive energy audit study in its Nakapally facility **Hetero Labs Limited.**

1.3 SCOPE OF STUDY

The scope for the Energy Audit would include

- Study of Individual Service blocks for Hetero Labs Limited.
- Evaluate the energy consumption of the major feeders / equipment such as HVAC, Chillers, Air Compressors, Nitrogen Plants, Pumps, Fans & Blowers, Heat Exchangers, Process Equipment, Solvent Recovery System, and Lighting.
- Detailed performance assessment of Captive Power Plant of 6.1 MW.
- Suggest ways to optimize the energy consumption where ever possible.
- Identification of technically and economically viable energy savings proposals.

1.4 Methodology of Audit

The Energy Audit is broadly divided into two phases and the methodology to be adopted is as given below

1.4.1 Phase – I (Field Visit)

- Preliminary visit of all the sections of the plant to obtain an overview of plant operations and processes.
- Data collection through the following sources**:**
    a. Interview with plant executives
    b. Past records

c. Available technical literature
d. Equipment specification
e. Performance guarantee report of the supplier

- Field studies in each of the electrical and utility areas involving:
  a) Performance assessment trials wherever possible.
  b) Measurement of electrical parameters wherever possible

1.4.2 Phase – II (Analysis)

- Detailed analysis of the data obtained pertaining to energy consumption, efficiency, conservation which will include:
  a) Performance evaluation of various equipment mentioned in the scope area.
  b) Comparison of operating efficiencies of these equipment's with performance guarantees figures / rated values / standards available with plant wherever possible.
  c) Establishing margins for performance improvement.
- Identification of energy conservation options.
- Preparation of the detailed report

1.5 Instruments Used

Apart from Onsite instruments, portable instruments used in the study include:

- 3 phase Power Analyzer
- Nanovip
- Ultrasonic water Flow meter
- Flue Gas Analyzer
- I.R Thermometer (Non-contact type)
- Digital Lux meter
- Digital Thermo-anemometer
- Humidity Meter
- Vane Type Anemometer
- Thermal Imager

2.0 ENERGY SCENARIO

2.1 Electrical Energy Scenario

Grid supply from APEPDCL at 132 kV and diesel generated power (in emergency) through DG sets constitute the electricity supply sources for HLL-03, HLL-09, HDL-09 & Honour Labs. Hetero Drugs Limited has also installed a back-pressure turbine captive power plant (CPP) of 6.1MW to meet the requirements of Steam & power.

HLL-09, HLL-03 receives supply from APEPDCL at 132 kV which will be step down to 33 kV by using step-down transformers. The step down lines will be received at substation at 33kv and distributed to various service blocks.

Hetero Labs and Drugs unit has three HT connections from Eastern Power Distribution Company of Andhra Pradesh Limited from Korapollu substation of 132/33kV which is 13 km away from the plant. The 3 HT connections from Korapollu substation is as given below:

- HDL-VI VSP-604, Maximum and Minimum Contract demand of 5000 KVA
- HLL-III VSP-689, Maximum and Minimum Contract demand of 4500 KVA
- HLL-IX VSP- 906, Maximum and Minimum Contract demand of 5000 KVA

Hetero Labs and Drugs unit has one dedicated feeder from Upamaka substation of 11kV from Eastern Power Distribution Company of Andhra Pradesh Limited. The connections from Upamaka substation is as given below:

- HDL-IX,Maximum Demand is 2000KVA.
- Hetero Infra SEZ VSP- 768, Maximum and Minimum Contract demand of 1500 KVA.

The HT tariff applicable is given as below.

S.No	Tariff Structure	HT Tariff
1.	Demand charges	Rs. 385.84/kVA
2.	Energy charges on KVAH basis	Rs. 5.68/KVAH
3.	Energy charges for Colony	Rs. 6.06/KVAH
4.	Electricity duty	Rs. 0.06/KVAH

Table 1 Tariff Structure of APEDPCL

Note: Penalty for exceeding contract demand: An additional charge at the rate of Rs. 600/kVA of the prevailing demand charges will be billed only for the excess demand over the contract demand.

Power from 33 kV line is stepped down to 11 kV by step-down transformers at four locations. The power is distributed to various transformers and feeders from incomer after further stepping down to 415 V.

The average energy demand, Power factor and contracted maximum demand for the four connections from April 2016 to Jan 2017 is as given below:

Connection	Average KVAH	Avg. PF	Avg. KVA
HDL-VI VSP-604	2104640	1.00	3724
HLL-III VSP-689	1882280	1.00	3946
HLL-IX VSP-906	2514400	1.00	4786
Hetero Infra SEZ VSP-768	79669	0.99	904.7

Table 2: Energy Consumption of 4 HT Connections

During field studies past twelve months electricity data from April 2016 to January 2017 was collected for all the four connections and were analyzed.

2.2 HDL-VI VSP-604

The above feeder comes from Korapollu substation of 132/33kV which 13 km away from plant. The contracted maximum demand is 5000kVA from the utility and minimum of 4000kVA needs to be paid to the utility.

Bill Analysis for the connection HDL-VI VSP-604				
Month	**kWh**	**KVAH**	**PF**	**Actual KVA**
Apr-16	2045900	2046300	1.000	3720
May-16	2113200	2113600	1.000	3610
Jun-16	1968500	1968600	1.000	3500
Jul-16	1907700	1907900	1.000	3560
Aug-16	2100400	2101200	1.000	3800
Sep-16	2179300	2180100	1.000	3700
Oct-16	2100200	2100200	1.000	3750
Nov-16	1995300	1995300	1.000	3610
Dec-16	2140700	2140800	1.000	3480
Jan-17	2492300	2492400	1.000	4510

Table 3: Bill Analysis for the connection HDL-VI VSP-604

The minimum demand charges to be paid to the utility is 4000KVA. The average actual KVA recorded during April'16 to Jan'17 is 3724 KVA. The maximum demand achieved during the observation period is 4510 KVA in the month of Jan'17**.**The pf maintained is good which is unity.

The trend of Contracted maximum demand, actual demand were represented graphically is given below:

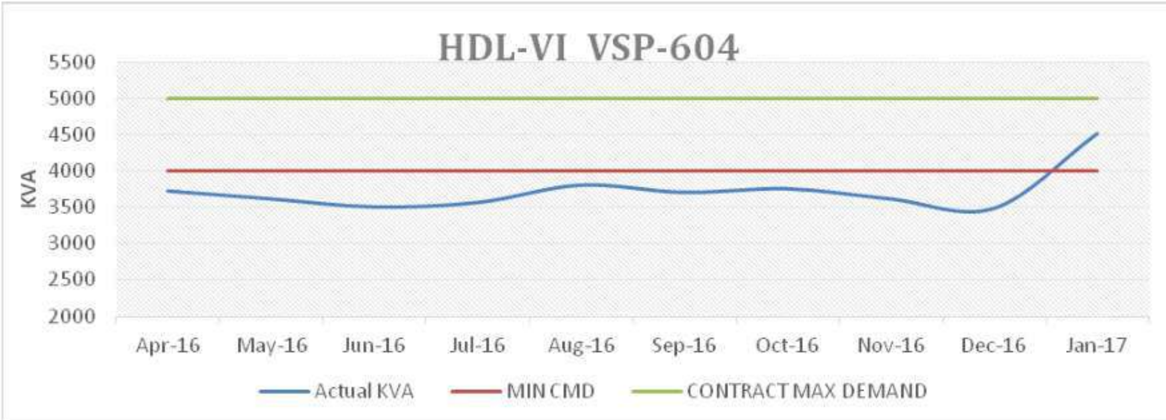


Figure 1: Trend of Actual KVA of HDL-VI VSP 604

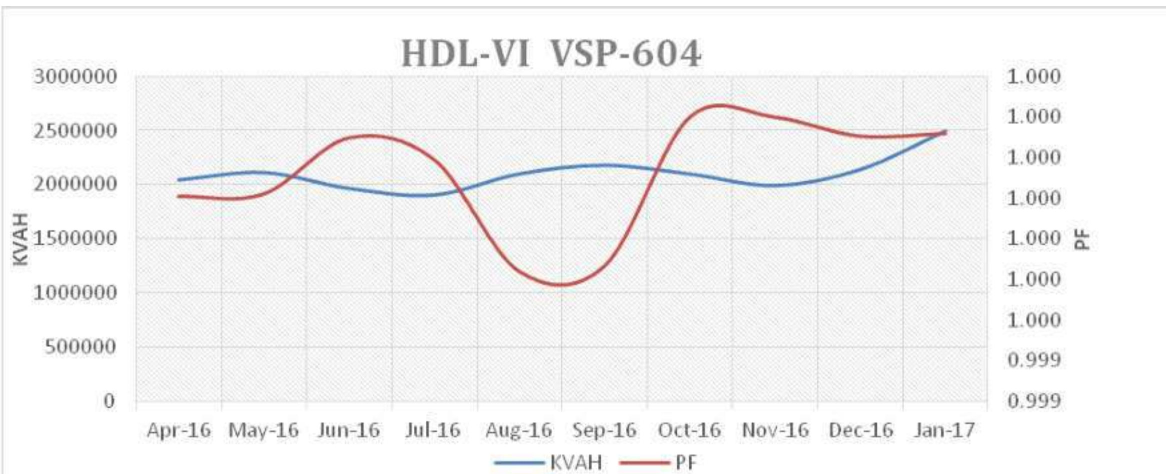


Figure 2: Trend of Actual KVAH & PF of HDL-VI VSP 604

As seen from the figure that Power factor was maintained at unity at all times. The average energy consumption is about 2104640 KVAH per month. The energy consumption pattern appears to be constant and fixed.

2.3 HLL-III VSP-689

The above feeder comes from Korapollu substation of 132/33kV which 13 km away from plant. The contracted maximum demand is 4500kVA from the utility and minimum of 3600kVA needs to be paid to the utility.

Bill Analysis for the connection HLL-III VSP-689				
Month	**kWh**	**KVAH**	**PF**	**Actual KVA**
Apr-16	1925700	1926600	1.000	3930
May-16	2177600	2178900	0.999	4120
Jun-16	1827900	1829600	0.999	4160
Jul-16	2112700	2114700	0.999	4130
Aug-16	1901200	1902600	0.999	4080
Sep-16	1898600	1899800	0.999	4160
Oct-16	1897800	1898800	0.999	3750
Nov-16	1707000	1708600	0.999	4050
Dec-16	1657000	1658000	0.999	3670
Jan-17	1704300	1705200	0.999	3410

Table 4: Bill Analysis for the connection HLL-III VSP-689

The minimum demand charges to be paid to the utility is 3600KVA. The average actual KVA recorded during April'16 to Jan'17 is 3946 KVA. The maximum demand achieved during the observation period is 4160 KVA in the month of Jun '16 & Sep'16**.**The pf maintained is good which is close to unity.

The trend of Contracted maximum demand, actual demand were represented graphically is given below:

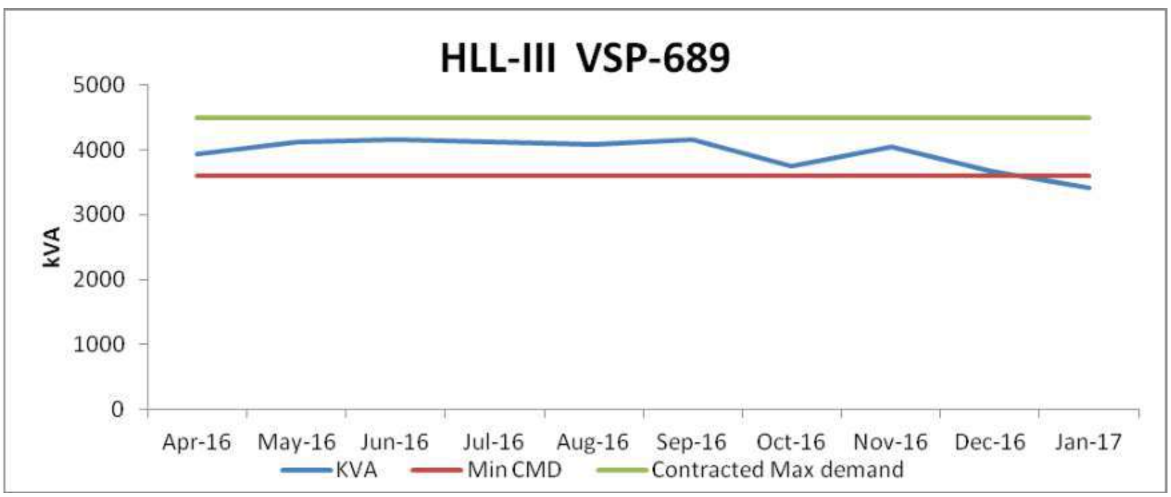


Figure 3: Trend of Actual KVA of HLL-III VSP - 689

It can be seen from the graph that there is no scope for reducing the contract demand.

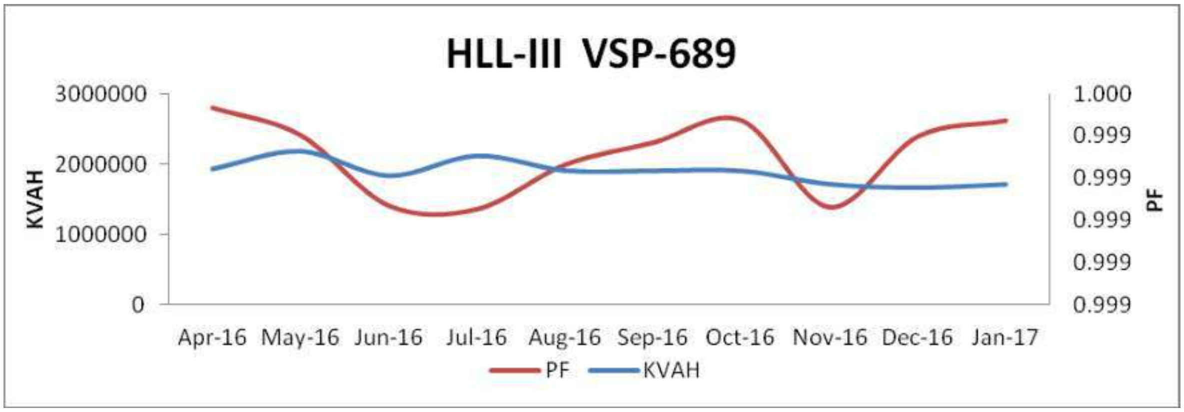


Figure 4: Trend of KVAH & PF of HLL-III VSP - 689

The Power factor was maintained close to unity at all times. The average energy consumption is about 1882280 kVAH per month. The energy consumption pattern appears to be constant throughout the year. The connection serves both the colony and utility area.

2.4 HLL-IX VSP-906

The above feeder comes from Korapollu substation of 132/33kV which 13 km away from plant. The contracted maximum demand is 5000kVA from the utility and minimum of 4000kVA needs to be paid to the utility.

Bill Analysis for the connection HLL-IX VSP-906				
Month	**kWh**	**KVAH**	**PF**	**Actual KVA**
Apr-16	2543800	2547000	0.999	4760
May-16	2951800	2956000	0.999	4860
Jun-16	2667200	2670400	0.999	4920
Jul-16	2614400	2618000	0.999	4980
Aug-16	2687800	2691600	0.999	4860
Sep-16	2439200	2440000	1.000	4600
Oct-16	2169200	2170600	0.999	4700
Nov-16	2231000	2231600	1.000	4720
Dec-16	2466800	2467200	1.000	4740
Jan-17	2350600	2351600	1.000	4720

Table 5; Bill Analysis for the connection HLL-IX VSP-906

The minimum demand charges to be paid to the utility is 4000KVA. The average actual KVA recorded during April'16 to Jan'17 is 4786 KVA. The maximum demand achieved during the observation period is 4980 KVA in the month of July '16**.**The pf maintained is good which is close to unity.

The trend of Contracted maximum demand, actual demand were represented graphically is given below:

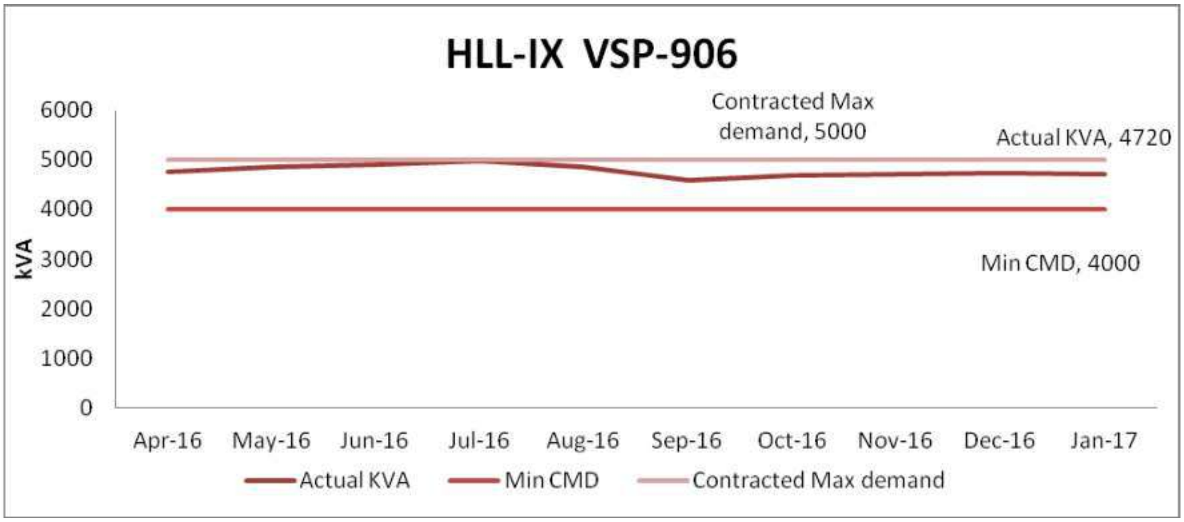


Figure 5: Trend of Actual KVA of HLL-09 VSP - 906

It can be seen from the graph that there is no scope for reducing the contract demand.

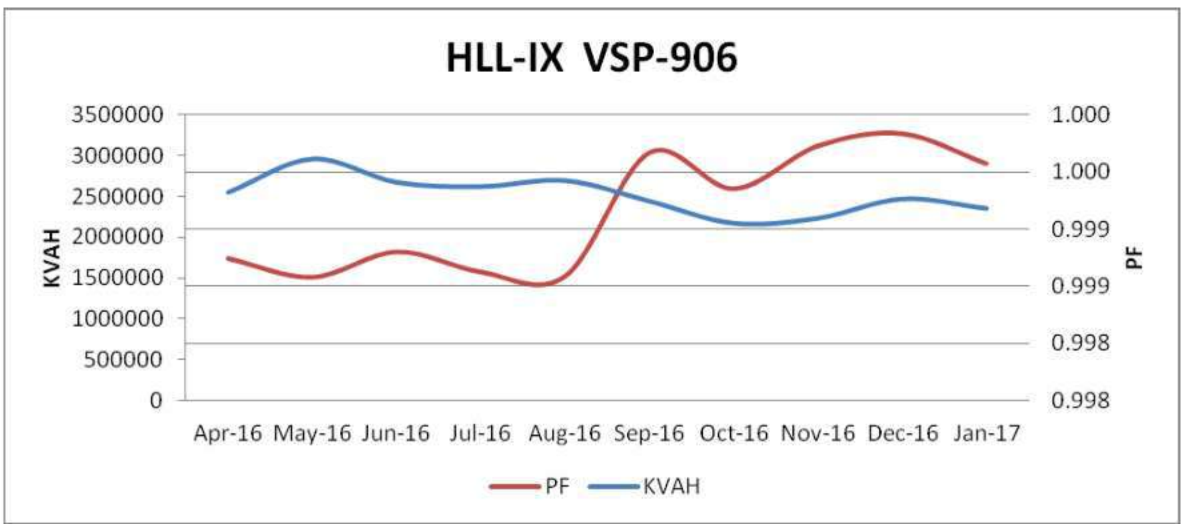


Figure 6: Trend of KVAH & PF of HLL-09 VSP - 906

The Power factor was maintained at unity at all times. The average energy consumption is about 2514400 kVAH per month. The energy consumption pattern appears to be constant throughout the year.

2.5 Hetero Infra SEZ VSP-768

The above feeder comes from Upamaka substation. The contracted maximum demand is 1500kVA from the utility and minimum of 1200kVA needs to be paid to the utility.

Bill Analysis for the connection Hetero Infra SEZ VSP-768				
Month	**kWh**	**KVAH**	**PF**	**Actual KVA**
Apr-16	33470	33500	0.999	558
May-16	35930	36120	0.995	1395
Jun-16	31120	31300	0.994	732
Jul-16	46670	47030	0.992	664
Aug-16	30330	30100	1.008	695
Sep-16	30030	30210	0.994	682
Oct-16	32410	32460	0.998	710
Nov-16	80700	83170	0.970	1314
Dec-16	30160	30320	0.995	1078
Jan-17	440150	442480	0.995	1219

Table 6: Bill Analysis for the connection Hetero Infra SEZ VSP-768

The minimum demand charges to be paid to the utility is 1200KVA. The average actual KVA recorded during April'16 to Jan'17 is 904 KVA. The maximum demand achieved during the observation period is 1395 KVA in the month of May '16**.**The pf maintained is good which is close to unity.

The trend of Contracted maximum demand, actual demand were represented graphically is given below:

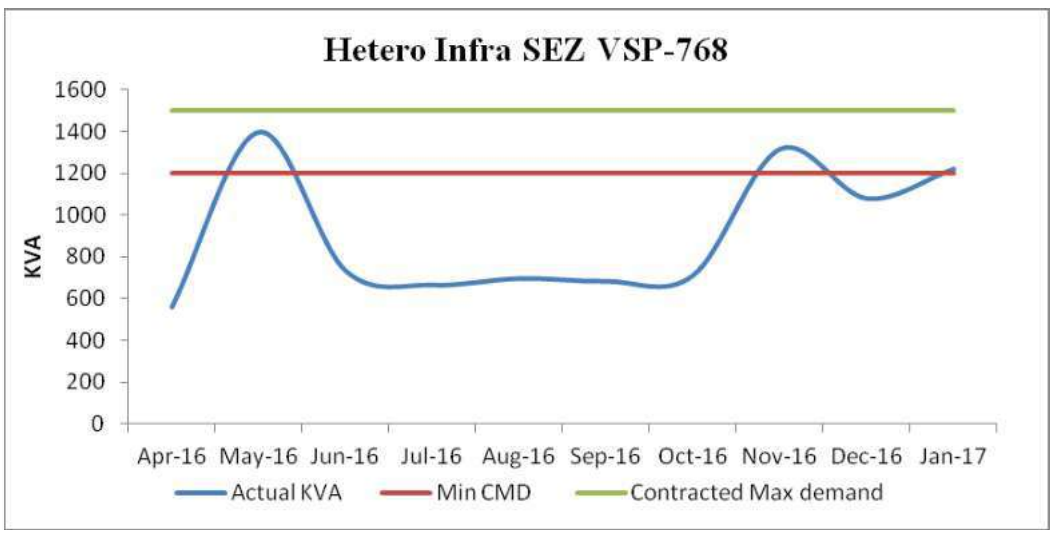


Figure 7: Trend of Actual KVA of Hetero Infra SEZ VSP-768

It can be seen from the graph that there is no scope for reducing the contract demand.

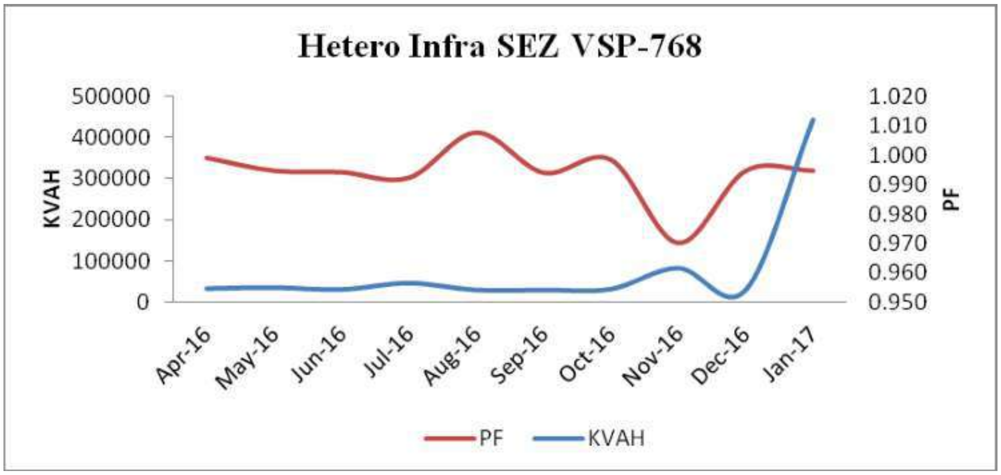


Figure 8: Trend of KVAH & PF of Hetero Infra SEZ VSP-768

The Power factor was maintained at unity at all times. The average energy consumption is about 79669 kVAH per month.

During field studies transformers were studied by placing NPC high end circutor instrument for one complete day at the transformer incomer. The following data was collected from the transformer incomers.

2.6 HLL-03 – 608 Service Incomer One Day Recording

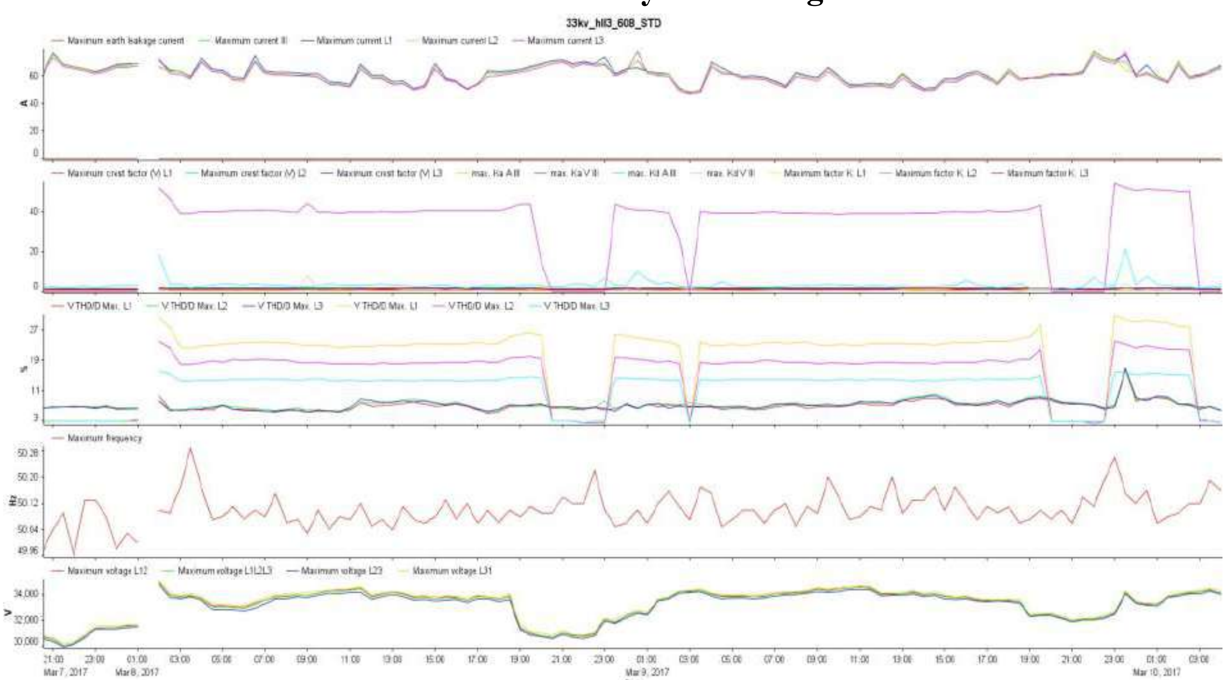


Figure 9:Maximum Values

The above trend shows there are no much fluctuations in voltage and frequency from the service incomer of HLL-03 608.

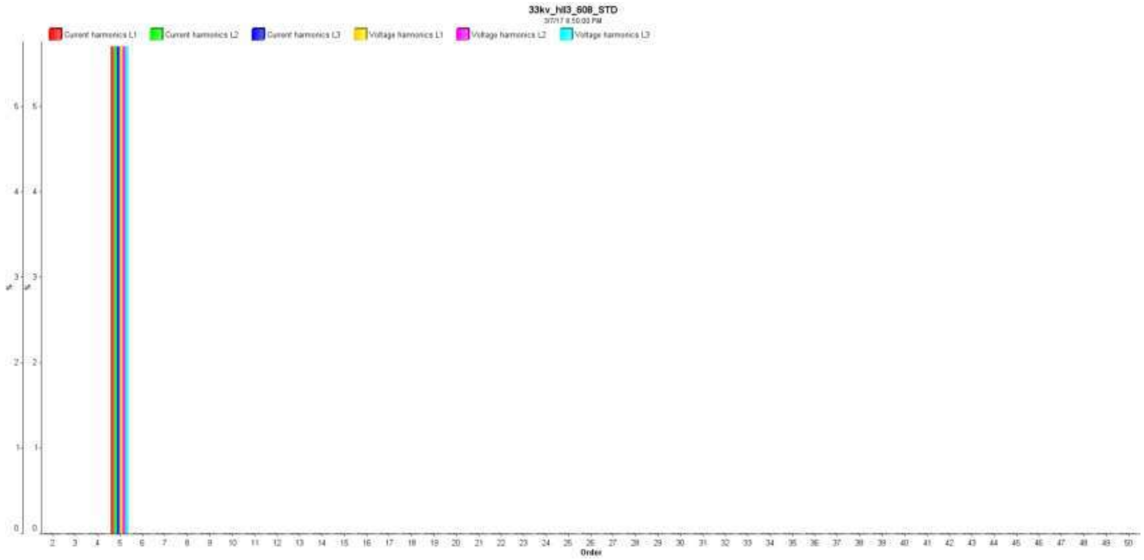


Figure 10:Trend of Harmonics

The above trend shows both the current and voltage harmonics are well within the limits i.e., 4.5% for current and 2.2% for voltage. For current and voltage harmonic limits the IEEE standards were annexed for ready reckoner.

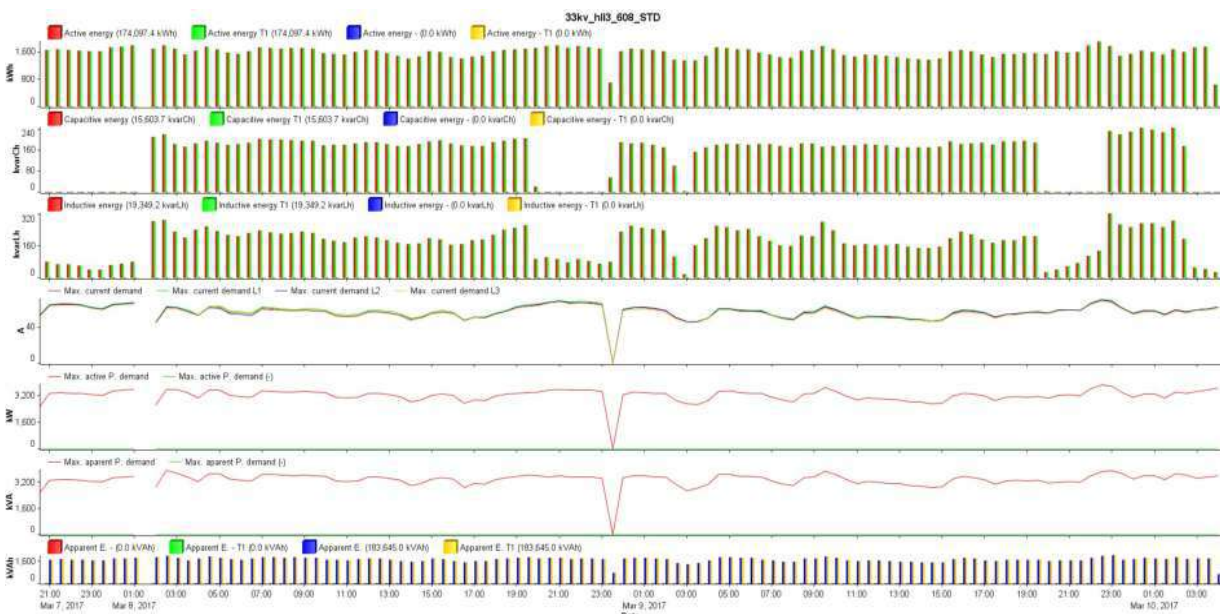


Figure 11:Maximum Energy and Demand

The above graph represents one day trend of kW, kVA, kVAh of HLL-03 608 service incomer.

2.7 HLL-09 Service Incomer One Day Recording

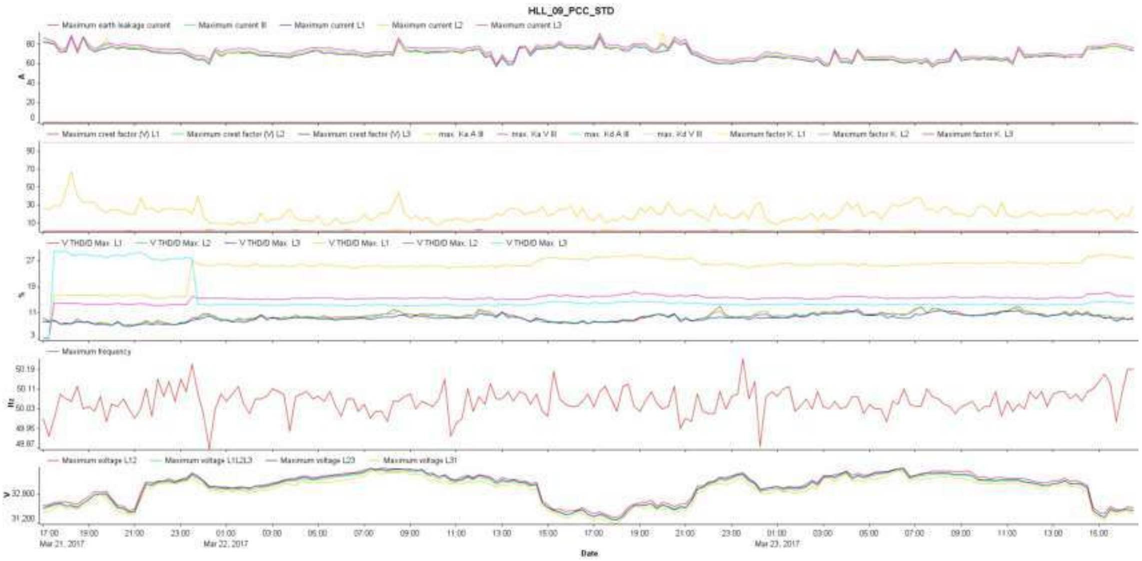


Figure 12: Maximum Values

The above trend shows there are no much fluctuations in voltage and frequency from the service incomer of HLL-09.

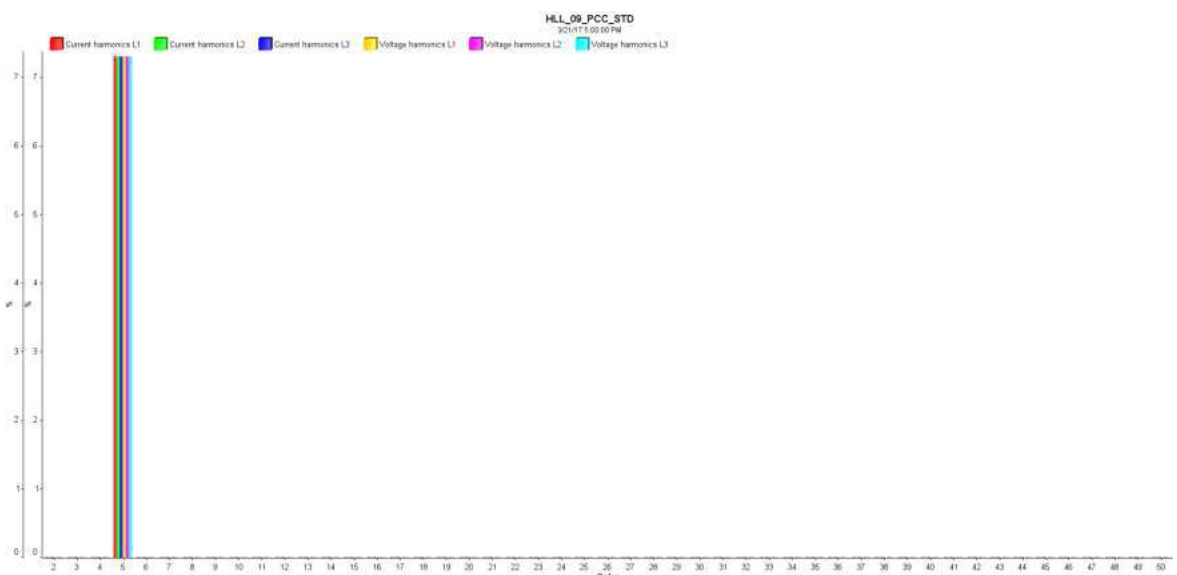


Figure 13: Trend of Harmonics

The above trend shows both the current and voltage harmonics are well within the limits i.e., 7% for current and 2.3% for voltage. For current and voltage harmonic limits the IEEE standards were annexed for ready reckoner.

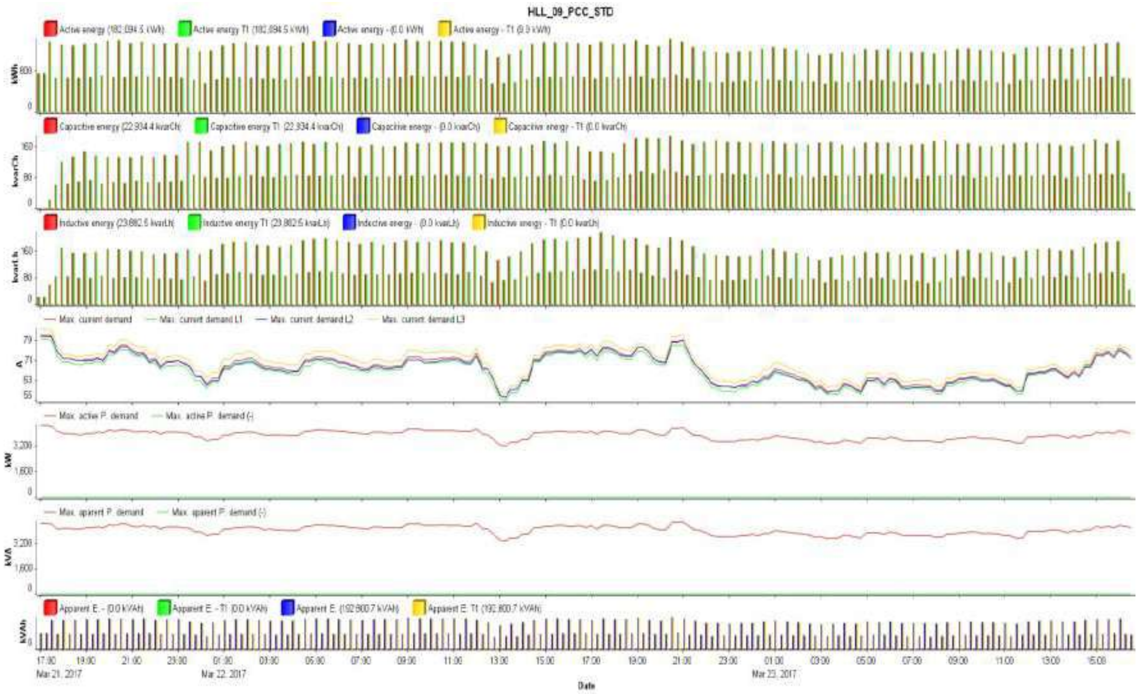


Figure 14: Maximum Energy and Demand

The above graph represents one day trend of kW, kVA, kVAh of HLL-09 service incomer.

2.7 Water Generation and Consumption Details of HLL-03, HLL-09 & HDL-09

Water for the process requirements, Captive Power Plant (CPP) and also for domestic use were met through desalination plant. Hetero labs limited has installed state of art Desalination units of capacities two plants of 2MLD capacity and two plants of 1MLD capacity for meeting the complete water requirements of the plant. The following table gives the details of desalination units installed.

Plant	Capacity	Make
1	1 MLD	ROCEM SEP SYSTEM
2	1 MLD	GE
3	2 MLD	PENTAIR
4	2 MLD	PENTAIR

Table 7: Capacities of Desalination Plant

The sea water is source of water which is having around 36,000 to 40,000 ppm and the suction line is 1.1 km into the sea. Out the installed 6 MLD capacity, 4 MLD is operated during normal conditions for meeting the daily water requirement of the Plant. The inlet water to the plant is drawn from sea using HDPE line with a low speed pump from a distance of 1.1 km in the sea. The pipelines are laid beneath the sea level.

The water is collected in a pre-treatment tank and the desalination plant has the following process. The block diagram of the desalination process is given below:

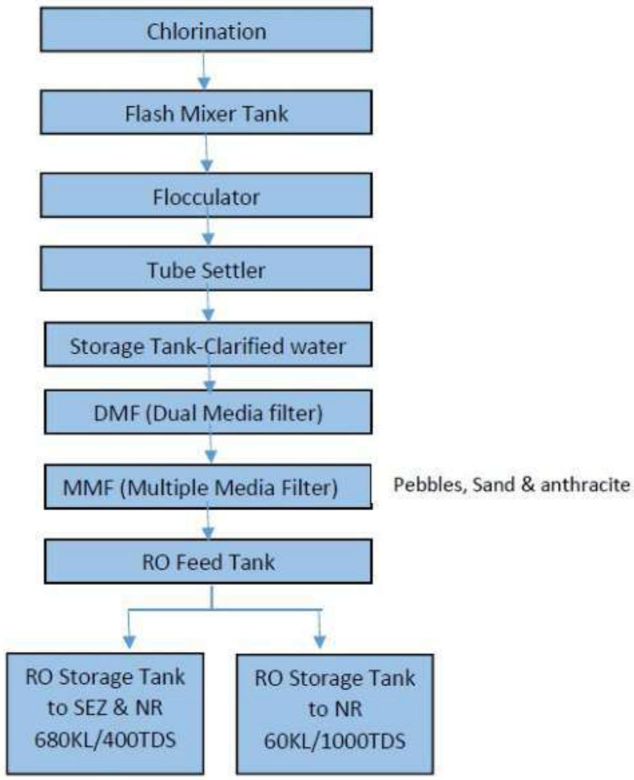


Figure 15: Process of Desalination

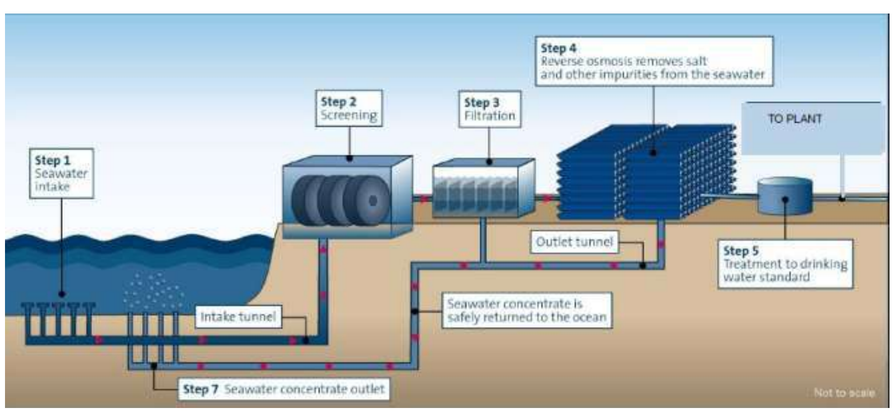


Figure 16: schematic representation of the desalination process

The schematic representation of the desalination process is as given below:

During the field studies data has been collected for analysing water generation and water consumption for HLL-03, HLL-09 and HDL-09.The Table given below shows water consumption and generation details from April 16 to Mar 17.

S. No	Month	Qty of Generation	Qty of Consumption(KL)			
			HLL-III	HLL-IX	HDL-IX	Total
1	Apr-16	93179	20542	28844	3479	52865
2	May-16	99708	23032	29072	3626	55730
3	Jun-16	92263	21936	25419	3789	51144
4	Jul-16	94638	21232	26184	3695	51111
5	Aug-16	99835	21535	25234	3624	50393
6	Sep-16	98854	18807	25243	3661	47711
7	Oct-16	107148	22413	22113	3662	48188
8	Nov-16	103819	25174	35667	6154	66995
9	Dec-16	106940	25584	22162	6097	53843
10	Jan-17	90865	22581	24020	6300	52901
11	Feb-17	82851	20821	16118	3055	39994
12	Mar-17	103727	24050	23983	3162	51195

Table 8: Water Generation and Consumption of HLL-03, HLL-09 & HDL-09

The below graph represents the trend of water consumption of the total plant and also individual units such as HLL-03, HLL-09 & HDL-09.The average generation from desalination plant accounts to 97818 KL and the average consumption of the entire plant accounts to 51839KL.The average consumption of HLL-03 is 22308KL whereas for HLL-09 it is 25338KL and for HDL-09 the average consumption is 4192KL.

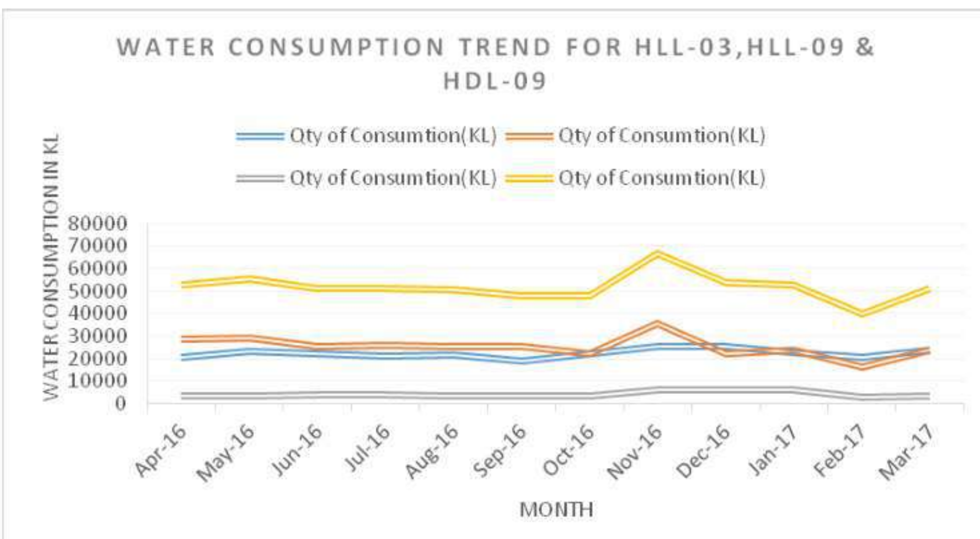
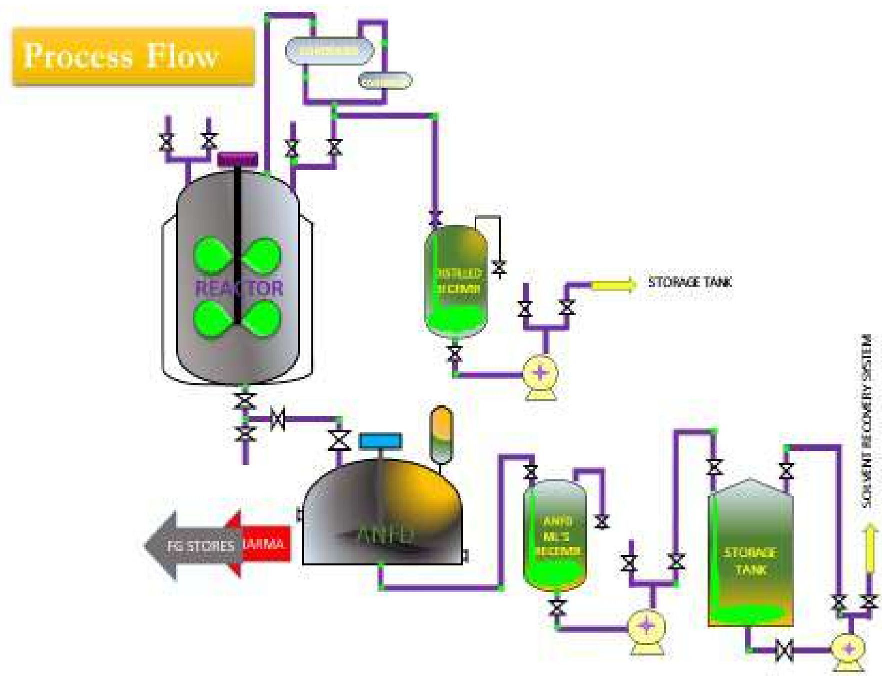


Figure 17: Water Consumption Trend for HLL-03, HLL-09 & HDL-09

The detailed pump efficiencies of desalination plant was discussed in the chapter process equipment's.

2.8 General Process Description:

In any production block there will be variety of reactors like SSR, GLR where the major reaction happens. Depending on the product the no of hours of the operation of the reactor varies and each batch may even go upto 10 days. As per the production requirement RT water +5,-5,-15,-20 & -40°C.Brine is passes through the rector jacket. The other major activity in production block is recovery of solvent from primary and secondary condensers. The solvent cost is one of the major cost involved in production. The mixed solvent is sent to SRS for solvent recovery. Any further left out mixed solvent is sell outside at the rate of Rs 9 – RS12/kg. A detailed schematic representation of the production is shown below:



The performance assessment of the following individual units and each service block in the units were evaluated and are presented in chapters given below.

- Hetero Labs Limited -03(HLL-03)
- Hetero Labs Limited -09(HLL-09)
- Hetero Drugs Limited-09(HDL-09)
- Captive Power Plant(CPP)
- Honour Labs
- Effluent Treatment Plant(ETP)
- Solvent Recovery System-1 & 2(SRS-1 & 2)
- Steam Distribution System
- Lighting System
- Desalination Plant

3.0 HLL-03

HLL-03 is one of the production blocks in Hetero Labs Limited Nakapally. The major utilities in the HLL-03 block are as given below.

HETERO LABS LIMITED		
HLL-III MAJOR EQUIPMENT LIST		
S NO	**Power House -I (4500 MD) VSP--689**	CAPACITY
1	DG Set-01	1165KVA
2	DG Set-02	2030KVA
3	Transformer -01	2MVA
4	Transformer -02	3MVA
	Power House-II (5000 MD) VSP--604	
1	DG Set -01	1165KVA
2	DG Set -02	2030KVA
3	DG Set -03	320KVA
4	Transformer -01	2MVA
5	Transformer -02	3MVA
	Utilities-I	
1	(+5°C Chilling Plant 173 TR)	160 KW
2	(-5°C Chilling Plant 120 TR)	160 KW
3	(-5°C Chilling Plant 120 TR)	160 KW
4	(-15°C Chilling Plant 158 TR)	132X2 KW
5	(-40°C Chilling Plant 158 TR)	55 KW
6	(+5°C Chilling Plant 158 TR)	315 KW
7	(-15°C Chilling Plant 158 TR)	160X2 KW
8	(-20°C Chilling Plant 51TR)	110 KW
9	(Air Compressor 356CFM)	55 KW
10	Nitrogen Compressor 500MM3/HR	90X2 KW
	Utilities-II	
1	(+5°C Chilling Plant 173TR)	160 KW
2	(+5°C Chilling Plant 173TR)	160 KW
3	(-20°C Chilling Plant 120TR)	132X2 KW
4	(-20°C Chilling Plant 120TR)	132X2 KW
5	(-40°C Chilling Plant 50TR)	55 KW
6	(+5°C Chilling Plant 173TR)	160 KW
7	(+5°C Chilling Plant 173TR)	160 KW
8	(-20°C Chilling Plant 175TR)	160X2 KW
9	(-15°C Chilling Plant 186TR)	160X2 KW
10	(Nitrogen Plant 200MM3/HR)	75 KW
11	(Nitrogen Plant 300MM3/HR)	132 KW
12	(Air Compressor 222CFM)	37 KW
13	(Air Compressor 222CFM)	37 KW
	N/BLOCK	
1	(+5°C Chilling Plant 100TR)	75 KW
2	(-15°C Chilling Plant 158TR)	132X2 KW
3	(Air Compressor 56CFM)	11 KW

4	(Nitrogen Compressor 100CFM)	22 KW
5	DG Set-01	725KVA
6	Transformer -01	1MVA
	Utilities-IV	
1	(+5°C Chilling Plant 400TR)	180X2 KW
2	(+5°C Chilling Plant 173TR)	-
3	(-5°C Chilling Plant 450TR)	400X2 KW
4	(-5°C Chilling Plant 120TR)	-
5	(-15°C Chilling Plant 158 TR)	-
6	(-15°C Chilling Plant 186 TR)	-
7	Transformer-01	1.6MVA
8	Transformer-02	2.5MVA

Table 9: HLL-III MAJOR EQUIPMENT LIST

HLL-03 is having 3 service blocks catering to meet the production requirements A,B,C,D,G,H,Q,M,J,K,E,L,I,N,P production blocks. In each service blocks there will be chillers ranging from -40^{0}C to +5 ^{0}C depending on the production requirements. The service blocks also consist of Air Compressors for instrumentation usage and for breathing air, Nitrogen plant to meet the production demand.

The major service blocks that were in operation during field studies are as given below

S.No	**Service Blocks**
1	Service block-SB01
2	Service block-SB02
3	Service block-SB04

Table 10: Service Blocks of HLL-03

Each of the above service blocks meets the requirements of the following production blocks.

S.No	Service Blocks	Production blocks
1	Service block-SB01	A,B,C,D,G,H
2	Service block-SB02	Q,M,J,K
3	Service block-SB04	E,L,K,I,N,P

Table 11: Service blocks w r t production blocks

3.1 Service Block -001

Service Block –SB001 has the following utilities to meet the production requirements of A, B, C, D, G, H.

3.1.1 Service Block-SB01:

S.No	Name of the utility	Capacity	No's
1	Chiller(+5^{0}C)	173TR	1
2	Chiller(+5^{0}C)	400TR	1
3	Chiller(-5^{0}C)	120TR	2
4	Chiller(-15^{0}C)-Skid System	158TR	1
5	Chiller(-15^{0}C)-Skid System	186TR	1
6	Air Compressor	360CFM	1
7	Nitrogen Compressor	500Nm3/hr	1

3.1.2 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference US-1/RFS 001/+5^{o}C/173TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**173**
Chilled Water Flow rate	m3/hr	105
Diff. Temperature	°C	5
Operating TR		**173.6**
Loading	%	
Power Consumption	kW	160.0
Specific. Power consumption	kW/TR	0.92
Coefficient of Performance (COP)	-	**3.8**

Table 12: Chiller Reference US-1/RFS 001/+5^{o}C/173TR

Chiller Reference US-1/RFS 006/+5 ^{o}C/400TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**400**
Chilled Water Flowrate	m3/hr	242
Diff. Temperature	°C	5
Operating TR		**400.1**
Loading	%	
Power Consumption	kW	350.0
Specific. Power consumption	kW/TR	0.87
Coefficient of Performance (COP)	-	**4.0**

Table 13: Chiller Reference US-1/RFS 006/+5 ^{o}C/400TR

Chiller Reference US-1/RFS 002/-5 ºC /120TR

Description	UNITS	DESIGN DETAILS
Date		
Capacity	**TR**	**120**
Chilled Water Flowrate	m3/hr	76
Diff. Temperature	°C	5
Operating TR		**120**
Loading	%	
Power Consumption	kW	160.0
Specific. Power consumption	kW/TR	1.33
Coefficient of Performance (COP)	-	**2.6**

Table 14: Design Details of Chillier Reference US-1/RFS 002/-5 oC /120TR

Chiller Reference US-1/RFS 004/-15 ºC /186TR

Description	UNITS	DESIGN DETAILS
Two Skid System		
Capacity-Skid system	**TR**	**186**
Chilled Water Flow rate	m3/hr	127
Diff. Temperature	°C	5
Operating TR		**186.0**
Loading	%	
Power Consumption	kW	320.0
Specific. Power consumption	kW/TR	1.72
Coefficient of Performance (COP)	-	**2.0**

Table 15: Design Details of Chiller Reference US-1/RFS 004/-15 ºC /186TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB001 of HLL-03 was given below:

3.1.3 Design Details of Pumps:

Chiller Reference US-1/RFS 001/+5ºC/173TR

Primary Pump Reference (+5 ºC)/ US-1/RFS 001/+5ºC/173TR

Description	UNITS	RATED
Flow	**m^3/hr**	90
Total Head	**m**	30
Hydraulic power	**kW**	7.35
Electrical Input power	**kW**	12.22
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	11.00
Pump Efficiency	**%**	**66.82**

Table 16: Design details of Primary Pump Reference (+5 oC)/ US-1/RFS 001/+5oC/173TR

Secondary Pump Reference (+5 ºC)/ US-1/RFS 001/+5ºC/173TR

Description	UNITS	RATED
Flow	m^3/hr	64
Total Head	m	52
Hydraulic power	kW	9.06
Electrical Input power	kW	12.42
Motor Efficiency	%	90.00
Pump Input power	kW	11.18
Pump Efficiency	%	**81.07**

Table 17: Design details of Secondary Pump Reference (+5 ºC)/ US-1/RFS 001/+5ºC/173TR

Chiller ReferenceUS-1/RFS 006/+5ºC/400TR
Primary Pumps Reference (+5 ºC)/ US-1/RFS 006/+5ºC/400TR

Description	UNITS	RATED
Flow	m^3/hr	150
Total Head	m	30
Hydraulic power	kW	12.25
Electrical Input power	kW	20.56
Motor Efficiency	%	90.00
Pump Input power	kW	18.50
Pump Efficiency	%	**66.22**

Table 18: Design details of Primary Pumps Reference (+5 ºC)/ US-1/RFS 006/+5ºC/400TR

Chiller Reference US-1/RFS 002/-5ºC/120TR
Primary Pumps Reference (-5 ºC)/ US-1/RFS 002/-5ºC/120TR

Description	UNITS	RATED
Flow	m^3/hr	64
Total Head	m	25
Hydraulic power	kW	4.31
Electrical Input power	kW	8.33
Motor Efficiency	%	90.00
Pump Input power	kW	7.50
Pump Efficiency	%	**58.07**

Table 19: Design details of Primary Pumps Reference (-5 ºC)/ US-1/RFS 002/-5ºC/120TR

Secondary Pumps Reference (-5 ºC)/ US-1/RFS 002/-5ºC/120TR

Description	UNITS	RATED
Flow	**m^3/hr**	64
Total Head	**m**	25
Hydraulic power	**kW**	4.31
Electrical Input power	**kW**	8.33
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	7.50
Pump Efficiency	**%**	58.07

Table 20: Design details Secondary Pumps Reference (-5 ºC)/ US-1/RFS 002/-5ºC/120TR

Primary Pumps Reference (-15ºC)/ US-1/RFS 002/-5ºC/120TR

Description	UNITS	RATED
Flow	**m^3/hr**	140
Suction Head	**m**	-
Discharge Head	**m**	-
Total Head	**m**	30
Hydraulic power	**kW**	11.09
Electrical Input power	**kW**	16.58
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	14.92
Pump Efficiency	**%**	**76.63**

Table 21: Design details of Primary Pumps Reference (-15ºC)/ US-1/RFS 002/-5ºC/120TR

3.1.4 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -40ºC to +5 ºC. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB001 is given below.

Chiller Reference US-1/RFS 001/+5ºC/173TR

Chiller Reference US-1/RFS 001/+5ºC/173TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**173**	**148.9**
Chilled Water Flowrate	m3/hr	105	137.83
Inlet Water Temperature	°C	10	13.53
Outlet Water Temperature	°C	5	10.3
Diff. Temp	°C	5	3.3
Operating TR		**173.6**	**148.9**
Loading	%		99.0
Power Consumption	kW	160.0	105.0
Specific. Power consumption	kW/TR	0.92	0.71
Coefficient of Performance (COP)	**-**	**3.8**	**5.0**
Gas Suction Pressure	kg/cm^2	-	0.5
Gas Suction Temperature	°C	-	5.2
Discharge Pressure	kg/cm^2	-	15
Discharge Temperature	°C	-	88.8

Table 22: Performance of Chiller Reference US-1/RFS 001/+5ºC/173TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 149TR as against to the design capacity of 173TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 137m3/hr when compared to design flow of 105m3/hr.
- The specific energy consumption of the above chiller is 0.71kW/TR as against to the design specific energy consumption of 0.92 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 5 as against to the design Coefficient of performance (COP) of 3.8.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 89ºC and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower. The detailed energy conservation option has been discussed in energy conservation measures.

- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-1/RFS 002/-5ºC/120TR

Chiller Reference US-1/RFS 002/-5ºC/120TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**120**	**62.8**
Chilled Water Flowrate	m3/hr	76	108.80
Inlet Water Temperature	°C	0	3.80
Outlet Water Temperature	°C	-5	2.0
Diff. Temp	°C	5	1.8
Specific Heat (Cp)	Kcal/kg °C	0.979	0.979
Specific Gravity		0.99	0.99
Operating TR		**120**	**62.8**
Loading	%		76
Power Consumption	kW	160.0	121.50
Specific. Power consumption	kW/TR	1.33	1.94
Coefficient of Performance (COP)	-	**2.6**	**1.8**
Gas Suction Pressure	kg/cm^2	-	-1
Gas Suction Temperature	°C	-	0.6
Discharge Pressure	kg/cm^2	-	15
Discharge Temperature	°C	-	92.8

Table 23: Performance of Chiller Reference US-1/RFS 002/-5ºC/120TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 62.8TR as against to the design capacity of 120TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 109m3/hr when compared to design flow of 76m3/hr.
- The specific energy consumption of the above chiller is 1.94 kW/TR as against to the design specific energy consumption of 1.33 kW/TR. The specific energy consumption is higher of the above chiller when compared to the design values.

- The coefficient of performance (COP) of above chiller is 1.8 as against to the design Coefficient of performance (COP) of 2.6.
- The loading of the above compressor is only 76% during the field performance assessment test, as the load is a pure function of production requirement.
- The chiller is equipped with evaporative cooling towers.
- The discharge gas temperature is around 93°C and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-1/RFS 004/-15°C/186TR

Chiller Reference US-1/RFS 004/-15°C/186TR				
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**	**ACTUAL**
Date		**Two Skid System**	**One skid operation**	**Two skid operation**
Capacity-Skid system	**TR**	**186**	**56.8**	**131.2**
Chilled Water Flowrate	m3/hr	127	145.00	145.00
Inlet Water Temperature	°C	-10	0.50	-2.40
Outlet Water Temperature	°C	-15	-0.8	-5.4
Diff. Temp	°C	5	1.3	3.0
Specific Heat (Cp)	Kcal/kg °C	0.94	0.94	0.94
Specific Gravity		0.97	0.97	0.97
Operating TR		**186.0**	**56.8**	**131.2**
Loading	%		93	93
Power Consumption	kW	320.0	149.00	298.00
Specific. Power consumption	kW/TR	1.72	2.62	2.27
coefficient of Performance (COP)	-	**2.0**	**1.3**	**1.5**
Gas Suction Pressure	kg/cm^2	-	1	1
Gas Suction Temperature	°C	-	-2.3	-2.3
Discharge Pressure	kg/cm^2	-	14	14
Discharge Temperature	°C	-	88	88

Table 24: Performance of Chiller Reference US-1/RFS 004/-15°C/186TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 56.8TR in single skid operation and 131.2TR in two skid operation as against to the design capacity of 186TR.
- The delta T in single skid operation is less when compared to design temperature difference (delta T) whereas the flow rate in operating conditions is145m3/hr which is on higher side when compared to design flow rate of 127m3/hr.
- The delta T in two skid operation is 3^0C when compared to design temperature difference (delta T) of 4.5^0C whereas the flow rate in operating conditions is145m3/hr which is on higher side when compared to design flow rate of 127m3/hr.
- The specific energy consumption in single skid operation is 2.62 kW/TR and in two skid operation is 2.27 kW/TR as against to the design specific energy consumption of 1.72 kW/TR.
- The coefficient of performance (COP) of above chiller in single skid operation is 1.3 and in two skid operation is 1.5 as against to the design Coefficient of performance (COP) of 2.
- The chiller is equipped with evaporative cooling towers.
- The discharge gas temperature is around 88°C and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower.
- It is observed during the field studies even when chiller is in off condition the primary pump is running which results in power loss and also heat addition in cold well. This will attract not only power loss but also increase in temperature of cold well. The detailed energy conservation option was discussed was discussed in energy conservation measures.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-1/RFS 006/+5ºC/400TR

Chiller Reference US-1/RFS 006/+5ºC/400TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**400**	**140.6**
Chilled Water Flowrate	m3/hr	242	245.29
Inlet Water Temperature	°C	10	11.53
Outlet Water Temperature	°C	5	9.8
Diff. Temp	°C	5	1.7
Operating TR		**400**	**140.6**
Loading	%		30.2
Power Consumption	kW	350.0	105.60
Specific. Power consumption	kW/TR	0.87	0.75
Coefficient of Performance (COP)	-	**4.0**	**4.7**
Gas Suction Pressure	kg/cm^2	-	-1
Gas Suction Temperature	°C	-	0.7
Discharge Pressure	kg/cm^2	-	15
Discharge Temperature	°C	-	93.8

Table 25: Performance of Chiller Reference US-1/RFS 006/+5ºC/400TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 141TR as against to the design capacity of 400TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 245m3/hr when compared to design flow of 242m3/hr.
- The specific energy consumption of the above chiller is 0.75kW/TR as against to the design specific energy consumption of 0.87 kW/TR.The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 4.7 as against to the design Coefficient of performance (COP) of 4.
- The loading of the above compressor is only 30% during the field performance assessment test, as the load is a pure function of production requirement.
- The chiller is equipped with evaporative cooling towers.
- The discharge gas temperature is around 94ºC and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower.

- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

3.1.5 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference US-1/RFS 001/+5ºC/173TR

The details of the primary and secondary pumps for the above chiller is as given below

Primary Pumps			Secondary Pumps		
Installed	Running	Standby	Installed	Running	Standby
2	1	1	4	2	2

Table 26: Primary Pumps & Secondary Pumps Installed in Chiller Reference US-1/RFS 001/+5oC/173TR

The performance of primary pumps and combined efficiency of 2 secondary pumps was evaluated and presented below

Pumps		PRIMARY +5 173 TR		SEC +5 173 TR	
Description	UNITS	RATED	ACTUAL	RATED	ACTUAL
Flow	m^3/hr	90	137.00	64	149.88
Suction Head	m	-	1.80	-	1.50
Discharge Head	m	-	16.00	-	42.00
Total Head	m	30	14.20	52	40.50
Hydraulic power	kW	7.35	5.30	9.06	16.52
Electrical Input power	kW	12.22	10.80	12.42	23.50
Motor Efficiency	%	90.00	90.00	90.00	90.00
Pump Input power	kW	11.00	9.72	11.18	21.15
Pump Efficiency	%	**66.82**	**54.48**	**81.07**	**78.13**

Table 27: Performance of Primary Pumps and Secondary pumps of US-1/RFS 001/+5oC/173TR

Observations and findings:

- The operating flow of primary pumps is 137m3/hr when compared to design flow of 90m3/hr.

- The hydraulic power of the primary pump is 5.3kW when compared to design hydraulic power of 7.35kW.
- The operating efficiency of the primary pump is 55% when compared to design efficiency of 67%.The primary pump operating performance is not satisfactory when compared to design whereas an energy efficient of pump with an efficiency of 75% is suggested to replace the existing pump.
- The operating flow of two secondary pumps is 150m3/hr when compared to design flow of 128m3/hr.
- The hydraulic power of the secondary pumps is 16.52 kW when compared to design hydraulic power of 18 kW.
- The operating efficiency of the secondary pump is 78% when compared to design efficiency of 81%.The secondary pump operating performance is good.
- It is observed that the design efficiency of primary pump is only 67% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference US-1/RFS 006/+5oC/400TR

The details of the primary pumps for the above chiller is given below

Primary Pumps		
Installed	Running	Standby
2	2	0

Table 28: Primary Pumps installed in Chiller Reference US-1/RFS 006/+5oC/400TR

The performance of combined efficiency of two primary pumps was evaluated and presented below

Pumps		PRIMARY +5 400 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	150	245.29
Suction Head	**m**	-	1.80
Discharge Head	**m**	-	13.00
Total Head	**m**	30	11.20
Hydraulic power	**kW**	12.25	7.48
Electrical Input power	**kW**	20.56	19.10
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	18.50	17.19
Pump Efficiency	**%**	**66.22**	**43.51**

Table 29: Performance of Primary Pumps and Secondary pumps of US-1/RFS 001/+5oC/173TR

Observations and findings:

- The operating flow of combined primary pumps is 245m3/hr when compared to design flow of 300 m3/hr.
- The hydraulic power of the primary pump is 7.48kW when compared to design hydraulic power of 24.5kW.
- The operating efficiency of the primary pump is 43.5% when compared to design efficiency of 66%.The primary pump can be replaced with high energy efficient pump(75%) and the details were discussed in the encon chapter.
- It is observed that the design efficiency of primary pump is only 66% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference US-1/RFS 002/-5oC/120TR

The details of the primary pumps for the above chiller is given below

Primary Pumps			Secondary Pumps		
Installed	Running	Standby	Installed	Running	Standby
2	1	1	4	2	2

Table 30: Details of Primary Pumps & Secondary Pumps of US-1/RFS 002/-5oC/120TR

The performance of primary pumps and combined efficiency of 2 secondary pumps was evaluated and presented below

Pumps		PRIMARY -5 120 TR		SECONDARY -5 120 TR	
Description	UNITS	RATED	ACTUAL	RATED	ACTUAL
Flow	**m^3/hr**	64	108.00	64	108.00
Suction Head	**m**	-	2.20	-	2.20
Discharge Head	**m**	-	14.00	-	14.00
Total Head	**m**	25	11.80	25	11.80
Hydraulic power	**kW**	4.31	3.43	4.31	3.43
Electrical Input power	**kW**	8.33	11.80	8.33	11.80
Motor Efficiency	**%**	90.00	90.00	90.00	90.00
Pump Input power	**kW**	7.50	10.62	7.50	10.62
Pump Efficiency	**%**	**57.49**	**32.34**	**57.49**	**32.34**

Table 31: Performance of Primary Pumps & Secondary Pumps of US-1/RFS 002/-5oC/120TR

Observations and findings:

- The operating flow of primary pump is 108m3/hr when compared to design flow of 64m3/hr.
- The hydraulic power of the primary pump is 3.43kW when compared to design hydraulic power of 4.31kW.
- The operating efficiency of the primary pump is 32.34% when compared to design efficiency of 57.49%.The primary pump operating performance is not satisfactory. It is suggested to replace the above pump with high energy efficient pump(75%) the details are discussed in the encon chapter.
- The operating flow of two secondary pumps is 130m3/hr when compared to design flow of 128m3/hr.
- The hydraulic power of the secondary pumps is 3.43 kW when compared to design hydraulic power of 4.31 kW.
- The operating efficiency of the secondary pump is 32% when compared to design efficiency of 58%.The secondary pump operating performance is not satisfactory. It is suggested to replace the above pump with high energy efficient pump(75%) the details are discussed in the encon chapter.

Chiller Reference US-1/RFS 006/-15ºC/186TR

The details of the primary pumps for the above chiller is given below

Primary Pumps		
Installed	Running	Standby
2	1	1

Table 32: Details of Primary Pumps of US-1/RFS 006/-15oC/186TR

- The performance of primary pump was evaluated and presented below

Pumps		PRIMARY -15 186 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	140	145.00
Suction Head	**m**	-	1.70
Discharge Head	**m**	-	14.50
Total Head	**m**	30	12.80
Hydraulic power	**kW**	11.09	4.90
Electrical Input power	**kW**	16.58	7.75
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	14.92	6.98
Pump Efficiency	**%**	**74.33**	**70.26**

Table 33: Performance of Primary pumps of US-1/RFS 006/-15oC/186TR

Observations and findings:

- The operating flow of primary pump is 145m3/hr when compared to design flow of 140 m3/hr.
- The hydraulic power of the primary pump is 4.90 kW when compared to design hydraulic power of 11.09 kW.
- The operating efficiency of the primary pump is 70.26% when compared to design efficiency of 74.33%.The primary pump operating performance is good.
- As far as secondary pumps is concerned, where ever flows were coming the efficiencies were calculated and presented in the report as primary pump flow is mandatory to evaluate performance of chillers.

3.1.6 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used. The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporator Reference US-1/RFS 001/+5^{o}C/173TR

Parameter Reference	US-1/RFS 001/+5^{o}C/173TR
CT Inlet Temp. ^{o}C	33.9
CT Outlet Temp. ^{o}C	30.9
Ambient Temp. ^{o}C	35.9
Wet BulbTemp. ^{o}C	29
Range ^{o}C	3
Approach ^{o}C	1.9
Effectiveness = Range/(Range + Approach)	61.22
Air inlet condition	
DBT, ^{o}C	35.9
RH, %	65
Enthalpy, kCal/kg	23.7
Air flow rate, m^3/hr	79372
Air flow rate, kg/hr	84177.3
Air outlet condition	
DBT, ^{o}C	37
RH, %	70
Enthalpy, kCal/kg	28.56
Enthalpy difference, kCal/kg	4.9
TR	147.97

Table 34: Performance of Evaporator Reference US-1/RFS 001/+5oC/173TR

Observations and findings:

- The operating range of the above evaporative condenser is 3^{0}C and approach is 1.9^{0}C.
- The operating effectiveness is to the tune of 61%.
- The TR rejected to atmosphere of the above evaporative condenser is 148TR.
- The performance of the above evaporative condenser is satisfactory.
- Wherever the flow and temperatures measurement approach is there performance of evaporative condensers were evaluated and presented in the report.

3.1.7 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-1/RFS 001/+5°C/173TR.

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of 9°C to 10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently +5°C chiller of capacity 173TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%. By increasing the set point there will be envisaged annual savings of 0.567 Lakh kWh with an annual monetary savings of Rs.3.4 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-1/RFS 001/+5^{o}C/173TR.		
Description	**Units**	**Value**
Chiller Ref		**US-1/RFS 001/+5^{o}C/173TR**
Normal operating inlet temperature of Water	°C	10.00
Normal operating outlet temperatures of Water	°C	5.0
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	105
Percentage reduction in power consumption of compressor	kW	12.6
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.567
Envisaged annual Monetary savings	Lakhs Rs	3.402
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 35: Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-1/RFS 001/+5^{o}C/173TR.

Encon 2: Optimization of chiller Evaporator temperature by adjusting the existing set point of 400TR chiller with reference US-1/RFS 006/+5°C/400TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of 9°C to 10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently +5°C chiller of capacity 400TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.567 Lakh kWh with an annual monetary savings of Rs.3.4 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 400TR chiller with reference US-1/RFS 006/+5°C/400TR		
Description	**Units**	**Value**
Chiller Ref		**US-1/RFS 006/+5°C/400TR**
Normal operating inlet temperatures of Water	°C	10.00
Normal operating out temperatures of Water	°C	5.0
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	105
Percentage reduction in power consumption of compressor	kW	12.6
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.567
Envisaged annual Monetary savings	Lakhs Rs	3.402
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 36: Optimization of chiller Evaporator temperature by adjusting the existing set point of 400TR chiller with reference US-1/RFS 006/+5oC/400TR

Encon 3: Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-1/RFS 002/-5oC/120TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -5°C chiller is in the range of 1°C to 3°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently -5°C chiller of capacity 120TR is running with a set point of -5°C to -2°C.The compressor will be in OFF condition once reaches -5°C and compressor will be ON once the temperature reaches -2°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 10°C i.e., keeping set point at -2°C to 5°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.65 Lakh kWh with an annual monetary savings of Rs.3.9 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-1/RFS 002/-5°C/120TR		
Description	**Units**	**Value**
Chiller Ref		**US-1/RFS 002/-5°C/120TR**
Normal operating inlet temperature of Water	°C	3.80
Normal operating out temperature of Water	°C	2.0
Present set point	°C	-5.0
Suggested to increase the set point	°C	5
Increase in set point	°C	3 to 10
Present power consumption	kW	121
Percentage reduction in power consumption of compressor	kW	14.52
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.65
Envisaged annual Monetary savings	Lakhs Rs	3.92
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 37: Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-1/RFS 002/-5°C/120TR

Encon 4: Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-1/RFS 004/-15oC/186TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of -4°C to -5°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently -15°C chiller of capacity 186TR is running with a set point of -15°C to -10°C.The compressor will be in OFF condition once reaches -15°C and compressor will be ON once the temperature reaches -10°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 10°C i.e., keeping set point at -12°C to -2°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.6 Lakh kWh with an annual monetary savings of Rs.9.66 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-1/RFS 004/-15°C/186TR		
Description	**Units**	**Value**
Chiller Ref		**US-1/RFS 004/-15°C/186TR**
Normal operating inlet temperature of Water	°C	-2.4
Normal operating out temperature of Water	°C	-5.4
Present set point	°C	-15.0
Suggested to increase the set point	°C	-2
Increase in set point	°C	3 to13
Present power consumption	kW	298
Percentage reduction in power consumption of compressor	kW	35.76
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.6092
Envisaged annual Monetary savings	Lakhs Rs	9.66
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 38: Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-1/RFS 004/-15oC/186TR

Encon 5: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C.By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-03/service block-01		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 39: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 6: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 001/+5°C/173TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 88.8°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-1/RFS 001/+5°C/173TR before it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 40 Kgs of coal per hour and equivalent annual monetary savings of Rs.5.4 Lakhs with a payback period of 20 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-1/RFS 001/+5°C/173TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**173.0**
Inlet Water Temperature	°C	13.53
Outlet Water Temperature	°C	10.3
Diff. Temp	°C	3.3
Operating TR		**148.9**
Gas Suction Temperature	°C	5.2
Discharge Temperature	°C	88.8
Amount of heat available before evaporative condenser	kcals/hr	450256
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	90051
Equivalent coal savings	kg/hr	40.0
Expected annual monetary savings	Lakhs Rs.	5.4
Investment	Lakhs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	20

Table 40: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 001/+5°C/173TR

Encon 7: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 006/+5oC/400TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 93.5°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-1/RFS 006/+5oC/400TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 37.8 Kgs of coal per hour and equivalent annual monetary savings of Rs.5.1 Lakhs with a payback period of 21.2 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-1/RFS 006/+5oC/400TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**400.0**
Inlet Water Temperature	°C	11.53
Outlet Water Temperature	°C	9.8
Diff. Temp	°C	1.7
Operating TR		**140.6**
Gas Suction Temperature	°C	0.7
Discharge Temperature	°C	93.5
Amount of heat available before evaporative condenser	kcals/hr	425174
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	85035
Equivalent coal savings	kg/hr	37.8
Expected annual monetary savings	Lakhs Rs.	5.1
Investment	Lakhs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	21.2

Table 41: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 006/+5°C/400TR

Encon 8: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 002/-5°C/120TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 92.8°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-1/RFS 002/-5oC/120TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 17 Kgs of coal per hour and equivalent annual monetary savings of Rs.2.3 Lakhs with a payback period of 47.4 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-1/RFS 002/-5°C/120TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**120.0**
Inlet Water Temperature	°C	3.80
Outlet Water Temperature	°C	2.0
Diff. Temp	°C	1.8
Operating TR		**62.8**
Gas Suction Temperature	°C	0.6
Discharge Temperature	°C	92.8
Amount of heat available before evaporative condenser	kcals/hr	189907
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	37981
Equivalent coal savings	kg/hr	16.9
Expected annual monetary savings	Lakhs Rs.	2.3
Investment	Lakhs Rs	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	47.4

Table 42: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 002/-5oC/120TR

Encon 9: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-1/RFS 004/-15oC/186TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 88°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-1/RFS 004/-15°C/186TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 35 Kgs of coal per hour and equivalent annual monetary savings of Rs.4.8 Lakhs with a payback period of 22.7 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-1/RFS 004/-15°C/186TR		
Description	**UNITS**	**ACTUAL**
Capacity	TR	186.0
Inlet Water Temperature	°C	-2.40
Outlet Water Temperature	°C	-5.4
Diff. Temp	°C	3.0
Operating TR		131.2
Gas Suction Temperature	°C	-2.3
Discharge Temperature	°C	88
Amount of heat available before evaporative condenser	kcals/hr	396749
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	79350
Equivalent coal savings	kg/hr	35.3
Expected annual monetary savings	Lakhs Rs.	4.8
Investment	Lakhs Rs	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	22.7

Table 43: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller eference US-1/RFS 004/-15°C/186TR

Encon 10: Energy savings by replacement of Primary Pump of (+5 °C) 173TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 173 TR chiller (+5 °C) is 54% as against to the design efficiency of 67% ,which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.24 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.1.45 Lakhs with a payback period of 6.6 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (+5 °C) 173TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**54.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	10.80
Proposed energy Consumption	kW	7.78
Expected Savings by Installation of New Pumps	kW	3.02
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Lakhs Kwh/annum	0.24
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	1.45
Investment	Lakhs Rs.	0.80
Simple payback period	Months	6.6

Table 44: Energy savings by replacement of Primary Pump of (+5 °C) 173TR with New Energy Efficient Pump

Encon 11: Energy savings by replacement of Primary Pump of (+5 °C) 400TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 400 TR chiller (+5 °C) is 43% as against to the design efficiency of 66% ,which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.34 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.2.05 Lakhs with a payback period of 8.2 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (+5 °C) 400TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	%	43.0
Proposed Efficiency of Pump	%	75.00
Average Operating Load of Primary Pump	kW	10.00
Proposed energy Consumption	kW	5.73
Expected Savings by Installation of New Pumps	kW	4.27
Operating Hours per Annum	Hrs	8000
Total Power Savings Per annum	Lakh Kwh/annum	0.34
Cost of Power	Rs. /kWh	6
Total Annual Savings	Lakhs Rs.	2.05
Investment	Lakhs Rs.	1.40
Simple payback period	Months	8.2

Table 45:Energy savings by replacement of Primary Pump of (+5 °C) 400TR with New Energy Efficient Pump

Encon 12: Energy savings by replacement of Primary Pump of (-5 °C) 120TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 120 TR chiller (-5 °C) is 32% as against to the design efficiency of 58%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.28 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.1.65 Lakhs with a payback period of 4.0 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-5 °C) 120TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**32.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	6.00
Proposed energy Consumption	kW	2.56
Expected Savings by Installation of New Pumps	kW	3.44
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum (in Lakhs)	0.28
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	1.65
Investment	Lakhs Rs.	0.55
Simple payback period	Months	4.0

Table 46: Energy savings by replacement of Primary Pump of (-5 °C) 120TR with New Energy Efficient Pump

Encon 13: Energy savings by replacement of Secondary Pump of (-5 °C) 120TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the secondary pump of 120 TR chiller (-5 °C) is 32% as against to the design efficiency of 58%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.28 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.1.65 Lakhs with a payback period of 4.0 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Secondary Pump of (-5 °C) 120TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**32.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	6.00
Proposed energy Consumption	kW	2.56
Expected Savings by Installation of New Pumps	kW	3.44
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.28
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	1.65
Investment	Lakhs Rs.	0.55
Simple payback period	Months	4.0

Table 47: Energy savings by replacement of Secondary Pump of (-5 °C) 120TR with New Energy Efficient Pump

3.2 Service Block-002

Service Block –SB002 has the following utilities to meet the production requirements of Q, M, J, and K

Service Block-SB02:

S.No	Name of the utility	Capacity	No's
1	Chiller(+5^{0}C)	173TR	4
2	Chiller(-20^{0}C)- Skid System	120TR	2
3	Chiller(-15^{0}C)- Skid System	186TR	1
4	Chiller(-40^{0}C)	50TR	1
5	Air Compressor	222CFM	1

Table 48: Major Equipment's in Service block -002

3.2.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference US-2/RFS 007/+5ºC/173TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**173**
Chilled Water Flowrate	m3/hr	105
Diff. Temp	°C	5
Operating TR		**173.6**
Loading	%	
Power Consumption	kW	160.0
Specific. Power consumption	kW/TR	0.92
Coefficient of Performance (COP)	-	**3.8**
Gas Suction Pressure	kg/cm^2	1.5
Gas Suction Temperature	°C	3.5
Discharge Pressure	kg/cm^2	16.3
Discharge Temperature	°C	78

Table 49: Design Details of US-2/RFS 007/+5oC/173TR

Chiller Reference US-2/RFS 002/+5ºC/173TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**173**
Chilled Water Flowrate	m3/hr	105
Diff. Temp	°C	5
Operating TR		**173.6**
Loading	%	
Power Consumption	kW	160.0
Specific. Power consumption	kW/TR	0.92
Coefficient of Performance (COP)	-	**3.8**
Gas Suction Pressure	kg/cm^2	1.5
Gas Suction Temperature	°C	3.5
Discharge Pressure	kg/cm^2	16.3
Discharge Temperature	°C	78

Table 50: Design Details of US-2/RFS 002/+5ºC/173TR

Chiller Reference US-2/RFS 003/-20ºC/120TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**120**
Chilled Water Flowrate	m3/hr	87.5
Diff. Temp	°C	4.2
Operating TR		**121.5**
Loading	%	
Power Consumption	kW	264.0
Specific. Power consumption	kW/TR	2.2
Coefficient of Performance (COP)	-	**1.6**
Gas Suction Pressure	kg/cm^2	1.54
Gas Suction Temperature	°C	-25
Discharge Pressure	kg/cm^2	16
Discharge Temperature	°C	74

Table 51: Design Details of US-2/RFS 003/-20oC/120TR

Chiller Reference US-2/RFS 009/-15ºC/186TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**186**
Chilled Water Flowrate	m3/hr	133
Diff. Temp	°C	4.25
Operating TR		**186.9**
Loading	%	
Power Consumption	kW	320.0
Specific. Power consumption	kW/TR	1.72
Coefficient of Performance (COP)	-	**2**

Table 52: Design Details of US-2/RFS 009/-15oC/186TR

Chiller Reference US-2/RFS 005/-40oC/50TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**50**
Chilled Water Flowrate	m3/hr	42
Diff. Temp	°C	3.6
Operating TR		**50.0**
Loading	%	
Power Consumption	kW	167.0
Specific. Power consumption	kW/TR	3.34
Coefficient of Performance (COP)	-	**1.1**
Gas Suction Pressure	kg/cm^2	1
Gas Suction Temperature	°C	-47
Discharge Pressure	kg/cm^2	1.54
Discharge Temperature	°C	46

Table 53: Design Details of US-2/RFS 005/-40oC/50TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB002 of HLL-03 was given below:

3.2.2 Design Details of Pumps:

Chiller Reference US-2/RFS 007/+5°C/173TR

Primary Pump Reference (+5 °C)/ US-2/RFS 007/+5°C/173TR

Description	UNITS	RATED
Flow	m^3/hr	90
Total Head	m	30
Hydraulic power	kW	7.35
Electrical Input power	kW	12.22
Motor Efficiency	%	90.00
Pump Input power	kW	11.00
Pump Efficiency	%	66.82

Table 54: Design Details of Primary Pump Reference (+5 oC)/ US-2/RFS 007/+5oC/173TR

Secondary Pump Reference (+5 °C) 173 TR

Description	UNITS	RATED
Flow	m^3/hr	64
Total Head	m	52
Hydraulic power	kW	9.06
Electrical Input power	kW	12.42
Motor Efficiency	%	90.00
Pump Input power	kW	11.18
Pump Efficiency	%	**81.07**

Table 55: Design Details of Secondary Pump Reference (+5 oC)/ US-2/RFS 007/+5oC/173TR

Chiller Reference US-2/RFS 003/-20°C/120TR

Primary Pump Reference (-20 °C) 120 TR

Description	UNITS	RATED
Flow	m^3/hr	90
Total Head	m	30
Hydraulic power	kW	7.06
Electrical Input power	kW	12.22
Motor Efficiency	%	90.00
Pump Input power	kW	11.00
Pump Efficiency	%	**66.82**

Table 56: Design Details of Primary Pump Reference (-20°C)/ US-2/RFS 003/-20oC/120TR

Chiller Reference US-2/RFS 009/-15°C/186TR

Primary Pump Reference (-15 °C) 186 TR

Description	UNITS	RATED
Flow	m^3/hr	130
Total Head	m	20
Hydraulic power	kW	6.87
Electrical Input power	kW	12.43
Motor Efficiency	%	90.00
Pump Input power	kW	11.19
Pump Efficiency	%	**63.25**

Table 57: Design Details of Primary Pump Reference (-15°C)/ US-2/RFS 009/-15oC/186TR

Chiller Reference US-2/RFS 005/-40°C/50TR
Primary Pump Reference (-40 °C) 50 TR

Description	UNITS	RATED
Flow	m^3/hr	45
Total Head	m	25
Hydraulic power	kW	2.79
Electrical Input power	kW	6.11
Motor Efficiency	%	90.00
Pump Input power	kW	5.50
Pump Efficiency	%	**55.68**

Table 58: Design Details of Primary Pump Reference (-40°C)/ US-2/RFS 005/-40oC/50TR

Chiller Reference US-2/RFS 002/+5°C/175TR

Primary Pump Reference (+5 °C) 175 TR

Description	UNITS	RATED
Flow	m^3/hr	90
Total Head	m	30
Hydraulic power	kW	7.35
Electrical Input power	kW	12.22
Motor Efficiency	%	90.00
Pump Input power	kW	11.00
Pump Efficiency	%	**66.82**

Table 59: Design Details of Primary Pump Reference US-2/RFS 002/+5oC/175TR

3.2.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -40°C to +5 °C.The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB002 is given below.

Chiller Reference US-2/RFS 007/+5°C/173TR

Chiller Reference US-2/RFS 007/+5°C/173TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**173**	**95.8**
Chilled Water Flowrate	m3/hr	105	117.00
Inlet Water Temperature	°C	10	9.65
Outlet Water Temperature	°C	5	7.2
Diff. Temp	°C	5	2.5
Operating TR		**173**	**95.8**
Loading	%		91.3
Power Consumption	kW	160.0	146.0
Specific. Power consumption	kW/TR	0.92	1.52
Coefficient of Performance (COP)	-	**3.8**	**2.3**
Gas Suction Pressure	kg/cm^2	1.5	1
Gas Suction Temperature	°C	3.5	5.9
Discharge Pressure	kg/cm^2	16.3	15
Discharge Temperature	°C	78	85.9

Table 60: Performance of US-2/RFS 007/+5°C/173TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 96TR as against to the design capacity of 173TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).

- The flow rate of the above chiller during performance assessment is 117m3/hr when compared to design flow of 105m3/hr.
- The specific energy consumption of the above chiller is 1.52kW/TR as against to the design specific energy consumption of 0.92 kW/TR. The operational efficiency of the above chiller is not satisfactory. And intervention is required during regular maintenance for the above chiller.
- The coefficient of performance (COP) of above chiller is 2.3 as against to the design Coefficient of performance (COP) of 3.8.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 86°C and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower. The detailed energy conservation option has been discussed in energy conservation measures.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-2/RFS 002/+5°C/173TR

Chiller Reference US-2/RFS 002/+5°C/173TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**173**	**74.8**
Chilled Water Flowrate	m3/hr	105	119.00
Inlet Water Temperature	°C	10	9.50
Outlet Water Temperature	°C	5	7.6
Diff. Temp	°C	5	1.9
Operating TR		**173**	**74.8**
Loading	%		78.1
Power Consumption	kW	160.0	125.0
Specific. Power consumption	kW/TR	0.92	1.67
Coefficient of Performance (COP)	-	**3.8**	**2.1**
Gas Suction Pressure	kg/cm^2	1.5	1
Gas Suction Temperature	°C	3.5	3.4
Discharge Pressure	kg/cm^2	16.3	15
Discharge Temperature	°C	78	86.7

Table 61: Performance of US-2/RFS 002/+5oC/173TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 75 TR as against to the design capacity of 173TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 119m3/hr when compared to design flow of 105m3/hr.
- The specific energy consumption of the above chiller is 1.67 kW/TR as against to the design specific energy consumption of 0.92 kW/TR. The operational efficiency of the above chiller is not satisfactory. And intervention is required during regular maintenance for the above chiller.
- The coefficient of performance (COP) of above chiller is 2.1 as against to the design Coefficient of performance (COP) of 3.8.
- The chiller is equipped with evaporative cooling tower.
- The discharge gas temperature is around 87ºC and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower. The detailed energy conservation option has been discussed in energy conservation measures.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-2/RFS 003/-20ºC/120TR

Chiller Reference US-2/RFS 003/-20ºC/120TR				
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL (003)**	**ACTUAL (004)**
			One skid Operation	One skid Operation
Capacity	**TR**	**120**	**28.4**	**31.1**
Chilled Water Flow rate	m3/hr	87.5	64.91	62.63
Inlet Water Temperature	°C	-15	-3.70	-3.90
Outlet Water Temperature	°C	-20	-5.2	-5.6
Diff. Temp	°C	5	1.5	1.7
Specific Heat(Cp)	Kcal/kg °C	0.919	0.919	0.919
Specific Gravity		0.96	0.96	0.96
Operating TR		**120**	**28.4**	**31.1**
Loading	%		35.7	100.0
Power Consumption	kW	264.0	94.13	94.13
Specific. Power consumption	kW/TR	2.20	3.31	3.03
Coefficient of Performance (COP)	-	**1.6**	**1.1**	**1.2**
Gas Suction Pressure	kg/cm^2	1.54	-1	-1
Gas Suction Temperature	°C	-25	6.2	6.4
Discharge Pressure	kg/cm^2	16	16	15.9
Discharge Temperature	°C	74	90	88.8

Table 62: Performance of US-2/RFS 003/-20oC/120TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 28.4TR for compressor 3 in operation and 31.1TR for compressor 4 in operation as against to the design capacity of 120TR for two skid operation(during single skid operation the rated capacity 60TR).
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 64.91m3/hr for compressor 3 in operation and 62.63 m3/hr for compressor 4 in operation when compared to design flow of 87.5m3/hr.
- The specific energy consumption of the above chiller is 3.31 kW/TR& 3.03 kW/TR for compressor 3 & 4 respectively as against to the design specific energy consumption of 2.2 kW/TR. The specific energy consumption is higher of the above chiller when compared to the design values. And intervention is required during regular maintenance for the above chiller.
- The coefficient of performance (COP) of above chiller is 1.1 & 1.2 for compressor 3 & 4 respectively as against to the design Coefficient of performance (COP) of 1.6.

- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 90^{o}C and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower.
- The discharge gas temperature is 16 kg/cm^2 & 15.9 kg/cm^2 for compressor 3 & 4 respectively. This indicates tube cleaning on evaporator side will not only help to reduce the discharge pressure but also reduces the energy consumption.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-2/RFS 009/-15ºC/186TR

Chiller Reference US-2/RFS 009/-15ºC/186TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date			**Two skids**
Capacity	**TR**	**186**	**125.5**
Chilled Water Flow rate	m3/hr	133	110.00
Inlet Water Temperature	°C	-10	-6.97
Outlet Water Temperature	°C	-15	-10.8
Diff. Temp	°C	5	3.8
Specific Heat(Cp)	Kcal/kg °C	0.94	0.94
Specific Gravity		0.97	0.97
Operating TR		**186**	**125.5**
Loading	%		64
Power Consumption	kW	320.0	206.22
Specific. Power consumption	kW/TR	1.72	1.64
Coefficient of Performance (COP)	-	**2**	**2.1**
Gas Suction Pressure	kg/cm^2	-	1
Gas Suction Temperature	°C	-	-5
Discharge Pressure	kg/cm^2	-	14.5
Discharge Temperature	°C	-	95

Table 63: Performance of US-2/RFS 009/-15oC/186TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 125.5TR during two skid operation as against to the design capacity of 186TR.
- The flow rate of the above chiller during performance assessment is 110m3/hr during two skid operation when compared to design flow of 133m3/hr.
- The specific energy consumption of the above chiller is 1.64kW/TR during two skid operation as against to the design specific energy consumption of 1.72 kW/TR.
- The coefficient of performance (COP) of above chiller is 2.1 during two skid operation as against to the design Coefficient of performance (COP) of 2.The coefficient of performance is on higher side when compared to design COP.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 95ºC and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower.

- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-2/RFS 005/-40°C/50TR

Chiller Reference US-2/RFS 005/-40°C/50TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**50**	**41.1**
Chilled Water Flowrate	m3/hr	42	67.00
Inlet Water Temperature	°C	-35	-30.30
Outlet Water Temperature	°C	-40	-32.8
Diff. Temp	°C	5	2.5
Specific Heat(Cp)	Kcal/kg °C	0.831	0.831
Specific Gravity		0.91	0.91
Operating TR		**50.0**	**41.1**
Loading	%		98
Power Consumption	kW	167.0	164.10
Specific. Power consumption	kW/TR	3.34	3.99
Coefficient of Performance (COP)	-	**1.1**	**0.9**
Gas Suction Pressure	kg/cm^2	1	-0.23
Gas Suction Temperature	°C	-47	-31.2
Discharge Pressure	kg/cm^2	1.54	2
Discharge Temperature	°C	46	67

Table 64: Performance of US-2/RFS 005/-40oC/50TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 41.1TR as against to the design capacity of 50TR.
- The flow rate of the above chiller during performance assessment is 67m3/hr when compared to design flow of 42m3/hr.
- The specific energy consumption of the above chiller is 3.99 kW/TR as against to the design specific energy consumption of 3.34 kW/TR.
- The coefficient of performance (COP) of above chiller is 0.9 as against to the design Coefficient of performance (COP) of 1.1.
- The chiller is equipped with evaporative cooling tower
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort.

This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

3.2.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference US-2/RFS 007/+5ºC/173TR

The details of the primary and secondary pumps for the above chiller is as given below

Primary Pumps			**Secondary Pumps**		
Installed	Running	Standby	Installed	Running	Standby
1	1	0	4	4	0

Table 65: Details of Primary Pumps & Secondary Pumps of US-2/RFS 007/+5oC/173TR

The performance of primary pump and combined efficiency of 4 secondary pumps was evaluated and presented below

Pumps		**PRIMARY +5 ºC 173 TR**		**SEC-(all four running) +5 ºC 173 TR**	
Description	**UNITS**	RATED	ACTUAL	RATED	ACTUAL
Flow	**m^3/hr**	90	117.00	64	167.00
Suction Head	**m**	-	1.30	-	1.30
Discharge Head	**m**	-	19.00	-	36.00
Total Head	**m**	30	17.70	52	34.70
Hydraulic power	**kW**	7.35	5.64	9.06	15.78
Electrical Input power	**kW**	12.22	10.30	12.42	27.00
Motor Efficiency	**%**	90.00	90.00	90.00	90.00
Pump Input power	**kW**	11.00	9.27	11.18	24.30
Pump Efficiency	**%**	**66.82**	**60.81**	**81.07**	**64.92**

Table 66: Performance of Primary & Secondary Pumps of US-2/RFS 007/+5oC/173TR

Observations and findings:

- The operating flow of primary pumps is 117m3/hr when compared to design flow of 90m3/hr.
- The hydraulic power of the primary pump is 5.64kW when compared to design hydraulic power of 7.35kW.

- The operating efficiency of the primary pump is 61% when compared to design efficiency of 67%.The primary pump operating performance is satisfactory.
- The combined flow of four operating secondary pumps is 167m3/hr when compared to design flow of 256m3/hr.
- The hydraulic power of the secondary pumps is 15.78kW when compared to design hydraulic power of36.24kW.
- The operating efficiency of the secondary pump is 65% when compared to design efficiency of 81%.The secondary pump operating performance is good.
- It is observed that the design efficiency of primary pump is only 67% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference US-2/RFS 003/-20ºC/120TR

The details of the primary pumps for the above chiller is given below

Primary Pumps		
Installed	Running	Standby
1	1	0

Table 67: Details of Primary Pumps US-2/RFS 003/-20oC/120TR

- The performance of primary pump was evaluated and presented below

Pumps		PRIMARY -20ºC 120 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	90	62.63
Suction Head	**m**	-	0.60
Discharge Head	**m**	-	20.00
Total Head	**m**	30	19.40
Hydraulic power	**kW**	7.06	3.18
Electrical Input power	**kW**	12.22	5.40
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	11.00	4.86
Pump Efficiency	**%**	**64.15**	**65.33**

Table 68: Performance of Primary Pump of US-2/RFS 003/-20oC/120TR

Observations and findings:

- The operating flow of primary pump is 62.63m3/hr when compared to design flow of 90 m3/hr.

- The hydraulic power of the primary pump is 3.18kW when compared to design hydraulic power of 7.06kW.
- The operating efficiency of the primary pump is 65.33% when compared to design efficiency of 64.15%.The primary pump operating performance is good.
- It is observed that the design efficiency of primary pump is only 66% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference US-2/RFS 009/-15ºC/186TR

The details of the primary pumps for the above chiller is given below

Primary Pumps		
Installed	Running	Standby
1	1	0

Table 69: Details of Primary Pumps of US-2/RFS 009/-15oC/186TR

The performance of primary pumps was evaluated and presented below

Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	130	110.00
Suction Head	**m**	-	0.60
Discharge Head	**m**	-	18.00
Total Head	**m**	20	17.40
Hydraulic power	**kW**	6.87	5.05
Electrical Input power	**kW**	12.43	10.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	11.19	9.00
Pump Efficiency	**%**	**61.35**	**56.16**

Table 70: Performance of Primary Pumps of US-2/RFS 009/-15oC/186TR

Observations and findings:

- The operating flow of primary pump is 110 m3/hr when compared to design flow of 130 m3/hr.
- The hydraulic power of the primary pump is 5.05kW when compared to design hydraulic power of 6.87kW.
- The operating efficiency of the primary pump is 56.16% when compared to design efficiency of 61.35%.The primary pump operating performance is satisfactory.

- A detailed energy conservation option for replacing old inefficient with new energy efficient pump has been discussed in encon chapter.
- It is observed that the design efficiency of primary pump is only 61.35% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference US-2/RFS 005/-40^{o}C/50TR

Primary Pumps		
Installed	Running	Standby
2	1	1

Table 71: Details of Primary Pumps US-2/RFS 005/-40oC/50TR

Pumps		PRIMARY -40^{o}C 50TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	45	67.00
Suction Head	**m**	-	1.30
Discharge Head	**m**	-	16.00
Total Head	**m**	25	14.70
Hydraulic power	**kW**	2.79	2.44
Electrical Input power	**kW**	6.11	6.45
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	5.50	5.81
Pump Efficiency	**%**	**50.67**	**42.03**

Table 72: Performance of Primary Pumps US-2/RFS 005/-40oC/50TR

Observations and findings:

- The operating flow of primary pump is 67 m3/hr when compared to design flow of 45 m3/hr.
- The hydraulic power of the primary pump is 2.44 kW when compared to design hydraulic power of 2.79 kW.
- The operating efficiency of the primary pump is 42% when compared to design efficiency of 50%.The primary pump operating performance is satisfactory.
- A detailed energy conservation option for replacing old inefficient with new energy efficient pump has been discussed in encon chapter.
- It is observed that the design efficiency of primary pump is only 56% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80%

are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference US-2/RFS 002/+5ºC/175TR

Primary Pumps		
Installed	Running	Standby
1	1	0

Table 73: Details of Primary Pumps of US-2/RFS 002/+5oC/175TR

Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	90	119.00
Suction Head	**m**	-	1.30
Discharge Head	**m**	-	20.00
Total Head	**m**	30	18.70
Hydraulic power	**kW**	7.35	6.06
Electrical Input power	**kW**	12.22	10.30
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	11.00	9.27
Pump Efficiency	**%**	**66.82**	**65.35**

Table 74: Performance of Primary Pumps of US-2/RFS 002/+5oC/175TR

Observations and findings:

- The operating flow of primary pump is 119 m3/hr when compared to design flow of 90 m3/hr.
- The hydraulic power of the primary pump is 6.06 kW when compared to design hydraulic power of 7.35 kW.
- The operating efficiency of the primary pump is 65% when compared to design efficiency of 67%.The primary pump operating performance is good.
- It is observed that the design efficiency of primary pump is only 67% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

3.2.5 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used. The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporator Reference US-2/RFS 007/+5^{o}C/173TR

Parameter Reference	US-2/RFS 07/+5^{o}C/173TR
CT Inlet Temp. ^{o}C	31.7
CT Outlet Temp. ^{o}C	29.5
Ambient Temp. ^{o}C	35.6
Wet BulbTemp. ^{o}C	28.1
Range ^{o}C	2.2
Approach ^{o}C	1.4
Effectiveness = Range/(Range + Approach)	61.11
Air inlet condition	
DBT, ^{o}C	35.6
RH, %	57.8
Enthalpy, kCal/kg	21.7
Air flow rate, m^3/hr	60966
Air flow rate, kg/hr	64719.85
Air outlet condition	
DBT, ^{o}C	35.6
RH, %	75
Enthalpy, kCal/kg	25.74
Enthalpy difference, kCal/kg	4.1
TR	95.28

Table 75: Performance of Evaporator of US-2/RFS 007/+5oC/173TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.2^{0}C and approach is 1.4^{0}C.
- The operating effectiveness is to the tune of 61%.
- The TR rejected to atmosphere of the above evaporative condenser is 95.28TR.
- The performance of the above evaporative condenser is satisfactory.

Evaporator Reference US-2/RFS 009/-15ºC/186TR

Parameter Reference	**US-2/RFS 009/-15ºC/186TR**
CT Inlet Temp. ºC	31.9
CT Outlet Temp. ºC	29.2
Ambient Temp. ºC	35.6
Wet BulbTemp. ºC	28
Range ºC	2.7
Approach ºC	1.2
Effectiveness = Range/(Range + Approach)	69.23
Air inlet condition	
DBT, ºC	35.6
RH, %	57.8
Enthalpy, kCal/kg	21.7
Air flow rate, m^3/hr	64139
Air flow rate, kg/hr	68087.98
Air outlet condition	
DBT, ºC	35.6
RH, %	78.5
Enthalpy, kCal/kg	26.79
Enthalpy difference, kCal/kg	5.1
TR	126.26

Table 76: Performance of Evaporator of US-2/RFS 007/+5oC/173TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.7^0C and approach is 1.2^0C.
- The operating effectiveness is to the tune of 69%.
- The TR rejected to atmosphere of the above evaporative condenser is 126.26TR.
- The performance of the above evaporative condenser is satisfactory.

Evaporator Reference US-2/RFS 003/-20°C/120TR

Parameter Reference	US-2/RFS 003/-20°C/120TR
CT Inlet Temp. °C	32.5
CT Outlet Temp. °C	30.1
Ambient Temp. °C	35.6
Wet BulbTemp. °C	28
Range °C	2.4
Approach °C	2.1
Effectiveness = Range/(Range + Approach)	53.33
Air inlet condition	
DBT, °C	35.6
RH, %	57.8
Enthalpy, kCal/kg	21.7
Air flow rate, m^3/hr	20368
Air flow rate, kg/hr	21621.54
Air outlet condition	
DBT, °C	35.6
RH, %	89.5
Enthalpy, kCal/kg	25.72
Enthalpy difference, kCal/kg	4.1
TR	31.68

Table 77: Performance of Evaporator of US-2/RFS 003/-20°C/120TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.4^{0}C and approach is 2.1^{0}C.
- The operating effectiveness is to the tune of 53%.
- The TR rejected to atmosphere of the above evaporative condenser is 31.68TR.
- The performance of the above evaporative condenser is satisfactory.

3.2.6 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 001/+5°C/173TR.

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of 9°C to 10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5°C chiller of capacity 173TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.784 Lakh kWh with an annual monetary savings of Rs.4.73 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 001/+5ºC/173TR.		
Description	**Units**	**Value**
Chiller Ref		**US-2/RFS 001/+5ºC/173TR**
Normal operating inlet temperature of Water	°C	10.00
Normal operating outlet temperatures of Water	°C	5.0
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	146
Percentage reduction in power consumption of compressor	kW	17.52
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.784
Envisaged annual Monetary savings	Lakhs Rs	4.73
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 78: Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 001/+5oC/173TR.

Encon 2: Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 002/+5^{o}C/173TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5^{o}C chiller is in the range of 9^{o}C to 10^{o}C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5^{o}C chiller of capacity 173TR is running with a set point of 5^{o}C to 7^{o}C.The compressor will be in OFF condition once reaches 5^{o}C and compressor will be ON once the temperature reaches 7^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3^{o}C to 5^{o}C i.e., keeping set point at 8^{o}C to 12^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.675 Lakh kWh with an annual monetary savings of Rs.4.05 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 002/+5ºC/173TR		
Description	**Units**	**Value**
Chiller Ref		**US-2/RFS 002/+5ºC/173TR**
Normal operating inlet temperatures of Water	°C	10.00
Normal operating out temperatures of Water	°C	5.0
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	125
Percentage reduction in power consumption of compressor	kW	15
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.675
Envisaged annual Monetary savings	Lakhs Rs	4.05
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5⁰Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 79: Optimization of chiller Evaporator temperature by adjusting the existing set point of 173TR chiller with reference US-2/RFS 002/+5oC/173TR

Encon 3: Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-2/RFS 009/-15oC/186TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15°C chiller is in the range of -4°C to -6°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15°C chiller of capacity 186TR is running with a set point of -15°C to -12°C.The compressor will be in OFF condition once reaches -15°C and compressor will be ON once the temperature reaches -12°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 5°C i.e., keeping set point at -10°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.85 Lakh kWh with an annual monetary savings of Rs.11.12 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-2/RFS 009/-15°C/186TR		
Description	**Units**	**Value**
Chiller Ref		**US-2/RFS 009/-15°C/186TR**
Normal operating inlet temperature of Water	°C	-6.97
Normal operating out temperature of Water	°C	-10.8
Present set point	°C	-15.0
Suggested to increase the set point	°C	-10
Increase in set point	°C	5
Present power consumption	kW	206
Percentage reduction in power consumption of compressor	kW	41.2
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.85
Envisaged annual Monetary savings	Lakhs Rs	11.124
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 80: Optimization of chiller Evaporator temperature by adjusting the existing set point of 186TR chiller with reference US-2/RFS 009/-15oC/186TR

Encon 4: Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-2/RFS 003/-20oC/120TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -20°C chiller is in the range of -9°C to -10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -20°C chiller of capacity 120TR is running with a set point of -15°C.The compressor will be in OFF condition once reaches -15°C and compressor will be ON once the temperature reaches -12°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by -10°C from -15°C i.e., keeping set point at -10°C to -8°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.846 Lakh kWh with an annual monetary savings of Rs.5.08 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-2/RFS 003/-20^{o}C/120TR		
Description	**Units**	**Value**
Chiller Ref		**US-2/RFS 003/-20^{o}C/120TR**
Normal operating inlet temperature of Water	°C	-3.9
Normal operating out temperature of Water	°C	-5.6
Present set point	°C	-15.0
Suggested to increase the set point	°C	-10 to -8
Increase in set point	°C	5
Present power consumption	kW	94
Percentage reduction in power consumption of compressor	kW	18.8
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.846
Envisaged annual Monetary savings	Lakhs Rs	5.08
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 81: Optimization of chiller Evaporator temperature by adjusting the existing set point of 120TR chiller with reference US-2/RFS 003/-20^{o}C/120TR

Encon 5: Stop running of primary pumps when chiller is in OFF condition

Present Condition:

During field studies it is observed that chiller reference no.US-2/RFS 004/-15oC/186TR is in OFF condition whereas the primary pump (PP08) is in running condition. The ideal running of the pump not only increases the power consumption by the way ideal running of the pump but also increases the compressor power by adding hot well brine solution to cold well.

Proposed Condition:

It is proposed to have a interlock system for chiller operation and primary pumps which will not only reduce the power consumption of the primary pumps but also reduces the compressor power. By having interlocking system for chiller and primary pumps the envisaged annual savings of 2.97 Lakh kWh with an annual monetary savings of Rs.20.56 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.

Encon Rationale:

Stopping Running of primary pumps when chiller is in OFF condition		
Description	**Units**	**Value**
HLL-03/service block-02/PP-08		**US-2/RFS 004/-15°C/186TR**
Number of Primary Pumps installed	no's	1.0
Design capacity of the pump	kW	15.0
Number of hours of Operation	Hrs	10
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.45
Envisaged annual Monetary savings	Lakhs Rs	**2.7**
Loss in refrigeration effect	TR	47.95
kW/TR generated in -15°C Chiller	kW/TR	2.07
Number of hours of Operation	Hrs	10
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	2.97768
Envisaged annual Monetary savings	Lakhs Rs	17.866
Total Monetary Savings	Lakhs Rs	20.566
Investment	Months	Nil
Payback period		Immediate
Action to be taken		Operational adjustments

Table 82: Stopping running of primary pumps when chiller is in OFF condition

Note: Running hours is estimated by observation during field studies and the running hours will change as the demand in production blocks.

Encon 6: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-03/service block-02		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 83: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 7: Energy Savings by changing operating compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for instrument air and also for breathing air requirements of the servicing production blocks. The existing pressure settings for the air compressors were 6.5 – 7 kg/cm$^{2.}$ .i.e. at 6.5 the compressor will be in OFF condition and at 7 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3.5 to 4 kgandcm2for 90% of the loads. It is also discussed that the pressure requirements for breathing air is only 2 – 2.5kg/cm$^{2.}$.

Proposed Condition:

It is proposed to change the pressure settings to 5 – 5.5 kg/cm^{2}for air compressors and in future the breathing air requirements can be segregated and a small roots blower will suffice the requirements of production blocks. The above operational adjustment will lead to 0.2 Lakh kWh savings with an annual monetary savings of Rs.1.11 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating compressor pressure settings		
Description	**Units**	**Value**
HLL-03/service block-02		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	7
Existing compressor pressure settings-on	kg/cm^2	6.5
Existing capacity of air Compressor	CFM	222.00
Power consumption of air Compressor	kW	29.3
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	25.198
Reduction in power consumption	kW	4.1
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.2
Envisaged annual Monetary savings	Lakhs Rs	1.11
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 84: Energy Savings by changing operating compressor pressure settings

Encon 8: Energy Savings by installing -5°C chiller in the place of -15°C chiller in service block -2

Present Condition:

It is observed during the field studies in service block -2 there is no -5**°C** chiller present even though there is a requirement production blocks. Because of absence of -5**°C** chiller the production requirement was met by -15**°C** chiller. A detailed discussion with the engineers and plant people in the production block concludes that a -5**°C** chiller will be sufficient to use instead -15**°C** chiller.

Proposed Condition:

It is proposed to install an energy efficient -5°C chiller in service block -2 to meet the production block requirement. The above energy conservation measure will lead to 5.5 Lakh kWh savings with an annual monetary savings of Rs.33.03 Lakhs with any investment of Rs 37.0 Lakhs with a simple payback period of 13 Months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by installation of (-5 °C) chiller system in the place of -15°C		
Description	**UNITS**	**ACTUAL**
Capacity of Existing (-15°C) Chiller	**TR**	**186.0**
Existing Power Consumption of (-15°C)	kW/TR	1.64
Proposed Chiller Power Consumption (-5°C)	kW/TR	1.27
Excess Power Consumed	kW/TR	0.37
Total Excess Power Consumption	kW	**68.8**
Operating Hours per Annum	Hrs	8000
Total Power Savings Per annum	Kwh/annum (in Lakhs)	5.5056
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	33.03
Investment	Lakhs Rs.	37.2
Simple payback period	Months	13.5

Table 85: Energy Savings by having -5°C energy efficient chiller in service block-2

Encon 9: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 007/+5ºC/173TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 85.9ºC and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-2/RFS 007/+5ºC/173TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 25.8 Kgs of coal per hour and equivalent annual monetary savings of Rs.3.5 Lakhs with an investment of Rs.31.1 lakhs with a payback period of 25 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-2/RFS 007/+5ºC/173TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**173.0**
Inlet Water Temperature	°C	9.65
Outlet Water Temperature	°C	7.2
Diff. Temp	°C	2.5
Operating TR		**95.8**
Gas Suction Temperature	°C	5.9
Discharge Temperature	°C	85.9
Amount of heat available before evaporative condenser	kcals/hr	289699
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	57940
Equivalent coal savings	kg/hr	25.8
Expected annual monetary savings	Lakhs Rs.	3.5
Investment	Lakhs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	31.1

Table 86: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 007/+5ºC/173TR

Encon 10: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 003/-20°C/120TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 88.8°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-2/RFS 003/-20°C/120TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 8.4 Kgs of coal per hour and equivalent annual monetary savings of Rs.1.1 Lakhs with a payback period of 95.7 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-2/RFS 003/-20°C/120TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**120.0**
Inlet Water Temperature	°C	-3.90
Outlet Water Temperature	°C	-5.6
Diff. Temp	°C	1.7
Operating TR		**31.1**
Gas Suction Temperature	°C	6.4
Discharge Temperature	°C	88.8
Amount of heat available before evaporative condenser	kcals/hr	94046
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	18809
Equivalent coal savings	kg/hr	8.4
Expected annual monetary savings	Lakhs Rs.	1.1
Investment	Lakhs Rs	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	95.7

Table 87: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 003/-20°C/120TR

Encon 11: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 009/-15oC/186TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 95°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-2/RFS 009/-15oC/186TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 34 Kgs of coal per hour and equivalent annual monetary savings of Rs.4.6 Lakhs with a payback period of 23.7 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-2/RFS 009/-15°C/186TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**186.0**
Inlet Water Temperature	°C	-6.97
Outlet Water Temperature	°C	-10.8
Diff. Temp	°C	3.8
Operating TR		**125.5**
Gas Suction Temperature	°C	-5
Discharge Temperature	°C	95
Amount of heat available before evaporative condenser	kcals/hr	379512
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	75902
Equivalent coal savings	kg/hr	33.7
Expected annual monetary savings	Lakhs Rs.	4.6
Investment	Lakhs Rs	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	23.7

Table 88: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 009/-15oC/186TR

Encon 12: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 002/+5oC/173TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 86.7°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference US-2/RFS 002/+5°C/173TRbefore it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 20 Kgs of coal per hour and equivalent annual monetary savings of Rs.2.7 Lakhs with an investment of Rs.9 lakhs with a payback period of 39.8 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water US-2/RFS 002/+5°C/173TR		
Description	**UNITS**	**ACTUAL**
Capacity	**TR**	**173.0**
Inlet Water Temperature	°C	9.50
Outlet Water Temperature	°C	7.6
Diff. Temp	°C	1.9
Operating TR		**74.8**
Gas Suction Temperature	°C	3.4
Discharge Temperature	°C	86.7
Amount of heat available before evaporative condenser	kcals/hr	226195
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	45239
Equivalent coal savings	kg/hr	20.1
Expected annual monetary savings	Lakhs Rs.	2.7
Investment	Lakhs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	39.8

Table 89: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference US-2/RFS 007/+5oC/173TR

Encon 13: Energy savings by replacement of primary Pump of (-15 °C) 186TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 186 TR chiller (-5 °C) is 56% as against to the design efficiency of 62%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.28 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.1.22 Lakhs with a payback period of 5.9 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-15 °C) 186TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**56.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	10.00
Expected Savings by Installation of New Pumps	kW	2.53
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.20
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	1.22
Investment	Lakhs Rs.	0.60
Simple payback period	Months	5.9

Table 90: Energy savings by replacement of Secondary Pump of (-5 °C) 186TR with New Energy Efficient Pump

Encon 14: Energy savings by replacement of primary Pump of (-40 °C) 50TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 186 TR chiller (-40 °C) is 42% as against to the design efficiency of 51%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.23 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.1.36 Lakhs with a payback period of 2.6 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-40 °C) 50TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**42.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	6.45
Expected Savings by Installation of New Pumps	kW	2.84
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.23
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	1.36
Investment	Lakhs Rs.	0.30
Simple payback period	Months	2.6

Table 91: Energy savings by replacement of primary Pump of (-40 °C) 50TR with New Energy Efficient Pump

3.3 Service Block-004

Service Block –SB004 has the following utilities to meet the production requirements of E, L, K, I, N, P

Service Block-SB004:

S.No	Name of the utility	Capacity	No's
1	Chiller(+5^{0}C)	173TR	1
2	Chiller(+5^{0}C)	400TR	1
3	Chiller(-5^{0}C)	120TR	2
4	Chiller(-15^{0}C)-Skid System	158TR	1
5	Chiller(-15^{0}C)-Skid System	186TR	1
6	Air Compressor	360CFM	1
7	Nitrogen Compressor	500Nm3/hr	1

Table 92:Major Equipment List of Service Block-004

3.3.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference US-4/RFS 002/+5^{o}C/395TR

Description	UNITS	DESIGN DETAILS
		Two skid
Capacity	**TR**	**395**
Chilled Water Flowrate	m3/hr	239
Diff. Temp	°C	5
Operating TR		**395.2**
Loading	%	
Power Consumption	kW	360.0
Specific. Power consumption	kW/TR	0.91
Coefficient of Performance (COP)	-	**3.9**

Table 93: Design Details of Chiller Reference US-4/RFS 002/+5oC/395TR

Chiller Reference US-4/RFS 001/+5^{o}C/395TR

Description	UNITS	DESIGN DETAILS
		Two skid
Capacity	**TR**	**395**
Chilled Water Flowrate	m3/hr	239
Diff. Temp	°C	5
Operating TR		**395.2**
Loading	%	
Power Consumption	kW	360.0
Specific. Power consumption	kW/TR	0.91
coefficient of Performance (COP)	-	**3.9**

Table 94: Design Details of Chiller Reference US-4/RFS 001/+5^{o}C/395TR

Chiller Reference US-4/RFS 003/-15^{o}C/450TR

Description	UNITS	DESIGN DETAILS
		Two skid
Capacity	**TR**	**450**
Chilled Water Flowrate	m3/hr	315
Diff. Temp	°C	4.4
Operating TR		**450**
Loading	%	
Power Consumption	kW	800.0
Specific. Power consumption	kW/TR	1.78
coefficient of Performance (COP)	-	**2.0**

Table 95: Design Details of Chiller Reference US-4/RFS 003/-15oC/450TR

Chiller Reference US-4/RFS 004/-20^{o}C/450TR

Description	UNITS	DESIGN DETAILS
Date		**Three compressors**
Capacity	**TR**	**450**
Chilled Water Flowrate	m3/hr	315
Diff. Temp	°C	4.4
Operating TR		450
Loading	%	
Power Consumption	kW	815.0
Specific. Power consumption	kW/TR	1.81
coefficient of Performance (COP)	-	1.91

Table 96: Design Details of Chiller Reference US-4/RFS 004/-20^{o}C/450TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB004 of HLL-03 was given below:

3.3.2 Design Details of Pumps:

Chiller Reference RFS 002/+5°C/395TR
Primary Pump Reference (+5 °C)/ RFS 002/+5°C/395TR

Description	UNITS	RATED
Flow	m^3/hr	239
Total Head	m	30
Hydraulic power	kW	19.52
Electrical Input power	kW	33.16
Motor Efficiency	%	90.00
Pump Input power	kW	29.84
Pump Efficiency	%	**65.41**

Table 97: Design Details of Primary Pump Reference (+5 oC)/ RFS 002/+5oC/395TR

Chiller Reference RFS 002/+5oC/395TR
Secondary Pump Reference (+5 °C)/ RFS 002/+5oC/395TR

Description	UNITS	RATED
Flow	m3/hr	250
Total Head	m	50
Hydraulic power	kW	34.03
Electrical Input power	kW	49.73
Motor Efficiency	%	90.00
Pump Input power	kW	44.76
Pump Efficiency	%	**76.02**

Table 98: Design Details of Secondary Pump Reference (+5 oC)/ RFS 002/+5oC/395TR

Chiller Reference RFS 003/-15°C/450TR
Primary Pump Reference (-15 °C)/ RFS 003/-15°C/450TR

Description	UNITS	RATED
Flow	m^3/hr	315
Total Head	m	30
Hydraulic power	kW	24.95
Electrical Input power	kW	41.44
Motor Efficiency	%	90.00
Pump Input power	kW	37.30
Pump Efficiency	%	**68.97**

Table 99: Design Details of Primary Pump Reference (-15 oC)/ RFS 003/-15oC/450TR

Chiller Reference RFS 004/-20^{o}C/450TR

Primary Pump Reference (-20 ^{o}C)/ RFS 004/-20^{o}C/450TR

Description	UNITS	RATED
Flow	**m^3/hr**	315
Total Head	**m**	30
Hydraulic power	**kW**	24.70
Electrical Input power	**kW**	41.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.30
Pump Efficiency	**%**	**68.97**

Table 100:Design Details of Primary Pump Reference (-20 oC)/ RFS 004/-20oC/450TR

Chiller Reference RFS 001/+5^{o}C/395TR
Primary Pump Reference (+5 ^{o}C)/ RFS 001/+5^{o}C/395TR

Description	UNITS	RATED
Flow	**m^3/hr**	239
Total Head	**m**	30
Hydraulic power	**kW**	19.52
Electrical Input power	**kW**	33.16
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	29.84
Pump Efficiency	**%**	**65.41**

Table 101: Design Details of Primary Pump Reference (+5 oC)/ RFS 001/+5oC/395TR

3.3.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -20^{o}C to +5 ^{o}C. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB004 is given below.

Chiller Reference US-4/RFS 001/+5°C/395TR

Chiller Reference US-4/RFS 001/+5°C/395TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two skid**	**One skid(B)**
Capacity	**TR**	**395**	**101.5**
Chilled Water Flowrate	m3/hr	239	161.62
Inlet Water Temperature	°C	10	14.60
Outlet Water Temperature	°C	5	12.7
Diff. Temp	°C	5	1.9
Operating TR		**395**	**101.5**
Loading	%		70.8
Power Consumption	kW	360.0	127.5
Specific. Power consumption	kW/TR	0.91	1.26
coefficient of Performance (COP)	-	**3.9**	**2.8**
Gas Suction Pressure	kg/cm^2	-	4.2
Gas Suction Temperature	°C	-	4.6
Discharge Pressure	kg/cm^2	-	12.4
Discharge Temperature	°C	-	70.9

Table 102: Performance of Chiller Reference US-4/RFS 001/+5oC/395TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 101TR as against to the design capacity of 395TR during two skid operation (during Single skid operation the design capacity is 197.5TR).
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) and also the chilled water flow as against the design temperature difference (delta T) and chilled water flow rate.
- The flow rate of the above chiller during performance assessment is 161m3/hr when compared to design flow of 239m3/hr.
- The specific energy consumption of the above chiller is 1.26kW/TR as against to the design specific energy consumption of 0.91 kW/TR. The operational efficiency of the above chiller is not satisfactory.
- The coefficient of performance (COP) of above chiller is 2.8 as against to the design Coefficient of performance (COP) of 3.9.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.

Chiller Reference US-4/RFS 002/+5ºC/395TR

Chiller Reference US-4/RFS 002/+5ºC/395TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
		Two skid	**One skid(A)**
Capacity	**TR**	**395**	**94.9**
Chilled Water Flowrate	m3/hr	239	151.00
Inlet Water Temperature	°C	10	13.90
Outlet Water Temperature	°C	5	12.0
Diff. Temp	°C	5	1.9
Operating TR		**395**	**94.9**
Loading	%		70.6
Power Consumption	kW	360.0	127.0
Specific. Power consumption	kW/TR	0.91	1.34
coefficient of Performance (COP)	-	**3.9**	**2.6**
Gas Suction Pressure	kg/cm^2	-	4.5
Gas Suction Temperature	°C	-	5.2
Discharge Pressure	kg/cm^2	-	12.5
Discharge Temperature	°C	-	60.8

Table 103: Performance of Chiller Reference US-4/RFS 002/+5oC/395TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 95TR as against to the design capacity of 395TR during two skid operation (during Single skid operation the design capacity is 197.5TR).
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) and also the chilled water flow as against the design temperature difference (delta T) and chilled water flow rate.
- The flow rate of the above chiller during performance assessment is 151m3/hr when compared to design flow of 239m3/hr.
- The specific energy consumption of the above chiller is 1.34kW/TR as against to the design specific energy consumption of 0.91 kW/TR. The operational efficiency of the above chiller is not satisfactory.
- The coefficient of performance (COP) of above chiller is 2.6 as against to the design Coefficient of performance (COP) of 3.9.
- The chiller is equipped with evaporative cooling towers.

Chiller Reference US-4/RFS 003/-15°C/450TR

Chiller Reference US-4/RFS 003/-15°C/450TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two skid**	**One Skid(B)**
Capacity	**TR**	**450**	**81.9**
Chilled Water Flowrate	m3/hr	315	61.90
Inlet Water Temperature	°C	-10	-5.20
Outlet Water Temperature	°C	-15	-9.2
Diff. Temp	°C	5	4.0
Specific Heat(Cp)	Kcal/kg °C	**0.94**	**0.94**
Specific Gravity		**0.97**	**0.97**
Operating TR		**450**	**74.7**
Loading	%		40.3
Power Consumption	kW	800.0	161.0
Specific. Power consumption	kW/TR	1.78	2.16
coefficient of Performance (COP)	-	**2.0**	**1.6**
Gas Suction Pressure	kg/cm^2	-	1.5
Gas Suction Temperature	°C	-	3.4
Discharge Pressure	kg/cm^2	-	11.5
Discharge Temperature	°C	-	68.7

Table 104: Performance of Chiller Reference US-4/RFS 003/-15oC/450TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 74.7TR as against to the design capacity of 458TR during two skid operation (during Single skid operation the design capacity is around 230TR).
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) and also the chilled water flow as against the design temperature difference (delta T) and chilled water flow rate.
- The flow rate of the above chiller during performance assessment is 62m3/hr when compared to design flow of 315m3/hr.
- The specific energy consumption of the above chiller is 2.16kW/TR as against to the design specific energy consumption of 1.78 kW/TR. The operational efficiency of the above chiller is not satisfactory.
- The coefficient of performance (COP) of above chiller is 1.6 as against to the design Coefficient of performance (COP) of 2.

- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.

Chiller Reference US-4/RFS 004/-20ºC/450TR

Chiller Reference US-4/RFS 004/-20ºC/450TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Three compressors**	**One in Operation(C)**
Capacity	**TR**	**450**	**42.6**
Chilled Water Flowrate	m3/hr	315	75.70
Inlet Water Temperature	°C	-15	-8.10
Outlet Water Temperature	°C	-20	-9.8
Diff. Temp	°C	5	1.7
Specific Heat(Cp)	Kcal/kg °C	0.919	0.919
Specific Gravity		**0.96**	**0.96**
Operating TR		**450**	**37.5**
Loading	%		40.3
Power Consumption	kW	815.0	100.70
Specific. Power consumption	kW/TR	1.81	2.68
coefficient of Performance (COP)	-	**1.9**	**1.3**
Gas Suction Pressure	kg/cm^2	-	1.2
Gas Suction Temperature	°C	-	4.8
Discharge Pressure	kg/cm^2	-	12.5
Discharge Temperature	°C	-	70.8

Table 105: Performance of Chiller Reference US-4/RFS 004/-20oC/450TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 37 TR as against to the design capacity of 450 TR during three compressors are in operation whereas the chiller is designed with three compressors of capacity 1x315kW and 2x250kW,only one will be working at a time.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) and also the chilled water flow as against the design temperature difference (delta T) and chilled water flow rate.
- The flow rate of the above chiller during performance assessment is 75 m3/hr when compared to design flow of 315 m3/hr.
- The specific energy consumption of the above chiller is 2.68 kW/TR as against to the design specific energy consumption of 1.81 kW/TR for two skid operation. The operational efficiency of the above chiller is not satisfactory.

- The coefficient of performance (COP) of above chiller is 1.3 as against to the design Coefficient of performance (COP) of 1.9.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.

3.3.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference RFS 002/+5°C/395TR

The details of the primary and secondary pumps for the above chiller is as given below

Primary Pumps			Secondary Pumps		
Installed	Running	Standby	Installed	Running	Standby
2	1	1	2	1	1

Table 106: Details of Primary Pumps & Secondary Pumps of Chiller Reference RFS 002/+5oC/395TR

The performance of primary pumps and secondary pumps was evaluated and presented below

		Primary Pumps		Secondary Pump	
Description	**UNITS**	**RATED**	**ACTUAL**	**RATED**	**ACTUAL**
Flow	**m3/hr**	239	151.00	250	217.40
Suction Head	**m**	-	1.50	-	2.50
Discharge Head	**m**	-	25.00	-	32.00
Total Head	**m**	30	23.50	50	29.50
Hydraulic power	**kW**	19.52	9.66	34.03	17.46
Electrical Input power	**kW**	33.16	23.88	49.73	29.00
Motor Efficiency	**%**	90.00	90.00	90.00	90.00
Pump Input power	**kW**	29.84	21.49	44.76	26.10
Pump Efficiency	**%**	65.41	44.95	76.02	66.89

Table 107: Performance of Primary & Secondary Pumps of Chiller Reference RFS 002/+5oC/395TR

Observations and findings:

- The operating flow of primary pump is 151 m3/hr when compared to design flow of 239m3/hr.

- The hydraulic power of the primary pump is 9.66 kW when compared to design hydraulic power of 19.52 kW.
- The operating efficiency of the primary pump is 45% when compared to design efficiency of 65%.The primary pump operating performance is satisfactory.
- The operating flow of secondary pump is 217m3/hr when compared to design flow of 250m3/hr.
- The hydraulic power of the secondary pumps is 17.46 kW when compared to design hydraulic power of 68kW.
- The operating efficiency of the secondary pump is 67% when compared to design efficiency of 76%.The secondary pump operating performance is satisfactory.
- It is observed that the design efficiency of primary pump is only 65% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference RFS 001/+5^{o}C/395TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

Table 108: Details of Primary Pumps of Chiller Reference RFS 001/+5oC/395TR

The performance of primary pumps was evaluated and presented below

Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	239	161.00
Suction Head	**m**	-	1.50
Discharge Head	**m**	-	26.00
Total Head	**m**	30	24.50
Hydraulic power	**kW**	19.52	10.74
Electrical Input power	**kW**	33.16	24.88
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	29.84	22.39
Pump Efficiency	**%**	**65.41**	**47.95**

Table 109 :Performance of Primary Pumps of Chiller Reference RFS 001/+5oC/395TR

Observations and findings:

- The operating flow of primary pump is 161m3/hr when compared to design flow of 239 m3/hr.

- The hydraulic power of the primary pump is 10.74 kW when compared to design hydraulic power of 19.52 kW.
- The operating efficiency of the primary pump is 48% when compared to design efficiency of 65%.The primary pump operating performance is satisfactory.
- It is observed that the design efficiency of primary pump is only 65% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference RFS 003/-15ºC/450TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

Table 110: Details of Primary Pumps of Chiller Reference RFS 003/-15ºC/450TR

The performance of primary pumps was evaluated and presented below

Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	315	61.90
Suction Head	**m**	-	9.00
Discharge Head	**m**	-	45.00
Total Head	**m**	30	36.00
Hydraulic power	**kW**	24.95	5.88
Electrical Input power	**kW**	41.44	21.50
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.30	19.35
Pump Efficiency	**%**	**66.90**	**30.41**

Table 111: Performance of Primary Pumps of Chiller Reference RFS 003/-15oC/450TR

Observations and findings:

- The operating flow of primary pump is 62m3/hr when compared to design flow of 315 m3/hr.
- The hydraulic power of the primary pump is 5.88kW when compared to design hydraulic power of 24.95 kW.
- The operating efficiency of the primary pump is 30.41% when compared to design efficiency of 66.90%.The primary pump operating performance is not satisfactory.

- A detailed energy conservation option for replacing old inefficient with new energy efficient pump has been discussed in encon chapter.
- It is observed that the design efficiency of primary pump is only 69% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference RFS 004/-20^{o}C/450TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

Table 112: Details of Primary Pumps of Chiller Reference RFS 004/-20oC/450TR

The performance of primary pumps was evaluated and presented below

Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	315	110.00
Suction Head	**m**	-	8.00
Discharge Head	**m**	-	45.00
Total Head	**m**	30	37.00
Hydraulic power	**kW**	24.70	10.64
Electrical Input power	**kW**	41.44	25.70
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.30	23.13
Pump Efficiency	**%**	**66.21**	**45.98**

Table 113:Performance of Primary Pumps of Chiller Reference RFS 004/-20oC/450TR

Observations and findings:

- The operating flow of primary pump is 110m3/hr when compared to design flow of 315 m3/hr.
- The hydraulic power of the primary pump is 10.64 kW when compared to design hydraulic power of 24.70 kW.
- The operating efficiency of the primary pump is 46% when compared to design efficiency of 66%.The primary pump operating performance is not satisfactory.
- A detailed energy conservation option for replacing old inefficient with new energy efficient pump has been discussed in encon chapter.
- It is observed that the design efficiency of primary pump is only 69% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80%

are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

3.3.5 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used. The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporator Reference US-4/RFS 001/+5°C/395TR

Parameter Reference	US-4/RFS 001/+5°C/395TR
CT Inlet Temp. °C	35.5
CT Outlet Temp. °C	30
Ambient Temp. °C	32
Wet BulbTemp. °C	28.3
Range °C	5.5
Approach °C	1.7
Effectiveness = Range/(Range + Approach)	76.39
Air inlet condition	
DBT, °C	35.5
RH, %	59
Enthalpy, kCal/kg	21.8
Air flow rate, m^3/hr	44413
Air flow rate, kg/hr	47704.28
Air outlet condition	
DBT, °C	36
RH, %	84.1
Enthalpy, kCal/kg	27.80
Enthalpy difference, kCal/kg	5.9
TR	101.37

Table 114: Performance of Evaporator Reference US-4/RFS 001/+5oC/395TR

Observations and findings:

- The operating range of the above evaporative condenser is 5.5^{0}C and approach is 1.7^{0}C.
- The operating effectiveness is to the tune of 76.5%.
- The TR rejected to atmosphere of the above evaporative condenser is 101.37TR.
- The performance of the above evaporative condenser is satisfactory.

Evaporator Reference US-4/RFS 003/-15ºC/450TR

Parameter Reference	US-4/RFS 003/-15ºC/450TR
CT Inlet Temp. ºC	32.3
CT Outlet Temp. ºC	30
Ambient Temp. ºC	35
Wet BulbTemp. ºC	28.4
Range ºC	2.3
Approach ºC	1.6
Effectiveness = Range/(Range + Approach)	58.97
Air inlet condition	
DBT, ºC	35
RH, %	59
Enthalpy, kCal/kg	21.3
Air flow rate, m^3/hr	40626
Air flow rate, kg/hr	43211.75
Air outlet condition	
DBT, ºC	36
RH, %	75
Enthalpy, kCal/kg	26.22
Enthalpy difference, kCal/kg	4.9
TR	75.98

Table 115:Performance of Evaporator Reference US-4/RFS 003/-15oC/450TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.3^0C and approach is 1.6^0C.
- The operating effectiveness is to the tune of 59%.
- The TR rejected to atmosphere of the above evaporative condenser is 75.98TR.
- The performance of the above evaporative condenser is satisfactory.

Evaporator Reference US-4/RFS 004/-20^{o}C/450TR

Parameter Reference	US-4/RFS 004/-20^{o}C/450TR
CT Inlet Temp ^{o}C	33.3
CT Outlet Temp. ^{o}C	30
Ambient Temp. ^{o}C	35.9
Wet BulbTemp. ^{o}C	28.4
Range ^{o}C	3.3
Approach ^{o}C	1.6
Effectiveness = Range/(Range + Approach)	67.35
Air inlet condition	
DBT, ^{o}C	35.9
RH, %	57.9
Enthalpy, kCal/kg	22.0
Air flow rate, m^3/hr	28669
Air flow rate, kg/hr	30404.69
Air outlet condition	
DBT, ^{o}C	36.4
RH, %	70
Enthalpy, kCal/kg	25.50
Enthalpy difference, kCal/kg	3.5
TR	38.57

Table 116: Performance of Evaporator Reference US-4/RFS 004/-20^{o}C/450TR

Observations and findings:

- The operating range of the above evaporative condenser is 3.3 ^{0}C and approach is 1.6^{0}C.
- The operating effectiveness is to the tune of 68%.
- The TR rejected to atmosphere of the above evaporative condenser is 38.57TR.
- The performance of the above evaporative condenser is satisfactory.

3.3.6 Energy Conservation Options (ENCON):

Encon 1: Operating Two skids instead One skid to attain set point for the chiller

Present Condition:

During field studies a trial has been conducted on 395TR capacity chiller with two skid arrangement (chiller reference no US-4/RFS 002/+5°C/395TR). In normal operation only one skid will be running between the set points the above chiller and to meet the production requirements.

Proposed Condition:

A trail for 4 hours has been conducted for the above chiller by operating the two skid instead of single skid during the trial measurements like compressor ON time, compressor OFF time, power consumption of the two skid system has been measured simultaneously.

It is observed during the trial single skid operation will be in operation for 15 hours consuming an average power of 1905kWh/day. Whereas the proposed two skid operation will be in operation for 5.2 hours per day with an average electricity consumption of 1325 kWh/day. The trial resulted in reduction of electricity consumption by 579 kWh/day only by chiller optimization and also 450 kWh/day by the way of stopping operation of primary pumps.

The above trial resulted in reduction of 1029 kWh/day which is estimated to be around 3.09 Lakh kWh/annum with an envisaged annual monetary savings of Rs.18.54 Lakhs.

The similar trail can be implemented in all service blocks where ever single skid in operation and as a rule of thumb the above initiative straight away reduce 50% of energy consumption when single skid in operation.

The detailed encon rationale is presented below.

Encon Rationale:

Operating Two skids instead One skid to attain set point for the chiller		
Description	**Units**	**Value**
HLL-03/service block-04		**US-4/RFS 002/+5^{o}C/395TR**
Capacity of the chiller	TR	395.0
Trail Duration	hrs	4.0
Set point for compressor-ON	°C	14.0
Set point for compressor-ON	°C	10.0
Average ON time of the compressor during the trial period	min	30.7
Average OFF time of the compressor during trial period	min	57.5
Operating hours of the compressor	hrs/day	15.0
ON time	hrs//day	5.2
OFF time	hrs/day	9.8
Power consumption with one skid in operation	kW	127.0
Electricity consumption with one skid operation	kWh/day	1905.0
power consumption with two skid in operation	kW	254.0
Electricity consumption with two skid operation	kWh/day	1325.2
Reduction in electricity consumption	kWh/day	579.8
Additional power savings due to stopping of primary pumps and cooling tower	kW	30.0
Electricity savings due to stopping of primary pumps and cooling tower	kWh/day	450.0
Total reduction in electricity savings	kWh/day	1029.8
Envisaged annual Energy savings	Lakh Kwh	3.09
Envisaged annual Monetary savings	**Lakhs Rs**	**18.54**
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 117: Operating Two skids instead One skid to attain set point for the chiller

Encon 2: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 002/+5°C/395TR.

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of 9°C to 10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5°C chiller of capacity 395TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.68 Lakh kWh with an annual monetary savings of Rs.4.11 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 002/+5ºC/395TR.		
Description	**Units**	**Value**
Chiller Ref		**US-4/RFS 002/+5ºC/395TR**
Normal operating inlet temperature of Water	°C	13.90
Normal operating outlet temperatures of Water	°C	12.0
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	127
Percentage reduction in power consumption of compressor	kW	15.24
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.68
Envisaged annual Monetary savings	Lakhs Rs	4.11
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 118: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 002/+5oC/395TR

Encon 3: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 001/+5°C/395TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of 9°C to 10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5°C chiller of capacity 395TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.68 Lakh kWh with an annual monetary savings of Rs.4.13 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 001/+5^{o}C/395TR		
Description	**Units**	**Value**
Chiller Ref		**US-4/RFS 001/+5^{o}C/395TR**
Normal operating inlet temperatures of Water	°C	14.60
Normal operating out temperatures of Water	°C	12.7
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	127.5
Percentage reduction in power consumption of compressor	kW	15.3
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.68
Envisaged annual Monetary savings	Lakhs Rs	4.13
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 119: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference US-4/RFS 001/+5oC/395TR

Encon 4: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 003/-15oC/450TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15°C chiller is in the range of -4°C to -6°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15°C chiller of capacity 450TR is running with a set point of -10°C to -12°C.The compressor will be in OFF condition once reaches -12°C and compressor will be ON once the temperature reaches -10°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C i.e., keeping set point at -7°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.86 Lakh kWh with an annual monetary savings of Rs.5.21 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 003/-15°C/450TR		
Description	**Units**	**Value**
Chiller Ref		**US-4/RFS 003/-15°C/450TR**
Normal operating inlet temperature of Water	°C	-5.2
Normal operating iout temperature of Water	°C	-9.2
Present set point	°C	-10.0
Suggested to increase the set point	°C	-7
Increase in set point	°C	3
Present power consumption	kW	161
Percentage reduction in power consumption of compressor	kW	19.32
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.86
Envisaged annual Monetary savings	Lakhs Rs	5.21
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 120: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 003/-15°C/450TR

Encon 5: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 004/-20^{o}C/450TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15^{o}C chiller is in the range of -9 ^{o}C to -10^{o}C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -20^{o}C chiller of capacity 450TR is running with a set point of -20^{o}C.The compressor will be in OFF condition once reaches -15^{o}C and compressor will be ON once the temperature reaches -12^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by -10^{o}C from -15^{o}C i.e., keeping set point at -10^{o}C to -8^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.54 Lakh kWh with an annual monetary savings of Rs.3.26 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 004/-20°C/450TR		
Description	**Units**	**Value**
Chiller Ref		**US-4/RFS 004/-20°C/450TR**
Normal operating inlet temperature of Water	°C	-8.1
Normal operating out temperature of Water	°C	-9.8
Present set point	°C	-15.0
Suggested to increase the set point	°C	-10
Increase in set point	°C	5
Present power consumption	kW	100.7
Percentage reduction in power consumption of compressor	kW	12.08
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.54
Envisaged annual Monetary savings	Lakhs Rs	3.26
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5⁰Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 121: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference US-4/RFS 004/-20°C/450TR

Encon 6:Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-03/service block-04		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 122: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 7: Energy Savings by changing operating compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for instrument air and also for breathing air requirements of the servicing production blocks. The existing pressure settings for the air compressors were 6.5 – 7 kg/cm$^{2.}$ .i.e. at 6.5 the compressor will be in OFF condition and at 7 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3.5 to 4 kg/cm2for 90% of the loads. It is also discussed that the pressure requirements for breathing air is only 2 – 2.5kg/cm$^{2.}$.

Proposed Condition:

It is proposed to change the pressure settings to 5 – 5.5 kg/cm^{2}for air compressors and in future the breathing air requirements can be segregated and a small roots blower will suffice the requirements of production blocks. The above operational adjustment will lead to 0.3 Lakh kWh savings with an annual monetary savings of Rs.1.66 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating compressor pressure settings		
Description	**Units**	**Value**
HLL-03/service block-04		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	7
Existing compressor pressure settings-on	kg/cm^2	6.5
Existing capacity of air Compressor	CFM	356.00
Power consumption of air Compressor	kW	44
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	37.84
Reduction in power consumption	kW	6.2
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.3
Envisaged annual Monetary savings	Lakhs Rs	1.66
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 123: Energy Savings by changing operating compressor pressure settings

Encon 8: Energy savings by replacement of primary Pump of RFS-001 (+5 °C) 395TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 395 TR chiller (+5 °C) is 48% as against to the design efficiency of 66%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.72 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.32 Lakhs with a payback period of 5.6 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of RFS-001 (+5 °C) 395TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Date		
Efficiency of Existing Pump	**%**	**48.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	25.00
Proposed energy Consumption	kW	16.00
Expected Savings by Installation of New Pumps	kW	9.00
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.72
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	4.32
Investment	Lakhs Rs.	2.00
Simple payback period	Months	5.6

Table 124: Energy savings by replacement of primary Pump of (+5 °C) 395TR with New Energy Efficient Pump

Encon 9: Energy savings by replacement of primary Pump of RFS-002 (+5 °C) 395TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 395 TR chiller (+5 °C) is 45% as against to the design efficiency of 66%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.76 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.58 Lakhs with a payback period of 5.2 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of RFS-002 (+5 °C) 395TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Date		
Efficiency of Existing Pump	**%**	**45.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	23.88
Proposed energy Consumption	kW	14.33
Expected Savings by Installation of New Pumps	kW	9.55
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.76
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	4.58
Investment	Lakhs Rs.	2.00
Simple payback period	Months	5.2

Table 125:Energy savings by replacement of primary Pump of (+5 °C) 395TR with New Energy Efficient Pump

Encon 10: Energy savings by replacement of primary Pump of (-15 °C) 450TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 450 TR chiller (-15 °C) is 31% as against to the design efficiency of 67%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 1.01 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.6.05 Lakhs with a payback period of 5.4 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-15 °C) 450TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Date		
Efficiency of Existing Pump	**%**	**31.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	21.50
Proposed energy Consumption	kW	8.89
Expected Savings by Installation of New Pumps	kW	12.61
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	1.01
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	6.05
Investment	Lakhs Rs.	2.70
Simple payback period	Months	5.4

Table 126: Energy savings by replacement of primary Pump of (-15 °C) 450TR with New Energy Efficient Pump

Encon 10: Energy savings by replacement of primary Pump of (-20°C) 450TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 450 TR chiller (-20 °C) is 46% as against to the design efficiency of 66%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.79 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.77 Lakhs with a payback period of 6.8 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-15 °C) 450TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Date		
Efficiency of Existing Pump	**%**	**46.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	25.7
Proposed energy Consumption	kW	15.76
Expected Savings by Installation of New Pumps	kW	9.94
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.79
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	4.77
Investment	Lakhs Rs.	2.70
Simple payback period	Months	6.8

Table 127: Energy savings by replacement of primary Pump of (-20 °C) 450TR with New Energy Efficient Pump

4.0 HLL-09

HLL-09 is one of the production blocks in Hetero Labs Limited Nakapally.The major utilities in the HLL-09 block are as given below.

Service Block-001			
S/NO	**DESCRIPTION**	**CAPACITY**	**KW**
1.	+5˚C Chilling Plant	395 TR	160X2
2.	+5˚C Chilling Plant	173 TR	162
3.	+5˚C Chilling Plant	173 TR	162
4.	+5˚C Chilling Plant	173 TR	162
5.	-15˚C Chilling Plant	158 TR	132X2
6.	-15˚C Chilling Plant	158 TR	132X2
7.	-15˚C Chilling Plant	158 TR	132X2
8.	-40˚C Chilling Plant	52 TR	75
9.	Nitrogen Plant	300 NM^3/HR	100
10.	Breathing Air Compressor	100 CFM	30
Service Block-002			
1	+5˚C Chilling Plant	395 TR	180X2
2	+5˚C Chilling Plant	395 TR	180X2
3	+5˚C Chilling Plant	395 TR	180X2
4	-15˚C Chilling Plant	450 TR	355X2
5	-40˚CHigh Stage Plant	150 TR	110X2
	-40˚C Booster Plant		160X2
6	Plant Air Compressor	150 CFM	26
7	Instrument Air Compressor	300 CFM	55
8	Nitrogen Plant	500 NM3/HR	90 x 2
Service Block-003			
1	+5˚C Chilling Plant	395 TR	180X2
2	+5˚C Chilling Plant	395 TR	180X2
3	+5˚C Chilling Plant	395 TR	180X2
4	-15˚C Chilling Plant	450 TR	355X2
5	-40˚High Stage Plant	150 TR	110X2
	-40˚C Booster Plant		160X2
6	Plant Air Compressor	150 CFM	26
7	Instrument Air Compressor	300 CFM	55
8	Nitrogen Plant	500 NM3/HR	90 x 2
Service Block-004			
1	-15˚C Chilling Plant	450 TR	375X2
2	-15˚C Chilling Plant	450 TR	375X2
3	-40˚C Chilling Plant (High Stage)	150 TR	110X2
4	-40˚C Chilling Plant (Booster)		355
Service Block-005			
1	+5˚C Chilling Plant	300 TR	VAM
2	+5˚C Chilling Plant	300 TR	VAM
3	-15˚C Chilling Plant	158TR	132X2
4	Ice Plant	58 TR	55
5	+5˚C Chilling Plant	250 TR	223
6	+5˚C Chilling Plant	250 TR	223

Service Block-005			
1	+5˚C Chilling Plant	350 TR	305
2	+5˚C Chilling Plant	350 TR	305
3	Air Compressor	890 CFM	160
4	Instrument Air Compressor	110 CFM	22
5	Breathing Air Compressor	150 CFM	30
6	Breathing Air Compressor	150 CFM	26
7	Breathing Air Compressor	105 CFM	19

Table 128:Major Equipment list of HLL-09

HLL-09 is having 6 service blocks catering to meet the production requirements of A,B,H_2,H_3,H_4,D_2,D,Hoourlab, H_7, H_7(Crystallizer), F, G, Pharma 3, Drugs, H_{10}, SRS1, SRS2, H_{12} production blocks. In each service blocks there will be chillers ranging from -40 ^{0}Cto+5 ^{0}C depending on the production requirements. The service blocks also consist of Air Compressors for instrumentation usage and for breathing air, Nitrogen plant to meet the production demand.

The major service blocks that were in operation during field studies are as given below

S.No	Name of the service block
1.	Service Block-01
2.	Service Block-02
3.	Service Block-03
4.	Service Block-04
5.	Service Block-05
6.	Service Block-06

Table 129:Major Service Blocks of HLL-09

Each of the above service blocks meets the requirements of the following production blocks.

S.No	Name of the service block	Production blocks
1.	Service Block-01	A,B & pharma 1
2.	Service Block-02	H_2,H_3,H_4,D_2,D Block and Honour lab
3.	Service Block-03	H_7,H_{10}
4.	Service Block-04	H_2,H_3,H_4,D,H_2,H_7,Honourlab
5.	Service Block-05	SRS 1,SRS2,H12
6.	Service Block-06	H_7,F,G,Pharma 3,drugs

Table 130:Service Blocks and production blocks

4.1 SERVICE BLOCK-001

Service Block –SB01 has the following utilities to meet the production requirements of A, B& pharma 1.

Service Block-SB01:

S/NO	DESCRIPTION	CAPACITY	KW
11.	+5˚C Chilling Plant	395TR	160X2
12.	+5˚C Chilling Plant	173 TR	162
13.	+5˚C Chilling Plant	173 TR	162
14.	+5˚C Chilling Plant	173 TR	162
15.	-15˚C Chilling Plant	158 TR	132X2
16.	-15˚C Chilling Plant	158 TR	132X2
17.	-15˚C Chilling Plant	158 TR	132X2
18.	-40˚C Chilling Plant	52 TR	75
19.	Nitrogen Plant	300 NM^3/HR	100
20.	Breathing Air Compressor	100 CFM	30

Table 131:Major Equipment list of Service Block-001

4.1.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference SB-08/+5^{o}C/395TR

Description	UNITS	DESIGN DETAILS
Date		**Two skid**
Capacity	**TR**	**395**
Chilled Water Flowrate	m3/hr	239
Diff. Temp	°C	5
Operating TR		**395**
Loading	%	
Power Consumption	kW	320.0
Specific. Power consumption	kW/TR	0.81
coefficient of Performance (COP)	-	**4.3**

Table 132:Design Details of chiller reference SB-08/+5oC/395TR

Chiller Reference SB-04/-15ºC/158TR

Description	UNITS	DESIGN DETAILS
		Two Skid System
Capacity-Skid system	**TR**	**158.0**
Chilled Water Flowrate	m3/hr	130
Diff. Temp	°C	3.7
Operating TR		**158**
Loading	%	
Power Consumption	kW	264.0
Specific. Power consumption	kW/TR	1.67
coefficient of Performance (COP)	-	**2.1**

Table 133:Design Details of chiller reference SB-04/-15oC/158TR

Chiller Reference SB-05/-40ºC/52TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**52**
Chilled Water Flowrate	m3/hr	43
Diff. Temp	°C	3.6
Operating TR		**52**
Loading	%	
Power Consumption	kW	188.0
Specific. Power consumption	kW/TR	3.61
coefficient of Performance (COP)	-	**1**

Table 134: Design Details of chiller reference SB-05/-40ºC/52TR

Depending on the requirements, each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB01 of HLL-09 was given below:

4.1.2Design Details of Pumps:

Chiller Reference SB 008/+5°C/395TR

Primary Pump Reference (+5 °C) 395TR

Description	UNITS	RATED
Flow	**m^3/hr**	239
Total Head	**m**	35
Hydraulic power	**kW**	22.77
Electrical Input power	**kW**	33.16
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	29.84
Pump Efficiency	**%**	**76.31**

Table 135: Design Details of Primary Pump Reference (+5 °C) 395TR

Chiller Reference SB 004/-15°C/158TR

Primary Pump Reference (-15 °C) 158TR

Description	UNITS	RATED
Flow	**m^3/hr**	130
Total Head	**m**	20
Hydraulic power	**kW**	7.08
Electrical Input power	**kW**	9.12
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	8.21
Pump Efficiency	**%**	**86.25**

Table 136: Design Details of Primary Pump Reference (-15 °C) 158TR

Chiller Reference SB 05/-40°C/52TR

Primary Pump Reference (-40 °C) 52TR

Description	UNITS	RATED
Flow	**m^3/hr**	50
Total Head	**m**	22
Hydraulic power	**kW**	2.99
Electrical Input power	**kW**	6.22
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	5.60
Pump Efficiency	**%**	**53.2**

Table 137: Design Details of Primary Pump Reference (-40 oC) 52TR

4.1.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -40°C to +5°C. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB01 is given below.

Chiller Reference SB-08/+5°C/395TR

Chiller Reference SB-08/+5°C/395TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
		Two skid	**Two skid**
Capacity	**TR**	**395**	**358.7**
Chilled Water Flowrate	m3/hr	239	206.60
Inlet Water Temperature	°C	10	15.55
Outlet Water Temperature	°C	5	10.3
Diff. Temp	°C	5	5.3
Operating TR		**395**	**358.7**
Loading	%		97.9
Power Consumption	kW	320.0	313.3
Specific. Power consumption	kW/TR	0.81	0.87
coefficient of Performance (COP)	-	**4.3**	**4.0**
Gas Suction Pressure	kg/cm^2	-	3.4
Gas Suction Temperature	°C	-	4.8
Discharge Pressure	kg/cm^2	-	13.6
Discharge Temperature	°C	-	75

Table 138: Performance of Chiller Reference SB-08/+5oC/395TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 358TR as against to the design capacity of 395TR on two skid operation.
- The flow rate of the above chiller during performance assessment is 206m3/hr when compared to design flow of 239m3/hr.
- The specific energy consumption of the above chiller is 0.87kW/TR as against to the design specific energy consumption of 0.81 kW/TR. The operational efficiency of the above chiller is satisfactory.
- The coefficient of performance (COP) of above chiller is 4 as against to the design Coefficient of performance (COP) of 4.3.

- The discharge gas temperature is around 75ºC and when compared to other chillers in HLL-09 the gas temperature is considerably low by 20 ºC.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-04/-15ºC/158TR

Chiller Reference SB-04/-15ºC/158TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
		Two Skid	**Two skid**
Capacity-Skid system	**TR**	**158.0**	**125.4**
Chilled Water Flowrate	m3/hr	130	130.00
Inlet Water Temperature	°C	-10	-1.00
Outlet Water Temperature	°C	-15	-4.2
Diff. Temp	°C	5	3.2
Specific Heat(Cp)	Kcal/Kg °C	0.94	0.94
Specific Gravity		0.97	0.97
Operating TR		**158**	**125.4**
Loading	%		82
Power Consumption	kW	264.0	217.00
Specific. Power consumption	kW/TR	1.67	1.73
coefficient of Performance (COP)	-	**2.1**	**2**
Gas Suction Pressure	kg/cm^2	-	-
Gas Suction Temperature	°C	-	-2.3
Discharge Pressure	kg/cm^2	-	12.5
Discharge Temperature	°C	-	88.5
Note: For the above calculation design flow is taken for arriving at Specific power consumption and coefficient of performance.			

Table 139: Performance of Chiller Reference SB-04/-15oC/158TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 125.4TR as against to the design capacity of 158TR on two skid system.
- During the field measurements various trials were conducted to get the flow of the above chiller as the instrument is unable to get proper signals to get the flow measurements and flow rate of the above chiller is taken as 130m3/hr which is design flow.
- The specific energy consumption of the above chiller is 1.73kW/TR as against to the design specific energy consumption of 1.67 kW/TR. The operational efficiency of the above chiller is good.

- The coefficient of performance (COP) of above chiller is 2 as against to the design Coefficient of performance (COP) of 2.1.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 88.5°C and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower. The detailed energy conservation option has been discussed in energy conservation measures.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-02/005/-40°C/52TR

Chiller Reference SB-02/005/-40°C/52TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**52**	**37.6**
Chilled Water Flowrate	m3/hr	43	43.00
inlet Water Temperature	°C	-35	-25.50
Outlet Water Temperature	°C	-40	-29.0
Diff. Temp	°C	5	3.5
Specific Heat(Cp)	Kcal/Kg °C	0.831	0.831
Specific Gravity		0.91	0.91
Operating TR		**52**	**37.6**
Loading	%		93
Power Consumption	kW	188.0	174.00
Specific. Power consumption	kW/TR	3.61	4.62
coefficient of Performance (COP)	-	**1.0**	**0.8**
Gas Suction Pressure	kg/cm^2	-	2.5
Gas Suction Temperature	°C	-	-
Discharge Pressure	kg/cm^2	-	12.5
Discharge Temperature	°C	-	-
Note: For the above calculation design flow is taken for arriving at Specific power consumption and coefficient of performance.			

Table 140: Performance of Chiller Reference SB-02/005/-40oC/52TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 37.6TR as against to the design capacity of 52TR.
- During the field measurements various trials were conducted to get the flow of the above chiller as the instrument is unable to get proper signals to get the flow

measurements and flow rate of the above chiller is taken as 43m3/hr which is design flow.

- The specific energy consumption of the above chiller is 4.62kW/TR as against to the design specific energy consumption of 3.61 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 0.8 as against to the design Coefficient of performance (COP) of 1.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

4.1.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference SB 008/+5^{o}C/395TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

The performance evaluation of primary pumps was evaluated and presented below

Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	239	206.00
Total Head	**m**	35	22.90
Hydraulic power	**kW**	22.77	12.84
Electrical Input power	**kW**	33.16	20.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	29.84	18.00
Pump Efficiency	**%**	**76.31**	**71.34**

Table 141:Performancce of Primary Pumps SB 008/+5oC/395TR

Observations and findings:

- The operating flow of primary pump is 206 m3/hr when compared to design flow of 239m3/hr.

- The hydraulic power of the primary pump is 12.84kW when compared to design hydraulic power of 22.77kW.
- The operating efficiency of the primary pump is 71% when compared to design efficiency of 76%. The primary pump operating performance is satisfactory.

Note: The performance of primary pumps of chiller SB-004/-15°C/158TR & SB-005/-40°C/52TR was not tabulated as design flow is considered for performance of chillers.

4.1.5 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used. The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporative Condenser Reference:SB-08/+5°C/395TR

Parameter Reference	SB-08/+5°C/395TR
CT Inlet Temp. °C	33.9
CT Outlet Temp. °C	30.9
Ambient Temp. °C	35.9
Wet BulbTemp. °C	29
Range °C	3
Approach °C	1.9
Effectiveness = Range/(Range + Approach)	61.22
Air inlet condition	
DBT, °C	35.9
RH, %	55
Enthalpy, kCal/kg	21.1
Air flow rate, m^3/hr	124682
Air flow rate, kg/hr	132230.29
Air outlet condition	
DBT, °C	37
RH, %	70
Enthalpy, kCal/kg	28.56
Enthalpy Difference, KCal/kg	7.5
TR	356.99

Table 142:Performanc e of evaporator condensor SB-08/+5oC/395TR

Observations and findings:

- The operating range of the above evaporative condenser is 3^{0}C and approach is 1.9^{0}C.
- The operating effectiveness is to the tune of 61.22%.
- The TR rejected to atmosphere of the above evaporative condenser is 356.99TR.
- The performance of the above evaporative condenser is satisfactory.

Evaporative Condenser Reference: SB 005/-40ºC/52TR

Parameter Reference	SB-02/SB 005/-40ºC/52TR
CT Inlet Temp. ºC	32
CT Outlet Temp. ºC	29.2
Ambient Temp. ºC	35.9
Wet Bulb Temp. ºC	27.5
Range ºC	2.8
Approach ºC	1.7
Effectiveness = Range/(Range + Approach)	62.22
Air inlet condition	
DBT, ºC	35.9
RH, %	58
Enthalpy, kCal/kg	22.0
Air flow rate, m^3/hr	20828
Air flow rate, kg/hr	22088.55
Air outlet condition	
DBT, ºC	37
RH, %	72
Enthalpy, kCal/kg	26.75
Enthalpy Difference, kCal/kg	4.7
TR	37.84

Table 143: Performanc e of evaporator condensor SB-02/SB 005/-40oC/52TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.8^{0}C and approach is 1.7^{0}C.
- The operating effectiveness is to the tune of 62.22%.
- The TR rejected to atmosphere of the above evaporative condenser is 37.84TR.
- The performance of the above evaporative condenser is satisfactory.

4.1.6 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-08/+5 ^{o}C/395TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5oC chiller is in the range of 9^{o}C to 10oC.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5oC,- 15oC ,- 20oC & -40oC.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently +5^{o}C chiller of capacity 395TR is running with a set point of 5^{o}C to 7^{o}C.The compressor will be in OFF condition once reaches 5^{o}C and compressor will be ON once the temperature reaches 7^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3^{o}C to 5^{o}C i.e., keeping set point at 8^{o}C to 12^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%. By increasing the set point there will be envisaged annual savings of 1.69 Lakh kWh with an annual monetary savings of Rs.10.15 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-08/+5 ºC/395TR		
Description	**Units**	**Value**
Chiller Ref		**SB-08/+5 ºC/395TR**
Normal operating inlet temperature of Water	°C	15.55
Normal operating outlet temperatures of Water	°C	10.3
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	313.3
Percentage reduction in power consumption of compressor	kW	37.6
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.69
Envisaged annual Monetary savings	Lakhs Rs	10.15
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 144: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-08/+5 oC/395TR

Encon 2: Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference SB-04/-15 oC/158TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15°C chiller is in the range of -4°C to -6°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15°C chiller of capacity 158TR is running with a set point of -10°C to -12°C. The compressor will be in OFF condition once reaches -12°C and compressor will be ON once the temperature reaches -10°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 5°C i.e., keeping set point at -5°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.73 Lakh kWh with an annual monetary savings of Rs.4.43 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference SB-04/-15 °C/158TR		
Description	**Units**	**Value**
Chiller Ref		**SB-04/-15 °C/158TR**
Normal operating inlet temperatures of Water	°C	-1
Normal operating out temperatures of Water	°C	-4.2
Present set point	°C	-10
Suggested to increase the set point	°C	-5
Increase in set point	°C	5
Present power consumption	kW	82
Percentage reduction in power consumption of compressor	kW	16.4
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.73
Envisaged annual Monetary savings	Lakhs Rs	4.43
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 145: Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference SB-04/-15 °C/158TR

Encon 3: Optimization of chiller Evaporator temperature by adjusting the existing set point of 52TR chiller with reference SB005/-40oC/52TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -40^{o}C chiller is in the range of -27 to -30^{o}C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -40^{o}C chiller of capacity 52TR is running with a set point of -35^{o}C.The compressor will be in OFF condition once reaches -35^{o}C and compressor will be ON once the temperature reaches -30^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by -30^{o}C from -35^{o}C i.e., increase the set point by 5^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.56 Lakh kWh with an annual monetary savings of Rs.9.39 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 52TR chiller with reference SB005/-40^{o}C/52TR		
Description	**Units**	**Value**
Chiller Ref		**US-4/RFS 004/-20^{o}C/450TR**
Normal operating inlet temperature of Water	°C	-25.50
Normal operating out temperature of Water	°C	-29
Present set point	°C	-35
Suggested to increase the set point	°C	-5
Increase in set point	°C	5
Present power consumption	kW	174
Percentage reduction in power consumption of compressor	kW	34.8
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.56
Envisaged annual Monetary savings	Lakhs Rs	9.39
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 146: Optimization of chiller Evaporator temperature by adjusting the existing set point of 52TR chiller with reference SB005/-40^{o}C/52TR

Encon 4: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve, the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-09/service block-01		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold-water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 147: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 5: Energy Savings by changing operating breathing air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for breathing air requirements of the servicing production blocks. The existing pressure settings for the air compressors were 5 – 6 kg/cm^{2}. .i.e. at 5 the compressor will be in OFF condition and at 6 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 2-2.5kg/cm^{2}.

Proposed Condition:

It is proposed to change the pressure settings to 3 – 3.5 kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.2 Lakh kWh savings with an annual monetary savings of Rs.1.01 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating breathing air compressor pressure settings		
Description	**Units**	**Value**
HLL-09/service block-01		**Compressors**
Existing compressor pressure settings-off	kg/cm^{2}	5
Existing compressor pressure settings-on	kg/cm^{2}	6
Existing capacity of air Compressor	CFM	100.00
Power consumption of air Compressor	kW	14.9
Existing compressor pressure settings-off	kg/cm3	3.5
Existing compressor pressure settings-on	kg/cm2	3
Estimated Power consumption for proposed power consumption	kW	11.17
Reduction in power consumption	kW	3.7
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.2
Envisaged annual Monetary savings	Lakhs Rs	1.01
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 148: Energy Savings by changing operating breathing air compressor pressure settings

Encon 6: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-04/-15 oC/158TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 88.5°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference SB-04/-15 oC/158TR before it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 33.7 Kgs of coal per hour and equivalent annual monetary savings of Rs.4.6 Lakhs with a payback period of 23.7 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water		
	SB-04/-15oC/158TR	
Description	**UNITS**	**ACTUAL**
Date		
Capacity	**TR**	**158.0**
Inlet Water Temperature	°C	-1.00
Outlet Water Temperature	°C	-4.2
Diff. Temp	°C	3.2
Operating TR		**125.4**
Gas Suction Temperature	°C	-2.3
Discharge Temperature	°C	88.5
Amount of heat available before evaporative condenser	kcals/hr	379210
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	75842
Equivalent coal savings	kg/hr	33.7
Expected annual monetary savings	Lakhs Rs.	4.6
Investment	Lakhs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	23.7

Table 149: Energy savings by recovering heat energy from hot refrigerant for making hot water

4.2 SERVICE BLOCK-002

Service Block –SB02 has the following utilities to meet the production requirements of H_2, H3, H4, D2, D Block and Honour lab.

Service Block-SB002:

S/NO	DESCRIPTION	CAPACITY	KW
1	+5˚C Chilling Plant	395 TR	180X2
2	+5˚C Chilling Plant	395 TR	180X2
3	+5˚C Chilling Plant	395 TR	180X2
4	-15˚C Chilling Plant	450 TR	355X2
5	-40˚CHigh Stage Plant	150 TR	110X2
	-40˚C Booster Plant		160X2
6	Plant Air Compressor	150 CFM	26
7	Instrument Air Compressor	300 CFM	55
8	Nitrogen Plant	500 NM3/HR	90 x 2

Table 150:Equipment List of Service block 002

4.2.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference:SB-2/+5ºC/362TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**362**
Chilled Water Flowrate	m3/hr	219
Diff. Temp	°C	5
Operating TR		**362**
Loading	%	
Power Consumption	kW	315.0
Specific. Power consumption	kW/TR	0.87
Coefficient of Performance (COP)	-	**4.0**

Table 151:Design Details of Chiller Reference:SB-2/+5ºC/362TR

In the above service block -15ºC and -40ºC chillers of capacities 450TR and 102TR were also installed whereas -40ºC of capacity 102TR is under breakdown. Hence the performance assessment was done for 362TR capacity only.

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB02 of HLL-09 was given below:

4.2.2 Design Details of Pumps:

Chiller Reference SB-2/+5oC/362TR

Primary Pump Reference (+5 ºC) 362TR

Description	UNITS	RATED
Flow	**m^3/hr**	220
Total Head	**m**	25
Hydraulic power	**kW**	14.97
Electrical Input power	**kW**	24.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	22
Pump Efficiency	**%**	**68**

Table 152:Design Details of Primary Pump Reference (+5 oC) 362TR

4.2.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -40ºC to +5ºC. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB02 is given below.

Chiller Reference SB-2/+5oC/362TR

Chiller Reference SB-2/+5ºC/362TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**362**	**121.9**
Chilled Water Flowrate	m3/hr	219	112.87
Inlet Water Temperature	°C	10	13.53
Outlet Water Temperature	°C	5	10.3
Diff. Temp	°C	5	3.3
Operating TR		**362**	**121.9**
Loading	%		99.0
Power Consumption	kW	315.0	105.0
Specific. Power consumption	kW/TR	0.87	0.86
Coefficient of Performance (COP)	-	**4.0**	**4.1**
Gas Suction Pressure	kg/cm^2	-	0.5
Gas Suction Temperature	°C	-	5.2
Discharge Pressure	kg/cm^2	-	15
Discharge Temperature	°C	-	88.8

Table 153:Performance of Chiller Reference SB-2/+5oC/362TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 122TR as against to the design capacity of 362TR.
- It is observed from the above table the flow rate is 112 m3/hr as against to the design flow of 219m3/hr.
- The specific energy consumption of the above chiller is 0.86 kW/TR as against to the design specific energy consumption of 0.87 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 4.1 as against to the design Coefficient of performance (COP) of 4.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

4.2.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference SB-2/+5ºC/362TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
3	1	2

The performance evaluation of primary pumps was evaluated and presented below

Pumps		PRIMARY (+5 ºC) /362TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	220	112.00
Suction Head	**m**	-	1.80
Discharge Head	**m**	-	18.00
Total Head	**m**	25	16.20
Hydraulic power	**kW**	14.97	4.94
Electrical Input power	**kW**	24.44	10.80
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	22.00	9.72
Pump Efficiency	**%**	**68.06**	**50.81**

Table 154:Performance of Primary Pumps (+5 oC) /362TR

Observations and findings:

- The operating flow of primary pump is 112m3/hr when compared to design flow of 220m3/hr.
- The hydraulic power of the primary pump is 4.94kW when compared to design hydraulic power of 14.97kW.
- The operating efficiency of the primary pump is 50.8% when compared to design efficiency of 68%.The primary pump operating performance is satisfactory.
- It is observed that the design efficiency of primary pump is only 68% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

4.2.5 Performance Assessment of Evaporative Condensers:

The service block chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used. The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporative Condenser Reference:SB-02/+5ºC/362TR

Parameter Reference	SB-2/+5oC/362TR
CT Inlet Temp. ºC	30.7
CT Outlet Temp. ºC	28.8
Ambient Temp. ºC	36
Wet BulbTemp. ºC	27.4
Range ºC	1.9
Approach ºC	1.4
Effectiveness = Range/(Range + Approach)	57.58
Air inlet condition	
DBT, ºC	36
RH, %	50
Enthalpy, kCal/kg	20.2
Air flow rate, m^3/hr	53880
Air flow rate, kg/hr	57123.74
Air outlet condition	
DBT, ºC	36
RH, %	80
Enthalpy, kCal/kg	27.46
Enthalpy difference, kCal/kg	7.3
TR	150.32

Table 155:Performance of Evaporator Condenser Reference:SB-02/+5oC/362TR

Observations and findings:

- The operating range of the above evaporative condenser is 1.9^0C and approach is 1.4^0C.
- The operating effectiveness is to the tune of 57%.
- The TR rejected to atmosphere of the above evaporative condenser is 150 TR.
- The performance of the above evaporative condenser is satisfactory.

4.2.6 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 362TR chiller with reference SB-2/+5ºC/362TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5ºC chiller is in the range of +9 to 10ºC.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5ºC,- 5ºC,- 15ºC ,- 20ºC & -40ºC.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5ºC chiller of capacity 362TR is running with a set point of 5ºC to 7ºC.The compressor will be in OFF condition once reaches 5ºC and compressor will be ON once the temperature reaches 7ºC.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3ºC to 5ºC i.e., keeping set point at 8ºC to 12ºC. For every 5.5ºC raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.56 Lakh kWh with an annual monetary savings of Rs.3.4 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 362TR chiller with reference SB-2/+5^{o}C/362TR		
Description	**Units**	**Value**
Chiller Ref		**SB-2/+5^{o}C/362TR**
Normal operating inlet temperature of Water	°C	13.53
Normal operating outlet temperatures of Water	°C	10.3
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	105
Percentage reduction in power consumption of compressor	kW	12.6
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.56
Envisaged annual Monetary savings	Lakhs Rs	3.4
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 156: Optimization of chiller Evaporator temperature by adjusting the existing set point of 362TR chiller with reference SB-2/+5oC/362TR

Encon 2: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.8 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-09/service block-02		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.8
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 157: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 3: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-2/+5oC/362TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 88.9°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference SB-2/+5°C/362TR before it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 32.8 Kgs of coal per hour and equivalent annual monetary savings of Rs.4.4 Lakhs with an investment of 9 lakh and the payback period of 24.4 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water		
	SB02/+5°C/362 TR	
Description	**UNITS**	**ACTUAL**
Date		
Capacity	**TR**	**362.0**
Inlet Water Temperature	°C	13.53
Outlet Water Temperature	°C	10.3
Diff. Temp	°C	3.3
Operating TR		**121.9**
Gas Suction Temperature	°C	5.2
Discharge Temperature	°C	88.8
Amount of heat available before evaporative condenser	kcals/hr	368626
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	73725
Equivalent coal savings	kg/hr	32.8
Expected annual monetary savings	Lakhs Rs.	4.4
Investment	Lakhs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	24.4

Table 158: Energy savings by recovering heat energy from hot refrigerant for making hot water

Encon 4: Energy Savings by changing operating air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for Instrument air requirements of the servicing production blocks. The existing pressure settings for the air compressors were 6.5 -7 kg/cm^{2}. .i.e. at 6.5 the compressor will be in OFF condition and at 7 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3 - 3.5kg/cm^{2}.

Proposed Condition:

It is proposed to change the pressure settings to 5 – 5.5 kg/cm^{2}for instrument air compressors. The above operational adjustment will lead to 0.5 Lakh kWh savings with an annual monetary savings of Rs.3.08 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating air compressor pressure settings		
Description	**Units**	**Value**
HLL-09/service block-02		**Compressors**
Existing compressor pressure settings-off	kg/cm^{2}	7
Existing compressor pressure settings-on	kg/cm^{2}	6.5
Existing capacity of air Compressor	CFM	300.00
Power consumption of air Compressor	kW	81.5
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	70.1
Reduction in power consumption	kW	11.4
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.5
Envisaged annual Monetary savings	Lakhs Rs	3.08
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note: For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 159: Energy Savings by changing operating air compressor pressure settings

4.3 Service Block-003

Service Block –SB003 has the following utilities to meet the production requirements of H_7,H_{10}.

Service Block-SB003:

S/NO	DESCRIPTION	CAPACITY	KW
1	+5˚C Chilling Plant	395 TR	180X2
2	+5˚C Chilling Plant	395 TR	180X2
3	+5˚C Chilling Plant	395 TR	180X2
4	-15˚C Chilling Plant	450 TR	355X2
5	-40˚High Stage Plant	150 TR	110X2
	-40˚C Booster Plant		160X2
6	Plant Air Compressor	150 CFM	26
7	Instrument Air Compressor	300 CFM	55
8	Nitrogen Plant	500 NM3/HR	90 x 2

Table 160:Equipment list of service block -003

4.3.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference SB-3/+5ºC/395TR/Comp-02

Description	UNITS	DESIGN DETAILS
Date		**Two Skids**
Capacity	**TR**	**395**
Chilled Water Flowrate	m3/hr	239
Diff. Temp	°C	5
Operating TR		**395**
Loading	%	
Power Consumption	kW	360.0
Specific. Power consumption	kW/TR	0.91
Coefficient of Performance (COP)	-	**3.9**

Table 161:Design details of Chiller Reference SB-3/+5ºC/395TR/Comp-02

Chiller Reference SB-3/+5ºC/395TR/Comp-01

Description	UNITS	DESIGN DETAILS
Date		**Two Skids**
Capacity	**TR**	**395**
Chilled Water Flowrate	m3/hr	239
Diff. Temp	°C	5
Operating TR		**395**
Loading	%	
Power Consumption	kW	360.0
Specific. Power consumption	kW/TR	0.91
Coefficient of Performance (COP)	-	**3.9**

Table 162:Design Details of Chiller Reference SB-3/+5oC/395TR/Comp-01

Chiller Reference SB-3/AM/Comp-4/-15ºC/450TR

Description	UNITS	DESIGN DETAILS
Date		**Two Skids**
Capacity	**TR**	**450**
Chilled Water Flowrate	m3/hr	315
Diff. Temp	°C	4.4
Operating TR		**450**
Loading	%	
Power Consumption	kW	670.0
Specific. Power consumption	kW/TR	1.49
Coefficient of Performance (COP)	-	**2.4**
Gas Suction Pressure	kg/cm^2	1
Gas Suction Temperature	°C	-20
Discharge Pressure	kg/cm^2	15
Discharge Temperature	°C	80

Table 163:Design Details of Chiller Reference SB-3/AM/Comp-4/-15ºC/450TR

Chiller Reference SB-3/-40ºC/150TR

Description	UNITS	DESIGN DETAILS
Date		**Two Skid**
Capacity-Skid system	**TR**	**150**
Chilled Water Flowrate	m3/hr	135
Diff. Temp	°C	3.5
Operating TR		**156.3**
Loading	%	
Power Consumption	kW	584
Specific. Power consumption	kW/TR	3.89
Coefficient of Performance (COP)	-	**0.9**

Table 164: Design Details of Chiller Reference SB-3/-40ºC/150TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB03 of HLL-09 was given below:

4.3.2 Design Details of Pumps:

Chiller Reference SB-3/+5ºC/395TR/Comp-02
Primary Pump Reference (+5 ºC) 395 TR

Description	UNITS	RATED
Flow	**m^3/hr**	175
Total Head	**m**	50
Hydraulic power	**kW**	23.82
Electrical Input power	**kW**	41.11
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.00
Pump Efficiency	**%**	**64.38**

Table 165: Design Details of Primary Pump (+5 ºC) 395TR/comp-02

Chiller ReferenceSB-3/+5oC/395TR/Comp-01
Primary Pump Reference (+5 ºC) 395 TR

Description	UNITS	RATED
Flow	**m^3/hr**	175
Total Head	**m**	50
Hydraulic power	**kW**	23.82
Electrical Input power	**kW**	41.11
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.00
Pump Efficiency	**%**	**64.38**

Table 166: Design Details of Primary Pump (+5 ºC) 395TR/comp-01

Chiller ReferenceSB-3/AM/Comp-4/-15oC/450TR
Primary Pump Reference (-15 ºC)450 TR

Description	UNITS	RATED
Flow	**m^3/hr**	315
Total Head	**m**	32
Hydraulic power	**kW**	26.62
Electrical Input power	**kW**	41.11
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.00
Pump Efficiency	**%**	**71.94**

Table 167: Design Details of Primary Pump (-15 ºC) 450TR

Chiller ReferenceSB-3/-40oC/150TR

Primary Pump Reference (-40 °C) 150 TR

Description	UNITS	RATED
Flow	**m^3/hr**	180
Total Head	**m**	40
Hydraulic power	**kW**	17.84
Electrical Input power	**kW**	33.33
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	30.00
Pump Efficiency	**%**	**59.45**

Table 168: Design Details of Primary Pump (-40 °C) 150TR

4.3.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -40°C to +5 °C. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB03 is given below

Chiller Reference SB-3/+5oC/395TR/Comp-02

Chiller Reference SB-3/+5°C/395TR/Comp-02			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
		Two Skids	**Two Skid**
Capacity	**TR**	**395**	**345.2**
Chilled Water Flowrate	m3/hr	239	180.00
Inlet Water Temperature	°C	10	14.30
Outlet Water Temperature	°C	5	8.5
Diff. Temp	°C	5	5.8
Operating TR		**395**	**345.2**
Loading	%		76.9
Power Consumption	kW	360.0	277.0
Specific. Power consumption	kW/TR	0.91	0.80
Coefficient of Performance (COP)	-	**3.9**	**4.4**
Gas Suction Pressure	kg/cm^2	-	3.5
Gas Suction Temperature	°C	-	4.8
Discharge Pressure	kg/cm^2	-	13.5
Discharge Temperature	°C	-	70

Table 169:Performance of Chiller Reference SB-3/+5oC/395TR/Comp-02

Observations and findings:

- It is observed from the above table that the chiller is delivering 345.2TR as against to the design capacity of 395TR.
- The flow rate of the above chiller during performance assessment is 180m3/hr when compared to design flow of 239m3/hr.
- The specific energy consumption of the above chiller is 0.8kW/TR as against to the design specific energy consumption of 0.91 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 4.4 as against to the design Coefficient of performance (COP) of 3.9.
- The chiller is equipped with evaporative cooling towers.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-3/+5°C/395TR/Comp-01

Chiller Reference SB-3/+5°C/395TR/Comp-01			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
		Two Skids	**One skid (B)**
Capacity	**TR**	**395**	**173.5**
Chilled Water Flowrate	m3/hr	239	218.56
InletWater Temperature	°C	10	11.90
Outlet Water Temperature	°C	5	9.5
Diff. Temp	°C	5	2.4
Operating TR		**395**	**173.5**
Loading	%		76.7
Power Consumption	kW	360.0	138.0
Specific. Power consumption	kW/TR	0.91	0.80
Coefficient of Performance (COP)	-	**3.9**	**4.4**
Gas Suction Pressure	kg/cm^2	-	4
Gas Suction Temperature	°C	-	4.9
Discharge Pressure	kg/cm^2	-	13.4
Discharge Temperature	°C	-	69.8

Table 170: Performance of Chiller Reference SB-3/+5oC/395TR/Comp-01

Observations and findings:

- It is observed from the above table that the chiller is delivering 173.5TR during single skid operation as against to the design capacity of 395TR during two skid operation (during single skid operation design capacity is 197.5TR).
- The flow rate of the above chiller during performance assessment is 218m3/hr when compared to design flow of 239m3/hr.

- The TR delivered is in line with the design capacity considering single skid operation.
- The specific energy consumption of the above chiller is 0.8kW/TR as against to the design specific energy consumption of 0.91 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 4.4 as against to the design Coefficient of performance (COP) of 3.9.
- The chiller is equipped with evaporative cooling tower.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-3/-15ºC/Comp-4/450TR

Chiller Reference SB-3/-15ºC/ Comp-4/450TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
		Two Skids	**One skid (B)**
Capacity	**TR**	**450**	**150.7**
Chilled Water Flowrate	m3/hr	315	277.72
Inlet Water Temperature	°C	-10	-6.60
Outlet Water Temperature	°C	-15	-8.4
Diff. Temp	°C	5	1.8
Specific Heat(Cp)	K Cal/Kg °C	0.94	0.94
Specific Gravity		0.97	0.97
Operating TR		**458.3**	**150.7**
Loading	%		92
Power Consumption	kW	670.0	309.00
Specific. Power consumption	kW/TR	1.49	2.05
Coefficient of Performance (COP)	-	**2.4**	**1.7**
Gas Suction Pressure	kg/cm^2	1	2
Gas Suction Temperature	°C	-20	-3
Discharge Pressure	kg/cm^2	15	11.3
Discharge Temperature	°C	80	71.2

Table 171: Performance of Chiller Reference SB-3/-15ºC/Comp-4/450TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 150.7 TR during single skid operation as against to the design capacity of 450TR during two skid operation. (during single skid operation design capacity is 225TR).
- The flow rate of the above chiller during performance assessment is 278m3/hr when compared to design flow of 315m3/hr.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as well as less flow as against the design temperature difference (delta T) and design flow.
- The specific energy consumption of the above chiller is 2.05kW/TR as against to the design specific energy consumption of 1.49 kW/TR. The operational efficiency of the

above chiller is not satisfactory. The above chiller requires attention during regular maintenance.

- The coefficient of performance (COP) of above chiller is 1.7 as against to the design Coefficient of performance (COP) of 2.4.
- The chiller is equipped with evaporative cooling tower
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-3/-40ºC/150TR

Chiller Reference SB-3/-40ºC/150TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two Skid**	**High Stage +Booster**
Capacity-Skid system	**TR**	**150**	**48.7**
Chilled Water Flowrate	m3/hr	135	139.00
Inlet Water Temperature	°C	-35	-23.20
Outlet Water Temperature	°C	-40	-24.6
Diff. Temp	°C	5	1.4
Specific Heat(Cp)	K Cal/Kg °C	0.831	0.831
Specific Gravity		0.91	0.91
Operating TR		**156.3**	**48.7**
Loading	%		35
Power Consumption	kW	584.0	207.00
Specific. Power consumption	kW/TR	3.89	4.25
Coefficient of Performance (COP)	-	**0.9**	0.8
Gas Suction Pressure	kg/cm^2	-	2.5
Gas Suction Temperature	°C	-	-
Discharge Pressure	kg/cm^2	-	13
Discharge Temperature	°C	-	75.5

Table 172: Performance of Chiller Reference SB-3/-40oC/150TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 48.7TR as against to the design capacity of 150TR.
- The flow rate of the above chiller during performance assessment is 139m3/hr when compared to design flow of 135m3/hr.
- The specific energy consumption of the above chiller is 4.25 kW/TR as against to the design specific energy consumption of 3.89 kW/TR. The operational efficiency of the above chiller is good.

- The coefficient of performance (COP) of above chiller is 0.8 as against to the design Coefficient of performance (COP) of 0.9.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

4.3.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference SB-3/+5ºC/395TR/Comp-02

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
4	1	3

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY +5ºC 395 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	175	180.00
Suction Head	**m**	-	8.00
Discharge Head	**m**	-	28.00
Total Head	**m**	50	20.00
Hydraulic power	**kW**	23.82	9.80
Electrical Input power	**kW**	41.11	29.40
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.00	26.46
Pump Efficiency	**%**	**64.38**	**37.04**

Table 173:Performance of Primary Pump +5ºC 395 TR

Observations and findings:

- The operating flow of primary pump is 180m3/hr when compared to design flow of 175m3/hr.
- The hydraulic power of the primary pump is 9.8kW when compared to design hydraulic power of 23.82kW.
- The operating efficiency of the primary pump is 37% when compared to design efficiency of 64%.The primary pump operating performance is not satisfactory.

- It is observed that the design efficiency of primary pump is only 64% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference SB-3/+5oC/395TR/Comp-01

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
4	1	3

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY +5°C 395 TR	
Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	175	173.50
Suction Head	**m**	-	8.00
Discharge Head	**m**	-	28.00
Total Head	**m**	50	20.00
Hydraulic power	**kW**	23.82	9.45
Electrical Input power	**kW**	41.11	28.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.00	25.20
Pump Efficiency	**%**	**64.38**	**37.48**

Table 174:Performance of Primary Pump +5oC 395 TR

Observations and findings:

- The operating flow of primary pump is 173.5m3/hr when compared to design flow of 175m3/hr.
- The hydraulic power of the primary pump is 9.45kW when compared to design hydraulic power of 23.82kW.
- The operating efficiency of the primary pump is 37.4% when compared to design efficiency of 64%.The primary pump operating performance is not satisfactory.
- It is observed that the design efficiency of primary pump is only 64% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference SB-3/AM/Comp-4/-15oC/450TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY -15°C 450 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	315	277.00
Suction Head	**m**	-	5.00
Discharge Head	**m**	-	28.00
Total Head	**m**	32	23.00
Hydraulic power	**kW**	26.62	16.8
Electrical Input power	**kW**	41.11	38.10
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.00	34.29
Pump Efficiency	**%**	**71.94**	**49.06**

Table 175:Performance of Primary Pump of -15oC 450 TR

Observations and findings:

- The operating flow of primary pump is 277m3/hr when compared to design flow of 315m3/hr.
- The hydraulic power of the primary pump is 16.8 kW when compared to design hydraulic power of 26.62 kW.
- The operating efficiency of the primary pump is 49% when compared to design efficiency of 74%.The primary pump operating performance is not satisfactory.

Chiller Reference SB-3/-40oC/150TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY -40^{o}C 150 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	180	139.00
Suction Head	**m**	-	1.60
Discharge Head	**m**	-	36.00
Total Head	**m**	40	34.40
Hydraulic power	**kW**	17.84	11.85
Electrical Input power	**kW**	33.33	22.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	30.00	19.80
Pump Efficiency	**%**	**59.45**	**59.8**

Table 176:Performance of primary pump -40oC 150 TR

Observations and findings:

- The operating flow of primary pump is 139m3/hr when compared to design flow of 180m3/hr.
- The hydraulic power of the primary pump is 11.85 kW when compared to design hydraulic power of 17.84 kW.
- The operating efficiency of the primary pump is 60% when compared to design efficiency of 60%. The primary pump operating performance is satisfactory.
- A detailed energy conservation option was discussed in encon chapter for replacing the above primary pump with new energy efficient pump.
- It is observed that the design efficiency of primary pump is only 60% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

4.3.5 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used.The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Chiller Reference SB-3/AM/Comp-4/-15oC/450TR

Parameter Reference	SB-3/AM/Comp-4/-15oC/450TR
CT Inlet Temp. °C	32.1
CT Outlet Temp. °C	29.2
Ambient Temp. °C	34.2
Wet BulbTemp. °C	27.3
Range °C	2.9
Approach °C	1.9
Effectiveness = Range/(Range + Approach)	60.42
Air inlet condition	
DBT, °C	34.2
RH, %	65
Enthalpy, kCal/kg	20.8
Air flow rate, m^3/hr	128700
Air flow rate, kg/hr	137245.99
Air outlet condition	
DBT, °C	34.2
RH, %	85
Enthalpy, kCal/kg	25.50
Enthalpy Difference, Kcal/kg	4.7
TR	233.85

Table 177:Performance of evaporator condenser SB-3/AM/Comp-4/-15oC/450TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.9^{0}C and approach is 1.9^{0}C.
- The operating effectiveness is to the tune of 60.42%.
- The TR rejected to atmosphere of the above evaporative condenser is 234TR.
- The performance of the above evaporative condenser is satisfactory.

4.3.6 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 ^{o}C/395TR/Comp-01

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5^{o}C chiller is in the range of +9 to 10^{o}C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5^{o}C chiller of capacity 395TR is running with a set point of 5^{o}C to 7^{o}C.The compressor will be in OFF condition once reaches 5^{o}C and compressor will be ON once the temperature reaches 7^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3^{o}C to 5^{o}C i.e., keeping set point at 8^{o}C to 12^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 0.74 Lakh kWh with an annual monetary savings of Rs.4.47 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 °C/395TR/Comp-01		
Description	**Units**	**Value**
Chiller Ref		**SB-03/+5 °C/395TR/Comp-01**
Normal operating inlet temperature of Water	°C	11.90
Normal operating outlet temperatures of Water	°C	9.5
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	138
Percentage reduction in power consumption of compressor	kW	16.56
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.74
Envisaged annual Monetary savings	Lakhs Rs	4.47
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 178: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 oC/395TR/Comp-01

Encon 2:Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 oC/395TR/Comp-02

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of +9 to 10°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently +5°C chiller of capacity 395TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.49 Lakh kWh with an annual monetary savings of Rs.8.97 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 °C/395TR/Comp-02		
Description	**Units**	**Value**
Chiller Ref		**SB-03/+5 °C/395TR/Comp-02**
Normal operating inlet temperature of Water	°C	14.30
Normal operating outlet temperatures of Water	°C	8.5
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	277
Percentage reduction in power consumption of compressor	kW	33.24
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.49
Envisaged annual Monetary savings	Lakhs Rs	8.97
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 179: Optimization of chiller Evaporator temperature by adjusting the existing set point of 395TR chiller with reference SB-03/+5 oC/395TR/Comp-02

Encon 3:Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-03/-15 oC/Comp-04/450TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15^{o}C chiller is in the range of -4 to -6^{o}C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15^{o}C chiller of capacity 450TR is running with a set point of -15^{o}C. The compressor will be in OFF condition once reaches -15^{o}C and compressor will be ON once the temperature reaches -12^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 5^{o}C i.e., keeping set point at -7^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 3.47 Lakh kWh with an annual monetary savings of Rs.20.85 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-03/-15 °C/Comp-04/450TR		
Description	**Units**	**Value**
Chiller Ref		**SB-03/-15 °C/Comp-04/450TR**
Normal operating inlet temperatures of Water	°C	-6.6
Normal operating outlet temperatures of Water	°C	-8.4
Present set point	°C	-15
Suggested to increase the set point	°C	-7
Increase in set point	°C	8
Present power consumption	kW	309
Percentage reduction in power consumption of compressor	kW	77.25
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	3.47
Envisaged annual Monetary savings	Lakhs Rs	20.85
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Centigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 180: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-03/-15 oC/Comp-04/450TR

Encon 4: Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB03/-40oC/150TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -40°C chiller is in the range of -27 to -30°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -40°C chiller of capacity 150TR is running with a set point of -30°C.The compressor will be in OFF condition once reaches -30°C and compressor will be ON once the temperature reaches -27°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by -25°C from -30°C i.e., increase the set point by 5°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.86 Lakh kWh with an annual monetary savings of Rs.11.17 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB03/-40°C/150TR		
Description	**Units**	**Value**
Chiller Ref		**US-4/RFS 004/-20°C/450TR**
Normal operating inlet temperature of Water	°C	-23.20
Normal operating iout temperature of Water	°C	-24.6
Present set point	°C	-30
Suggested to increase the set point	°C	-25
Increase in set point	°C	5
Present power consumption	kW	207
Percentage reduction in power consumption of compressor	kW	41.4
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.86
Envisaged annual Monetary savings	Lakhs Rs	11.17
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 181: Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB03/-40oC/150TR

Encon 5:Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-09/service block-03		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 182: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 6:Energy Savings by changing operating air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for instrument air requirements of the servicing production blocks. The existing pressure settings for the air compressors were 6.5 – 7 kg/cm^{2}. .i.e. at 6.5 the compressor will be in OFF condition and at 7 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3 - 3.5kg/cm^{2}.

Proposed Condition:

It is proposed to change the pressure settings to 5 – 5.5 kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.3 Lakh kWh savings with an annual monetary savings of Rs.1.99 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating air compressor pressure settings		
Description	**Units**	**Value**
HLL-09/service block-01		**Compressors**
Existing compressor pressure settings-off	kg/cm^{2}	7
Existing compressor pressure settings-on	kg/cm^{2}	6.5
Existing capacity of air Compressor	CFM	300.00
Power consumption of air Compressor	kW	52.7
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	45.32
Reduction in power consumption	kW	7.4
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.3
Envisaged annual Monetary savings	Lakhs Rs	1.99
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 183: Energy Savings by changing operating air compressor pressure settings

Encon 7: Energy savings by replacement of primary Pump of (-40°C) 150TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 150 TR chiller (-40 °C) is 60% as against to the design efficiency of 60%, which can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.35 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.2.11 Lakhs with a payback period of 12.5 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-40 °C) 150TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Date		
Efficiency of Existing Pump	**%**	**60.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	22.00
Expected Savings by Installation of New Pumps	kW	4.40
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum (in Lakhs)	0.35
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	2.11
Investment	Lakhs Rs.	2.20
Simple payback period	Months	12.5

Table 184: Replacement of Primary Pump of (-40 °C) 150TR with New Energy Efficient Pump

4.4 Service Block-004

Service Block –SB004 has the following utilities to meet the production requirements of H_2, H3, H4, D, H2, H7, Honour lab.

Service Block-SB004

S/NO	DESCRIPTION	CAPACITY	KW
1	-15˚C Chilling Plant	450 TR	375X2
2	-15˚C Chilling Plant	450 TR	375X2
3	-40˚C Chilling Plant (High Stage)	150 TR	110X2
	-40˚C Chilling Plant (Booster)		-

Table 185:Equipment List of Service Block-004

4.4.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference SB-4/AM Comp-001/-15^{o}C/450TR

Description	UNITS	DESIGN DETAILS
		Two Skid
Capacity	**TR**	**450**
Chilled Water Flowrate	m3/hr	307
Diff. Temp	°C	4.5
Operating TR		**450**
Loading	%	
Power Consumption	kW	710.0
Specific. Power consumption	kW/TR	1.58
Coefficient of Performance (COP)	-	**2.2**

Table 186:Design Details of Chiller Reference SB-4/AM Comp-001/-15^{o}C/450TR

Chiller Reference SB-4/AM Comp-002/-15^{o}C/450TR

Description	UNITS	DESIGN DETAILS
Date		**Two Skids**
Capacity	**TR**	**450**
Chilled Water Flowrate	m3/hr	307
Diff. Temp	°C	4.5
Operating TR		**450**
Loading	%	
Power Consumption	kW	710.0
Specific. Power consumption	kW/TR	1.58
Coefficient of Performance (COP)	-	**2.2**

Table 187:Design Details of Chiller Reference SB-4/AM Comp-002/-15^{o}C/450TR

Chiller Reference SB-4/-40ºC/150TR

Description	UNITS	DESIGN DETAILS
Date		**Two Skid**
Capacity	**TR**	**150**
Chilled Water Flowrate	m3/hr	124
Diff. Temp	°C	3.7
Operating TR		**150**
Loading	%	
Power Consumption	kW	510.0
Specific. Power consumption	kW/TR	3.4
Coefficient of Performance (COP)	-	**1**

Table 188:Design Details of Chiller Reference SB-4/-40ºC/150TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB04 of HLL-09 was given below:

4.4.2 Design Details of Pumps:

Chiller Reference SB-4/AM Comp-001/-15ºC/450TR
Primary Pump Reference (-15 ºC) 450 TR

Description	UNITS	RATED
Flow	**m^3/hr**	315
Total Head	**m**	32
Hydraulic power	**kW**	26.62
Electrical Input power	**kW**	41.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.30
Pump Efficiency	**%**	**71.36**

Table 189:Design Details of Primary Pump Comp-001/(-15 oC) 450 TR

Chiller Reference SB-4/AM Comp-002/-15oC/450TR
Primary Pump Reference (-15 ºC) 450 TR

Description	UNITS	RATED
Flow	**m^3/hr**	315
Total Head	**m**	32
Hydraulic power	**kW**	26.62
Electrical Input power	**kW**	41.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.30
Pump Efficiency	**%**	**71.36**

Table 190:Design Details of Primary Pump Comp-002/(-15 oC) 450 TR

Chiller Reference SB-4/AM Comp-003/-40°C/150TR

Primary Pump Reference (-40 °C) 150 TR

Description	UNITS	RATED
Flow	**m^3/hr**	150
Total Head	**m**	35
Hydraulic power	**kW**	13.01
Electrical Input power	**kW**	24.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	22.00
Pump Efficiency	**%**	**59.12**

Table 191:Details of Primary Pump Comp-003/(-15 oC) 450 TR

4.4.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -40°C to +5 °C. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB04 is given below.

Chiller Reference SB-4/AM Comp-002/-15°C/450TR

Chiller Reference SB-4/AM Comp-002/-15°C/450TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two Skids**	**One Skid (A)**
Capacity	**TR**	**450**	**119.4**
Chilled Water Flowrate	m3/hr	307	330.00
Inlet brain Temperature	°C	-10	-0.20
Outlet brain Temperature	°C	-15	-1.4
Diff. Temp	°C	5	1.2
Specific Heat(Cp)	Kcal/kg °C	0.94	0.94
Specific Gravity		0.97	0.97
Operating TR		**450**	**119.4**
Loading	%		62.3
Power Consumption	kW	710.0	221.0
Specific. Power consumption	kW/TR	1.58	1.85
Coefficient of Performance (COP)	-	**2.2**	**1.9**
Gas Suction Pressure	kg/cm^2	-	3.5
Gas Suction Temperature	°C	-	-
Discharge Pressure	kg/cm^2	-	12.2
Discharge Temperature	°C	-	101

Table 192:Performance of Chiller Reference SB-4/AM Comp-002/-15oC/450TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 119.4TR in single skid operation as against to the design capacity of 450TR during two skid operation (single skid design capacity is 225TR).
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 330m3/hr when compared to design flow of 307m3/hr.
- The specific energy consumption of the above chiller is 1.85 kW/TR as against to the design specific energy consumption of 1.58 kW/TR. The operational efficiency of the above chiller is satisfactory.
- The coefficient of performance (COP) of above chiller is 1.9 as against to the design Coefficient of performance (COP) of 2.2.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 101°C and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower. The detailed energy conservation option has been discussed in energy conservation measures.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-4/AM Comp-001/-15ºC/450TR

SB-4/AM Comp-001/-15ºC/450TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two Skids**	**One Skid (A)**
Capacity	**TR**	**450**	**168.9**
Chilled Water Flowrate	m3/hr	307	200.00
Inlet Water Temperature	°C	-10	0.80
Outlet Water Temperature	°C	-15	-2.0
Diff. Temp	°C	5	2.8
Specific Heat(Cp)	Kcal/kg °C	0.94	0.94
Specific Gravity		0.97	0.97
Operating TR		**450**	**168.9**
Loading	%		86.5
Power Consumption	kW	710.0	307.0
Specific. Power consumption	kW/TR	1.58	1.82
Coefficient of Performance (COP)	-	**2.2**	**1.9**
Gas Suction Pressure	kg/cm^2	-	2.1
Gas Suction Temperature	°C	-	-
Discharge Pressure	kg/cm^2	-	13.9
Discharge Temperature	°C	-	95.8

Table 193:Performance of Chiller Reference SB-4/AM Comp-001/-15oC/450TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 168.9 TR in single skid operation as against to the design capacity of 450TR during two skid operations (single skid design capacity is 225TR).
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 200m3/hr when compared to design flow of 307m3/hr.
- The specific energy consumption of the above chiller is 1.82 kW/TR as against to the design specific energy consumption of 1.58 kW/TR. The operational efficiency of the above chiller is satisfactory.
- The coefficient of performance (COP) of above chiller is 1.9 as against to the design Coefficient of performance (COP) of 2.2.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- The discharge gas temperature is around 95.8ºC and having potential to recover heat from gas side otherwise the waste heat is dissipated into atmosphere by evaporative cooling tower. The detailed energy conservation option has been discussed in energy conservation measures.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy

consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference SB-4/AM Comp-003/-40°C/150TR

Chiller Reference SB-4/AM Comp-003/-40°C/150TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two Skids**	**H stage + booster**
Capacity	**TR**	**150**	**66.5**
Chilled Water Flowrate	m3/hr	124	139.90
Inlet Water Temperature	°C	-35	-24.20
Outlet Water Temperature	°C	-40	-26.1
Diff. Temp	°C	5	1.9
Specific Heat(Cp)	Kcal/kg °C	-0.831	0.831
Specific Gravity		0.91	0.91
Operating TR		**150**	**66.5**
Loading	%		52.5
Power Consumption	kW	510.0	293.9
Specific. Power consumption	kW/TR	3.4	4.42
Coefficient of Performance (COP)	-	**1**	**0.8**
Gas Suction Pressure	kg/cm^2	-	1.4
Gas Suction Temperature	°C	-	-
Discharge Pressure	kg/cm^2	-	12.1
Discharge Temperature	°C	-	72

Table 194:Performance of Chiller Reference SB-4/AM Comp-003/-40oC/150TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 66.5TR in s against to the design capacity of 150TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 140m3/hr when compared to design flow of 124m3/hr.
- The specific energy consumption of the above chiller is 4.42 kW/TR as against to the design specific energy consumption of 3.4 kW/TR. The operational efficiency of the above chiller is satisfactory.
- The coefficient of performance (COP) of above chiller is 0.8 as against to the design Coefficient of performance (COP) of 1.
- The chiller is equipped with evaporative cooling towers.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

4.4.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference SB-4/AM Comp-001/-15°C/450TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
3	2	1

The performance of primary pumps was evaluated and presented below

Service Block-04		SB-4/AM Comp-001/-15°C/450TR	
Pumps		PRIMARY -15 °C 450TR	
Description	UNITS	RATED	ACTUAL
Flow	**m^3/hr**	315	200.00
Suction Head	**m**	-	2.45
Discharge Head	**m**	-	36.00
Total Head	**m**	32	33.55
Hydraulic power	**kW**	26.62	17.72
Electrical Input power	**kW**	41.44	28.00
Motor Effciency	**%**	90.00	90.00
Pump Input power	**kW**	37.30	25.20
Pump Efficiency	**%**	**71.36**	**70.31**

Table 195:Performance of Primary Pump -15 °C 450TR

Observations and findings:

- The operating flow of primary pumps is 200m3/hr when compared to design flow of 315 m3/hr.
- The hydraulic power of the primary pump is 17.72 kW when compared to design hydraulic power of 26.62kW.
- The operating efficiency of the primary pump is 71% when compared to design efficiency of 71%.The primary pump operating performance is satisfactory

Chiller Reference SB-4/AM Comp-002/-15°C/450TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
3	2	1

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY -15 °C 450TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	315	330.00
Suction Head	**m**	-	2.00
Discharge Head	**m**	-	25.00
Total Head	**m**	32	23.00
Hydraulic power	**kW**	26.62	20.04
Electrical Input power	**kW**	41.44	31.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.30	27.90
Pump Efficiency	**%**	**71.36**	**71.83**

Table 196: Performance of Primary Pump -15 °C 450TR

Observations and findings:

- The operating flow of primary pumps is 330m3/hr when compared to design flow of 315 m3/hr.
- The hydraulic power of the primary pump is 20.04kW when compared to design hydraulic power of 26.62kW.
- The operating efficiency of the primary pump is 71% when compared to design efficiency of 71%.The primary pump operating performance is satisfactory.

Chiller Reference SB-4/AM Comp-003/-40°C/150TR

The details of the primary pumps for the above chiller is as given below

Primary Pumps		
Installed	Running	Standby
2	1	1

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY -40 °C 150TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	150	139.90
Suction Head	**m**	-	2.40
Discharge Head	**m**	-	25.00
Total Head	**m**	35	22.60
Hydraulic power	**kW**	13.01	7.83
Electrical Input power	**kW**	24.44	22.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	22.00	19.80
Pump Efficiency	**%**	**59.12**	**39.56**

Table 197: Performance of Primary Pump -40 °C 150TR

Observations and findings:

- The operating flow of primary pumps is 140m3/hr when compared to design flow of 150 m3/hr.
- The hydraulic power of the primary pump is 7.83 kW when compared to design hydraulic power of 13.01 kW.
- The operating efficiency of the primary pump is 39% when compared to design efficiency of 59%.The primary pump operating performance is not satisfactory.
- A detailed energy conservation option for replacement of old inefficient pump with new energy efficient pump as discussed in encon chapter.
- It is observed that the design efficiency of primary pump is only 65% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

4.4.5 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used. The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporator Reference SB-4/AM Comp-002/-15ºC/450TR

Parameter Reference	SB-4/AM Comp-002/-15ºC/450TR
CT Inlet Temp. ºC	31.2
CT Outlet Temp. ºC	28.3
Ambient Temp. ºC	29
Wet BulbTemp. ºC	25.3
Range ºC	2.9
Approach ºC	3
Effectiveness = Range/(Range + Approach)	49.15
Air inlet condition	
DBT, ºC	29
RH, %	65
Enthalpy, kCal/kg	17.0
Air flow rate, m^3/hr	143758
Air flow rate, kg/hr	155944.56
Air outlet condition	
DBT, ºC	29
RH, %	90
Enthalpy, kCal/kg	20.98
Enthalpy Difference, kCal/kg	4.0
TR	220.32

Table 198:Performance of Evaporator Reference SB-4/AM Comp-002/-15ºC/450TR

Observations and findings:

- The operating range of the above evaporative condenser is 2.9^{0}C and approach is 3 ^{0}C.
- The operating effectiveness is to the tune of 49%.
- The TR rejected to atmosphere of the above evaporative condenser is 220.32TR.
- The performance of the above evaporative condenser is not satisfactory.

4.4.6 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-001/-15 ºC/450TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15ºC chiller is in the range of -4 to -6ºC.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5ºC,- 5ºC,- 15ºC ,- 20ºC & -40ºC.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15ºC chiller of capacity 450TR is running with a set point of -15ºC. The compressor will be in OFF condition once reaches -15ºC and compressor will be ON once the temperature reaches -12ºC.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 8ºC to 10ºC i.e., keeping set point at -7ºC. For every 5.5ºC raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 3.45 Lakh kWh with an annual monetary savings of Rs.20.72 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-001/-15 °C/450TR		
Description	**Units**	**Value**
Chiller Ref		**SB-04/Comp-001/-15 °C/450TR**
Normal operating inlet temperature of Water	°C	0.8
Normal operating outlet temperatures of Water	°C	-2.0
Present set point	°C	-15
Suggested to increase the set point	°C	-7 to -10
Increase in set point	°C	8 to 10
Present power consumption	kW	307
Percentage reduction in power consumption of compressor	kW	76.75
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	3.45
Envisaged annual Monetary savings	Lakhs Rs	20.72
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 199: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-001/-15 °C/450TR

Encon 2: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-002/-15 oC/450TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15^{o}C chiller is in the range of -4 to -6^{o}C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15^{o}C chiller of capacity 450TR is running with a set point of -15^{o}C. The compressor will be in OFF condition once reaches -15^{o}C and compressor will be ON once the temperature reaches -12^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 8^{o}C to 10^{o}C i.e., keeping set point at -7^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 2.48 Lakh kWh with an annual monetary savings of Rs.14.92 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-002/-15 ^{o}C/450TR		
Description	**Units**	**Value**
Chiller Ref	**SB-04/Comp-001/-15 ^{o}C/450TR**	
Normal operating inlet temperature of Water	°C	-0.2
Normal operating outlet temperatures of Water	°C	-1.4
Present set point	°C	-15
Suggested to increase the set point	°C	-7 to -10
Increase in set point	°C	8 to 10
Present power consumption	kW	221
Percentage reduction in power consumption of compressor	kW	55.25
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	2.48
Envisaged annual Monetary savings	Lakhs Rs	14.92
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken	Operational adjustments	
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 200: Optimization of chiller Evaporator temperature by adjusting the existing set point of 450TR chiller with reference SB-04/Comp-002/-15 oC/450TR

Encon 3: Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB04/comp-003/-40oC/150TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -40°C chiller is in the range of -27 to -30°C.Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -40°C chiller of capacity 150TR is running with a set point of -30°C to -35°C.The compressor will be in OFF condition once reaches -35°C and compressor will be ON once the temperature reaches -30°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by -25°C from -28°C i.e., increase the set point by 5°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%. By increasing the set point there will be envisaged annual savings of 1.58 Lakh kWh with an annual monetary savings of Rs.9.52 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB04/comp-003/-40°C/150TR		
Description	**Units**	**Value**
Chiller Ref		**SB04/comp-003/-40°C/150TR**
Normal operating inlet temperature of Water	°C	-24.2
Normal operating out temperature of Water	°C	-26.1
Present set point	°C	-30 to -35
Suggested to increase the set point	°C	-25 to -28
Increase in set point	°C	4 to 10
Present power consumption	kW	293.9
Percentage reduction in power consumption of compressor	kW	35.26
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.58
Envisaged annual Monetary savings	Lakhs Rs	9.52
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 201: Optimization of chiller Evaporator temperature by adjusting the existing set point of 150TR chiller with reference SB04/comp-003/-40°C/150TR

Encon 4: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-09/service block-03		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold-water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 202: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 5: Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-4/AM Comp-001/-15oC/450TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 95.8°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference SB-4/AM Comp-001/-15oC/450TR before it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 45.4 Kgs of coal per hour and equivalent annual monetary savings of Rs.6.1 Lakhs with an investment of Rs.9 Lakhs and the payback period of 17.6 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water		
	SB-04/Comp-001/-15oc/450 TR	
Description	**UNITS**	**ACTUAL**
Date		
Capacity	**TR**	**450.0**
Inlet Water Temperature	°C	0.80
Outlet Water Temperature	°C	-2.0
Diff. Temp	°C	2.8
Operating TR		**168.9**
Gas Suction Temperature	°C	-
Discharge Temperature	°C	95.8
Amount of heat available before evaporative condenser	kcals/hr	510754
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	102151
Equivalent coal savings	kg/hr	45.4
Expected annual monetary savings	Lakhs Rs.	6.1
Investment	Lakshs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	17.6

Table 203: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 6:Energy savings by recovering heat energy from hot refrigerant for making hot water from chiller reference SB-4/AM Comp-002/-15oC/450TR

Present Condition:

It is observed during the field studies that the hot exit gas from the chiller is at 101°C and getting cooled by passing through evaporative cooling tower. The heat gained by circulating water is vent out to atmosphere in evaporative cooling tower.

Proposed Condition:

It is proposed to install stage-I heat recovery from hot gas of the chiller reference SB-4/AM Comp-002/-15°C/450TR before it goes to evaporative cooling tower. The hot water generated from all the chillers in the service block can be used in the process. The above proposed option will save 32.1 Kgs of coal per hour and equivalent annual monetary savings of Rs.4.3 Lakhs with an investment of Rs.9 Lakhs and the payback period of 24.9 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by recovering heat energy from hot refrigerant for making hot water		
	SB-04/Comp-002/-15oc/450 TR	
Description	**UNITS**	**ACTUAL**
Date		
Capacity	**TR**	**450.0**
Inlet Water Temperature	°C	-0.20
Outlet Water Temperature	°C	-1.4
Diff. Temp	°C	1.2
Operating TR		**119.4**
Gas Suction Temperature	°C	-
Discharge Temperature	°C	101
Amount of heat available before evaporative condenser	kcals/hr	361066
Expected amount of heat recovery by heating water (considering 50%)	kcals/hr	72213
Equivalent coal savings	kg/hr	32.1
Expected annual monetary savings	Lakhs Rs.	4.3
Investment	Lakshs Rs.	9.0
For Plate Heat Exchanger-(Rs.5 Lakhs)		
Piping Work-(Rs.2 Lakhs)		
Installation Cost-(Rs 2 Lakhs)		
Simple payback period	Months	24.9

Table 204: Energy savings by recovering heat energy from hot refrigerant for making hot water

Encon 7: Energy savings by replacement of primary Pump of (-40°C) 150TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 150 TR chiller (-40 °C) is 40% as against to the design efficiency of 60%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.82 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.93 Lakhs with a payback period of 4.1 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (-40 °C) 150TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**40.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	22.00
Expected Savings by Installation of New Pumps	kW	10.27
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum (in Lakhs)	0.82
Cost of Power	Rs. /kWh	6
Total Annual Savings	Lakhs Rs.	4.93
Investment	Lakhs Rs.	1.67
Simple payback period	Months	4.1

Table 205: Energy savings by recovering heat energy from hot refrigerant for making hot water

4.5 Service Block-005

Service Block –SB05 has the following utilities to meet the production requirements of SRS 1, SRS2, and H12

Service Block-SB05

S/NO	DESCRIPTION	CAPACITY	KW
1	+5˚C VAM system	300 TR	-
2	+5˚C VAM system	300 TR	-
3	Ice Plant	58 TR	55
4	+5˚C Chilling Plant	250 TR	223
5	+5˚C Chilling Plant	250 TR	223

Table 206:Equipment details of service block -005

The above service block completely runs only on two Vapour Absorption machines of capacities 300TR.

4.5.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference SB-5/VAM -001/+5ºC/300TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**300**
Chilled Water Flowrate	m3/hr	181
Diff. Temp	°C	5
Cooling water Flow rate	m3/hr	425
Operating TR		**299.3**
Heating Capacity	kW	1097
	kCals	943420
Specific Energy Consumption	**kCals/TR**	**3145**

Table 207:Design Details of Chiller Reference SB-5/VAM -001/+5oC/300TR

Chiller Reference SB-5/VAM -002/+5ºC/300TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**300**
Chilled Water Flowrate	m3/hr	181
Diff. Temp	°C	5
Cooling water Flow rate	m3/hr	425
Operating TR		**299.3**
Heating Capacity	kW	1097
	kCals	943420
Specific Energy Consumption	**kCals/TR**	**3145**

Table 208:Design Details of Chiller Reference SB-5/VAM -00/+5oC/300TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB05 of HLL-09 was given below:

4.5.2 Design Details of Pumps:

Chiller Reference SB-5/VAM -001/+5°C/300TR
Primary Pump Reference (+5 °C) 300 TR

Description	UNITS	RATED
Flow	**m^3/hr**	180
Total Head	**m**	30
Hydraulic power	**kW**	14.70
Electrical Input power	**kW**	20.72
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	18.65
Pump Efficiency	**%**	**78.82**

Table 209:Design Details of Primary Pump SB-5/VAM -001/+5oC/300TR

Chiller Reference SB-5/VAM -002/+5°C/300TR
Primary Pump Reference (+5 °C) 300 TR

Description	UNITS	RATED
Flow	**m^3/hr**	180
Total Head	**m**	30
Hydraulic power	**kW**	14.70
Electrical Input power	**kW**	20.72
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	18.65
Pump Efficiency	**%**	**78.82**

Table 210:Design Details of Primary Pump SB-5/VAM -002/+5oC/300TR

Chiller Reference SB-5/VAM -001/+5°C/300TR
Cooling Water Pump Reference (+5 °C) 300 TR

Description	UNITS	RATED
Flow	**m^3/hr**	420
Total Head	**m**	25
Hydraulic power	**kW**	28.58
Electrical Input power	**kW**	49.73
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	44.76
Pump Efficiency	**%**	**63.86**

Table 211:Design Details of Cooling Water SB-5/VAM -001/+5oC/300TR

Chiller Reference SB-5/VAM -002/+5°C/300TR
Cooling Water Pump Reference (+5 °C) 300 TR

Description	UNITS	RATED
Flow	**m^3/hr**	420
Total Head	**m**	25
Hydraulic power	**kW**	28.58
Electrical Input power	**kW**	49.73
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	44.76
Pump Efficiency	**%**	**63.86**

Table 212:Design Details of Cooling Water Pump SB-5/VAM -002/+5oC/300TR

4.5.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements in the range of +5 °C and the requirements were met through Vapour absorption machines of capacities 300TR each. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. Basically, chilled water requirements of solvent recovery unit-1(SRS-1) and solvent recovery unit-2(SRS-2) was supplied from the above block.

The performance assessment of individual running chillers during field studies was evaluated for Specific Energy consumption (SEC) and operating TR.

The performance assessment of individual chiller of service block-SB05 is given below.

Chiller Reference SB-5/VAM -001/+5°C/300TR

Chiller Reference SB-5/VAM -001/+5°C/300TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**300**	**200.4**
Chilled Water Flowrate	m3/hr	181	183.60
Inlet Water Temperature	°C	10	14.50
Outlet Water Temperature	°C	5	11.2
Diff. Temp	°C	5	3.3
Cooling water Inlet Temperature	°C	-	32.3
Cooling water Outlet Temperature	°C	-	35.2
Cooling water Flow rate	m3/hr	425	429.9
Heat Reject by Cooling Tower	TR	-	412.3
Operating TR		**299.3**	**200.4**
Steam Flowrate	Kg/hr	-	1441.0
Steam Enthalpy	Kcals		664.0
Heating Capacity	kW	1097	911.5
	kCals	943420	783904.0
Specific Energy Consumption	**kCals/TR**	**3145**	**3913**
Specific Energy Consumption	**kg/TR**	**-**	**7.19**

Table 213:Performance of Chiller Reference SB-5/VAM -001/+5oC/300TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 200TR as against to the design capacity of 300TR and it is operating in partial loading.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 183.6m3/hr when compared to design flow of 181m3/hr.
- The Cooling water flow rate is 430 m3/hr as against to the design flow of 425 m3/hr.
- The specific energy consumption of the above chiller is 3913 kCals/TR as against to the design specific energy consumption of 3145 kCals/TR. The operational efficiency of the above chiller is not satisfactory.

Chiller Reference SB-5/VAM -002/+5°C/300TR

Chiller Reference SB-5/VAM -002/+5°C/300TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**300**	**184.3**
Chilled Water Flowrate	m3/hr	181	199.00
Inlet Water Temperature	°C	10	14.50
Outlet Water Temperature	°C	5	11.7
Diff. Temp	°C	5	2.8
Cooling water Inlet Temperature	°C	-	31.2
Cooling water Outlet Temperature	°C	-	33.0
Cooling water Flow rate	m3/hr	425	345.8
Heat Reject by Cooling Tower	TR	-	205.8
Operating TR		**299.3**	**184.3**
Steam Flowrate	Kg/hr	-	1425
Steam Enthalpy	Kcals		664.0
Heating Capacity	kW	1097	901.4
	kCals	943420	775200.0
Specific Energy Consumption	**kCals/TR**	**3145**	**4207**
Specific Energy Consumption	**kg/TR**	-	**7.73**

Table 214:Performance of Chiller Reference SB-5/VAM -002/+5oC/300TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 184TR as against to the design capacity of 300TR and it is operating in partial loading.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 199m3/hr when compared to design flow of 181m3/hr.
- The Cooling water flow rate is 346m3/hr as against to the design flow of 425 m3/hr.
- The specific energy consumption of the above chiller is 4207kCals/TR as against to the design specific energy consumption of 3145 kCals/TR. The operational efficiency of the above chiller is not satisfactory.

4.5.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and cooling water pumps to meet the chilling requirements of production blocks. The no. of primary pumps and cooling water pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference SB-5/VAM -001/+5ºC/300TR

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY +5ºC 300TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	180	183.60
Suction Head	**m**	-	2.00
Discharge Head	**m**	-	28.00
Total Head	**m**	30	26.00
Hydraulic power	**kW**	14.70	12.99
Electrical Input power	**kW**	20.72	19.10
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	18.65	17.19
Pump Efficiency	**%**	**78.82**	**75.60**

Table 215:Performance of Primary Pump SB-5/VAM -001/+5oC/300TR

Observations and findings:

- The operating flow of primary pumps is 183m3/hr when compared to design flow of 180 m3/hr.
- The hydraulic power of the primary pump is 12.99kW when compared to design hydraulic power of 14.7kW.
- The operating efficiency of the primary pump is 75% when compared to design efficiency of 78%.The primary pump operating performance is good.

Chiller Reference SB-5/VAM -002/+5oC/300TR

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY +5 ºC 300TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	180	199.00
Suction Head	**m**	-	2.00
Discharge Head	**m**	-	24.50
Total Head	**m**	30	22.50
Hydraulic power	**kW**	14.70	12.19
Electrical Input power	**kW**	20.72	17.70
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	18.65	15.93
Pump Efficiency	**%**	78.82	76.51

Table 216:Performance of Primary Pump SB-5/VAM -002/+5oC/300TR

Observations and findings:

- The operating flow of primary pumps is 199m3/hr when compared to design flow of 180 m3/hr.
- The hydraulic power of the primary pump is 12.19kW when compared to design hydraulic power of 14.7kW.
- The operating efficiency of the primary pump is 76% when compared to design efficiency of 78%.The primary pump operating performance is good.

Chiller Reference SB-5/VAM -001/+5°C/300TR
Cooling Water Pumps (+5) VAM -001/300TR

Pumps		Cooling water +5 °C 300TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	420	429.00
Suction Head	**m**	-	2.00
Discharge Head	**m**	-	19.00
Total Head	**m**	25	17.00
Hydraulic power	**kW**	28.58	19.85
Electrical Input power	**kW**	49.73	38.60
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	44.76	34.74
Pump Efficiency	**%**	**63.86**	**57.15**

Table 217:Performance of Cooling Water Pumps SB-5/VAM -001/+5oC/300TR

Observations and findings:

- The operating flow of cooling water pumps is 429m3/hr when compared to design flow of 420 m3/hr.
- The hydraulic power of the primary pump is 19.85kW when compared to design hydraulic power of 28.58kW.
- The operating efficiency of the primary pump is 57% when compared to design efficiency of 64%.The primary pump operating performance is satisfactory.
- It is observed that the design efficiency of cooling water pump is only 64% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference SB-5/VAM -001/+5oC/300TR

Cooling Water Pumps (+5) VAM -002/300TR

Pumps		Cooling Tower+5 °C 300TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	420	345.00
Suction Head	**m**	-	2.00
Discharge Head	**m**	-	24.00
Total Head	**m**	25	22.00
Hydraulic power	**kW**	28.58	20.66
Electrical Input power	**kW**	49.73	38.90
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	44.76	35.01
Pump Efficiency	**%**	**63.86**	**59.02**

Table 218:Performance of Cooling Water Pumps SB-5/VAM -002/+5oC/300TR

Observations and findings:

- The operating flow of cooling water pumps is 345m3/hr when compared to design flow of 420 m3/hr.
- The hydraulic power of the primary pump is 20.66kW when compared to design hydraulic power of 28.58kW.
- The operating efficiency of the primary pump is 59% when compared to design efficiency of 64%.The primary pump operating performance is satisfactory.
- It is observed that the design efficiency of cooling water pump is only 64% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

4.5.5 Energy Conservation Options (ENCON):

Encon 1:Energy Savings by changing operating air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for RS plant & VAM valve operation. The existing pressure settings for the air compressors were 6.5 – 7 kg/cm$^{2.}$ .i.e. at 6.5 the compressor will be in OFF condition and at 7 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3 - 3.5kg/cm^2.

Proposed Condition:

It is proposed to change the pressure settings to 5 – 5.5 kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.1 Lakh kWh savings with an annual monetary savings of Rs.0.55 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating air compressor pressure settings		
Description	**Units**	**Value**
HLL-09/service block-05		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	7
Existing compressor pressure settings-on	kg/cm^2	6.5
Existing capacity of air Compressor	CFM	58
Power consumption of air Compressor	kW	14.5
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	12.47
Reduction in power consumption	kW	2
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.1
Envisaged annual Monetary savings	Lakhs Rs	0.55
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 219: Energy Savings by changing operating air compressor pressure settings

Encon 2: Energy savings by replacement of cooling water Pump of VAM-001 (+5°C) 300TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the cooling water Pump of VAM-001 of capacity 300 TR chiller (+5 °C) is 57% as against to the design efficiency of 64%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.74 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.45 Lakhs with a payback period of 9 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of SB-05/VAM-001/ (+5 °C) 300TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**57.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	38.60
Proposed energy Consumption	kW	29.34
Expected Savings by Installation of New Pumps	kW	9.26
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.74
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	4.45
Investment	Lakhs Rs.	3.35
Simple payback period	Months	9.0

Table 220: Replacement of Primary Pump of SB-05/VAM-001/ (+5 °C) 300TR with New Energy Efficient Pump

Encon 3: Energy savings by replacement of cooling water Pump of VAM-002 (+5°C) 300TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the cooling water Pump of VAM-002 of capacity 300 TR chiller (+5 °C) is 59% as against to the design efficiency of 64%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.74 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.45 Lakhs with a payback period of 9 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of SB-05/VAM-002/(+5 °C) 300TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**59.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	38.90
Proposed energy Consumption	kW	30.60
Expected Savings by Installation of New Pumps	kW	8.30
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.66
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	3.98
Investment	Lakhs Rs.	3.35
Simple payback period	Months	10.1

Table 221: Replacement of Primary Pump of SB-05/VAM-002/(+5 °C) 300TR with New Energy Efficient Pump

4.6 Service Block-006

Service Block –SB06 has the following utilities to meet the production requirements of H_7, Crystallizer, F, G, Pharma 3, Drugs.

Service Block-SB06

S/NO	DESCRIPTION	CAPACITY	KW
1	+5˚C Chilling Plant	350 TR	305
2	+5˚C Chilling Plant	350 TR	305
3	Air Compressor	890 CFM	160
4	Instrument Air Compressor	110 CFM	22
5	Breathing Air Compressor	150 CFM	30
6	Breathing Air Compressor	150 CFM	26
7	Breathing Air Compressor	105 CFM	19

Table 222:Equipment list of Service Block-006

4.6.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference SB-6/FN Comp-001/+5ºC/350TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**350**
Chilled Water Flowrate	m3/hr	212
Diff. Temp	°C	5
Operating TR		**350.5**
Loading	%	
Power Consumption	kW	339.6
Specific. Power consumption	kW/TR	0.97
Coefficient of Performance (COP)	-	**3.6**

Table 223:Design Details of Chiller Reference SB-6/FN Comp-001/+5ºC/350TR

Chiller Reference SB-6/FN Comp-002/+5oC/350TR

Description	UNITS	DESIGN DETAILS
Capacity	**TR**	**350**
Chilled Water Flowrate	m3/hr	212
Diff. Temp	°C	5
Operating TR		**350.5**
Loading	%	
Power Consumption	kW	339.6
Specific. Power consumption	kW/TR	0.97
Coefficient of Performance (COP)	-	**3.6**

Table 224:Design Details of Chiller Reference SB-6/FN Comp-002/+5ºC/350TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB06 of HLL-09 was given below:

4.6.2 Design Details of Pumps:

Chiller Reference SB-6/FN Comp-001/+5^{o}C/350TR
Primary Pump Reference (+5 ^{o}C) 350 TR

Description	UNITS	RATED
Flow	**m^3/hr**	220
Total Head	**m**	40
Hydraulic power	**kW**	23.96
Electrical Input power	**kW**	41.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.30
Pump Efficiency	**%**	**64.22**

Table 225:Design Details of Primary Pump SB-6/FN Comp-001/+5^{o}C/350TR

Chiller Reference SB-6/FN Comp-002/+5^{o}C/350TR
Primary Pump Reference (+5 ^{o}C) 350 TR

Description	**UNITS**	**RATED**
Flow	**m^3/hr**	220
Total Head	**m**	40
Hydraulic power	**kW**	23.96
Electrical Input power	**kW**	41.44
Motor Efficiency	**%**	90.00
Pump Input power	**kW**	37.30
Pump Efficiency	**%**	**64.22**

Table 226:Design Details of Chiller Reference SB-6/FN Comp-002/+5^{o}C/350TR

4.6.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements is in the range of +5 ^{o}C. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB06 is given below.

Chiller Reference SB-6/FN Comp-001/+5ºC/350TR

Chiller Reference SB-6/FN Comp-001/+5ºC/350TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**350**	**238.1**
Chilled Water Flowrate	m3/hr	212	120.00
Inlet Water Temperature	°C	10	12.80
Outlet Water Temperature	°C	5	6.8
Diff. Temp	°C	5	6.0
Operating TR		**350**	**238.1**
Loading	%		62.4
Power Consumption	kW	339.6	212.0
Specific. Power consumption	kW/TR	0.97	0.89
Coefficient of Performance (COP)	-	**3.6**	**3.9**

Table 227:Performance of Chiller Reference SB-6/FN Comp-001/+5ºC/350TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 238TR as against to the design capacity of 350TR.
- The flow rate of the above chiller during performance assessment is 120m3/hr when compared to design flow of 212m3/hr.
- The specific energy consumption of the above chiller is 0.89kW/TR as against to the design specific energy consumption of 0.97 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 3.9 as against to the design Coefficient of performance (COP) of 3.6.
- The chiller is equipped with air cooled cooling towers.

Chiller Reference SB-6/FN Comp-002/+5ºC/350TR

Chiller Reference SB-6/FN Comp-002/+5ºC/350TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Capacity	**TR**	**350**	**299.1**
Chilled Water Flowrate	m3/hr	212	177.36
Inlet Water Temperature	°C	10	11.80
Outlet Water Temperature	°C	5	6.7
Diff. Temp	°C	5	5.1
Operating TR		**350**	**299.1**
Loading	%		72.7
Power Consumption	kW	339.6	247.0
Specific. Power consumption	kW/TR	0.97	0.83
Coefficient of Performance (COP)	-	**3.6**	**4.3**

Table 228:Performance of Chiller Reference SB-6/FN Comp-002/+5ºC/350TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 299TR as against to the design capacity of 350TR.
- The flow rate of the above chiller during performance assessment is 177m3/hr when compared to design flow of 212m3/hr.
- The specific energy consumption of the above chiller is 0.83kW/TR as against to the design specific energy consumption of 0.97 kW/TR. The operational efficiency of the above chiller is good.
- The coefficient of performance (COP) of above chiller is 4.3 as against to the design Coefficient of performance (COP) of 3.6.
- The chiller is equipped with air cooled cooling towers.

4.6.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference SB-6/FN Comp-001/+5ºC/350TR

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY +5 ºC 350TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	220	120.00
Suction Head	**m**	-	1.10
Discharge Head	**m**	-	37.00
Total Head	**m**	40	35.90
Hydraulic power	**kW**	23.96	11.73
Electrical Input power	**kW**	41.44	26.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.30	23.40
Pump Efficiency	**%**	**64.22**	**50.12**

Table 229:Performance of Primar Pump SB-6/FN Comp-001/+5ºC/350TR

Observations and findings:

- The operating flow of combined primary pumps is 120m3/hr when compared to design flow of 220 m3/hr.
- The hydraulic power of the primary pump is 11.73kW when compared to design hydraulic power of 23.96kW.
- The operating efficiency of the primary pump is 50% when compared to design efficiency of 64%.The primary pump operating performance is satisfactory.
- It is observed that the design efficiency of cooling water pump is only 64% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

Chiller Reference SB-6/FN Comp-002/+5ºC/350TR

The performance of primary pumps was evaluated and presented below

Pumps		PRIMARY +5 ºC 350TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	220	177.36
Suction Head	**m**	-	1.10
Discharge Head	**m**	-	31.00
Total Head	**m**	40	29.90
Hydraulic power	**kW**	23.96	14.44
Electrical Input power	**kW**	41.44	28.00
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	37.30	25.20
Pump Efficiency	**%**	**64.22**	**57.29**

Table 230:Performance of Primary Pumps SB-6/FN Comp-002/+5ºC/350TR

Observations and findings:

- The operating flow of combined primary pumps is 177m3/hr when compared to design flow of 220 m3/hr.
- The hydraulic power of the primary pump is 14.44kW when compared to design hydraulic power of 23.96kW.
- The operating efficiency of the primary pump is 57% when compared to design efficiency of 64%.The primary pump operating performance is satisfactory.
- It is observed that the design efficiency of cooling water pump is only 64% whereas in market new energy efficient pumps with higher efficiencies to the tune of 75% to 80% are available. It is suggested that in a long run all the old pumps with lesser efficiencies can be replaced with energy efficient new pumps in a phased manner.

4.6.5 Energy Conservation Options (ENCON):

Encon 1: Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-001/+5 ^{o}C/350TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5^{o}C chiller is in the range of 9 to 10 ^{o}C. Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently +5^{o}C chiller of capacity 395TR is running with a set point of 5^{o}C to 7^{o}C.The compressor will be in OFF condition once reaches 5^{o}C and compressor will be ON once the temperature reaches 7^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3^{o}C to 5^{o}C i.e., keeping set point at 8^{o}C to 12^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.44 Lakh kWh with an annual monetary savings of Rs.6.86 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-001/+5 °C/350TR		
Description	**Units**	**Value**
Chiller Ref		**SB-06/FN Comp-001/+5 °C/350TR**
Normal operating inlet temperature of Water	°C	12.8
Normal operating outlet temperatures of Water	°C	6.8
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	212
Percentage reduction in power consumption of compressor	kW	25.44
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.14
Envisaged annual Monetary savings	Lakhs Rs	6.86
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 231: Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-001/+5 oC/350TR

Encon 2:Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-002/+5 oC/350TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for +5°C chiller is in the range of 9 to 10 °C. Even though production requirements changes from batch to batch as each reactor will be having a supply of +5°C,- 5°C,- 15°C ,- 20°C & -40°C.It is suggested to optimize evaporator temperature for considerable energy savings.

Currently +5°C chiller of capacity 395TR is running with a set point of 5°C to 7°C.The compressor will be in OFF condition once reaches 5°C and compressor will be ON once the temperature reaches 7°C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3°C to 5°C i.e., keeping set point at 8°C to 12°C. For every 5.5°C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.61 Lakh kWh with an annual monetary savings of Rs.9.68 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments.The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-002/+5 °C/350TR		
Description	**Units**	**Value**
Chiller Ref		**SB-06/FN Comp-002/+5 °C/350TR**
Normal operating inlet temperature of Water	°C	11.8
Normal operating outlet temperatures of Water	°C	6.7
Present set point	°C	5 to 7
Suggested to increase the set point	°C	10
Increase in set point	°C	3 to 5
Present power consumption	kW	299
Percentage reduction in power consumption of compressor	kW	35.88
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.61
Envisaged annual Monetary savings	Lakhs Rs	9.68
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5^{0}Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 232: Optimization of chiller Evaporator temperature by adjusting the existing set point of 350TR chiller with reference SB-06/FN Comp-002/+5 oC/350TR

Encon 3: Energy Savings by changing operating air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for breathing requirements of the production blocks. The existing pressure settings for the air compressors were 6 – 7 kg/cm$^{2.}$ .i.e. at 7 the compressor will be in OFF condition and at 7 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3 - 3.5kg/cm^2.

Proposed Condition:

It is proposed to change the pressure settings to 3 - 3.5kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.3 Lakh kWh savings with an annual monetary savings of Rs.1.63 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating air compressor pressure settings		
Description	**Units**	**Value**
HLL-09/service block-06		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	7
Existing compressor pressure settings-on	kg/cm^2	6
Existing capacity of air Compressor	CFM	150
Power consumption of air Compressor	kW	21.6
Existing compressor pressure settings-off	kg/cm3	3.5
Existing compressor pressure settings-on	kg/cm2	3
Estimated Power consumption for proposed power consumption	kW	15.52
Reduction in power consumption	kW	6
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.3
Envisaged annual Monetary savings	Lakhs Rs	1.63
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 233: Energy Savings by changing operating air compressor pressure settings

Encon 4: Energy savings by replacement of primary Pump of (+5°C) SB-6/FN Comp 01(+5°C) 350TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 350 TR chiller (+5°C) is 50% as against to the design efficiency of 64%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.69 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.4.16 Lakhs with a payback period of 7.8 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of SB-6/FN Comp 01(+5°C) 350TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**50.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	26.00
Proposed energy Consumption	kW	17.33
Expected Savings by Installation of New Pumps	kW	8.67
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.69
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	4.16
Investment	Lakhs Rs.	2.70
Simple payback period	Months	7.8

Table 234: Replacement of Primary Pump of SB-6/FN Comp 01(+5°C) 350TR with New Energy Efficient Pump

Encon 4: Energy savings by replacement of primary Pump of (+5°C) SB-6/FN Comp 02(+5°C) 350TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 350 TR chiller (+5°C) is 57% as against to the design efficiency of 64%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.54 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.3.23 Lakhs with a payback period of 10 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of SB-6/FN Comp 02(+5°C) 350TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Efficiency of Existing Pump	**%**	**57.0**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	28.00
Proposed energy Consumption	kW	21.28
Expected Savings by Installation of New Pumps	kW	6.72
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.54
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	3.23
Investment	Lakhs Rs.	2.70
Simple payback period	Months	10.0

Table 235: Replacement of Primary Pump of SB-6/FN Comp 02(+5°C) 350TR with New Energy Efficient Pump

5.0 HDL-09

HDL-09 is one of the production blocks in Hetero Labs Limited Nakapally. The major utilities in the HDL-09 block are as given below.

S.No	Description	Capacity	Motor Hp/Kw
01	+ 5˚c Chilling Plant	173 TR	215/160
02	-15˚c Chilling Plant	158 TR	175/132
03	-40˚c Chilling Plant	52TR	75/55
04	Air Comp	484 Cfm	100/75
05	Air Comp	484 Cfm	100/75
08	Air Comp	40 cfm	10 HP
09	Air Comp	105 CFM	25 HP
10	Air Comp	105 CFM	25 HP
11	Air Comp	30 CFM	

Table 236:Equipment List of HDL-09

HDL-09 is having one service blocks catering to meet the production requirements A, B, D, pharma production blocks. In one service blocks there will be chillers ranging from -15 ^{0}C to +5 ^{0}C depending on the production requirements. The service blocks also consist of Air Compressors for instrumentation usage and for breathing air, Nitrogen plant to meet the production demand.

The major service blocks that were in operation during field studies are as given below

S.No	Service Block
1	Service block-SB01

Service Block –SB01 has the following utilities to meet the production requirements of A, B, D,pharma production

Service Block-SB01:

S.No	Description	Capacity	Motor Hp/Kw
01	+ 5˚c Chilling Plant	173 TR	215/160
02	-15˚c Chilling Plant	158 TR	175/132
03	-40˚c Chilling Plant	52TR	75/55
04	Air Comp	484 Cfm	100/75
05	Air Comp	484 Cfm	100/75
08	Air Comp	40 cfm	10 HP
09	Air Comp	105 CFM	25 HP
10	Air Comp	105 CFM	25 HP
11	Air Comp	30 CFM	

Table 237:Equipment List of Service Block-01

5.1 Design Details of Chillers:

The design details of the above utilities along with design specifications are as given below:

Chiller Reference US-HDL-9/-15°C/158TR

Description	UNITS	DESIGN DETAILS
		Two Skid System
Capacity-Skid system	**TR**	**158**
Chilled Water Flowrate	m3/hr	113
Diff. Temp	°C	4.2
Operating TR		**158**
Power Consumption	kW	264.0
Specific. Power consumption	kW/TR	1.67
Coefficient of Performance (COP)	-	**2.1**

Table 238:Design Details of Chiller Reference US-HDL-9/-15°C/158TR

Chiller Reference US-HDL-9/+5°C/158TR

Description	UNITS	DESIGN DETAILS
		Two Skid System
Capacity-Skid system	**TR**	**158**
Chilled Water Flowrate	m3/hr	113
Diff. Temp	°C	4.2
Operating TR		**158**
Power Consumption	kW	264.0
Specific. Power consumption	kW/TR	1.68
Coefficient of Performance (COP)	-	**2.1**

Table 239:Design Details of Chiller Reference US-HDL-9/+5°C/158TR

Depending on the requirements each chiller will be equipped with one or two primary and secondary pumps. A detailed performance evaluation of individual primary pumps was assessed and reported in performance evaluation chapter. Wherever possible secondary flows were also measured and the performance of secondary pumps wherever flows were measured was reported in performance evaluation chapter. The design details of each primary pump in service block-SB01 of HDL-09 was given below:

5.2 Design Details of Pumps:

Chiller Reference US-HDL_9/-15°C/158TR

Primary Pump Reference (-15 °C) 158 TR

Description	UNITS	RATED
Flow	m^3/hr	130
Suction Head	m	-
Discharge Head	m	-
Total Head	m	25
Hydraulic power	kW	8.58
Electrical Input power	kW	15.00
Motor Efficiency	%	90.00
Pump Input power	kW	11.00
Pump Efficiency	%	**78.02**

Table 240:Design Details of Primary Pump US-HDL-9/-15°C/158TR

Chiller Reference US-HDL_9/+5oC/173TR

Primary Pump Reference (+5 °C) 173 TR

Description	UNITS	RATED
Flow	m^3/hr	90
Suction Head	m	-
Discharge Head	m	-
Total Head	m	30
Hydraulic power	kW	7.36
Electrical Input power	kW	11.89
Motor Efficiency	%	92.50
Pump Input power	kW	11.00
Pump Efficiency	%	**66.89**

Table 241:Design Details of Primary Pump US-HDL-9/+5°C/173TR

5.3 Performance Assessment of Chillers:

The production blocks requires chilled water requirements ranging from -15°C to +5 °C. The basic requirement of chilled water in production block is for recovery of solvent in primary and secondary heat exchangers. The chilled water temperature in each reactor varies and depends on the solvent to be recovered. It is observed during field studies even though chillers were designed for different temperature but most of the chillers are operating at higher temperature. It is suggested to further increase the set point of chillers which will reduce the specific energy consumption of chillers. The detailed energy conservation option for individual chillers is discussed in energy conservation measures.

The performance assessment of individual running chillers during field studies was evaluated for coefficient of Performance (COP) and Specific Energy consumption (SEC).

The performance assessment of individual chiller of service block-SB001 is given below.

Chiller Reference US-HDL-9/-15°C/158TR

Chiller Reference US-HDL-9/-15°C/158TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two Skid System**	**Two skid**
Capacity-Skid system	**TR**	**158**	**77.6**
Chilled Water Flowrate	m3/hr	113	107.21
Inlet Water Temperature	°C	-10	3.20
Outlet Water Temperature	°C	-15	0.8
Diff. Temp	°C	5	2.4
Specific Heat	Kcal/kg°C	0.94	0.94
Specific Gravity		0.97	0.97
Operating TR		**158**	**77.6**
Loading	%		98
Power Consumption	kW	264.0	260.00
Specific. Power consumption	kW/TR	1.67	3.35
Coefficient of Performance (COP)	-	**2.1**	**1.0**
Gas Suction Pressure	kg/cm^2	-	2
Discharge Pressure	kg/cm^2	-	16

Table 242:Performance of Chiller Reference US-HDL-9/-15°C/158TR

Observations and findings:

- It is observed from the above table that the chiller is delivering 77.6TR as against to the design capacity of 158TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 107m3/hr when compared to design flow of 113m3/hr.
- The specific energy consumption of the above chiller is 3.35kW/TR as against to the design specific energy consumption of 1.67 kW/TR. The operational efficiency of the above chiller is not satisfactory. And intervention is required for the above chiller during regular maintenance like cleaning of evaporator tubes and condenser tubes.
- The coefficient of performance (COP) of above chiller is 1.0 as against to the design Coefficient of performance (COP) of 2.1.
- The chiller is equipped with evaporative cooling towers and the performance of the same as also been evaluated.
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

Chiller Reference US-HDL_9/+5ºC/175TR

Chiller Reference US-HDL_9/+5ºC/175TR			
Description	**UNITS**	**DESIGN DETAILS**	**ACTUAL**
Date		**Two Skid System**	**Two skid**
Capacity-Skid system	**TR**	**175**	**15.7**
Chilled Water Flowrate	m3/hr	106	95
Diff. Temp	°C	5	0.5
Operating TR		**175**	**15.7**
Loading	%		32
Power Consumption	kW	160	85
Specific. Power consumption	kW/TR	0.91	5.41
Coefficient of Performance (COP)	-	**3.9**	**0.6**
Gas Suction Pressure	kg/cm^2	-	2
Gas Suction Temperature	°C	-	-
Discharge Pressure	kg/cm^2	-	16

Table 243:Performance of Chiller Reference US-HDL-9/+5ºC/175TR

Observations and findings:

- During the field studies it has observed that the performance of the above chiller is poor and immediate maintenance activity should be carried out to improve the performance of the above chiller by the way of cleaning the evaporator tubes. The output from the above chiller is no chilling effect and it consumes 8kW of power.
- It is observed from the above table that the chiller is not delivering 15.7TR as against to the design capacity of 175TR.
- The TR delivered is less when compared to design is majorly because of less diff in temperature (delta T) as against the design temperature difference (delta T).
- The flow rate of the above chiller during performance assessment is 95m3/hr when compared to design flow of 106m3/hr.
- **The specific energy consumption of the above chiller is 5.41 kW/TR as against to the design specific energy consumption of 0.91 kW/TR. The operational efficiency of the above chiller is poor and a detailed energy conservation option has been given in Encon chapter. And intervention is required for the above chiller during regular maintenance**.
- The coefficient of performance (COP) of above chiller is 0.6 as against to the design Coefficient of performance (COP) of 3.9
- It is observed during the field studies that the hot well and cold well tanks were interconnected with a valve, the valve is in open condition for operational comfort. This will lead for mixing of chilled water and hot return water which will in turn increase the temperature of chilled water. This will lead in increase energy consumption and detailed energy conservation option was discussed in energy conservation measures.

5.4 Performance Assessment of Pumps:

The service blocks chillers are equipped with primary and secondary pumps to meet the chilling requirements of production blocks. The no. of primary pumps and secondary pumps vary from chiller to chiller. The performance assessment of individual running primary pumps during field studies was evaluated for individual pumps efficiency.

Chiller Reference US-HDL-9/-15ºC/158TR

The performance of primary pump was evaluated and presented below

Pumps		PRIMARY -15 ºC 158 TR	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	130	107.21
Suction Head	**m**	-	3.90
Discharge Head	**m**	-	20.00
Total Head	**m**	25	16.10
Hydraulic power	**kW**	8.58	4.56
Electrical Input power	**kW**	15.00	9.14
Motor Efficiency	**%**	90.00	90.00
Pump Input power	**kW**	11.00	8.23
Pump Efficiency	**%**	**78.02**	**55.41**

Table 244:Performance of Primary Pump US-HDL-9/-15ºC/158TR

Observations and findings:

- The operating flow of primary pumps is 107.21m3/hr when compared to design flow of 130 m3/hr.
- The hydraulic power of the primary pump is 4.56 kW when compared to design hydraulic power of 8.58kW.
- The operating efficiency of the primary pump is 55% when compared to design efficiency of 78%.The primary pump operating performance is satisfactory.

Chiller Reference US-HDL-9/+5ºC/173TR

The performance of primary pump was evaluated and presented below

Pumps		PRIMARY +5 ºC TR/173	
Description	**UNITS**	**RATED**	**ACTUAL**
Flow	**m^3/hr**	90	95.00
Suction Head	**m**	-	2.60
Discharge Head	**m**	-	14.00
Total Head	**m**	30	11.40
Hydraulic power	**kW**	7.35	2.86
Electrical Input power	**kW**	11.89	9.14
Motor Efficiency	**%**	92.50	90
Pump Input power	**kW**	11.00	8.23
Pump Efficiency	**%**	**66.82**	**34.76**

Table 245:Performance of Primary Chiller Reference US-HDL-9/+5ºC/173TR

Observations and findings:

- The operating flow of primary pumps is 95m3/hr when compared to design flow of 90 m3/hr.
- The hydraulic power of the primary pump is 2.86 kW when compared to design hydraulic power of11.89kW.
- The operating efficiency of the primary pump is 34.76% when compared to design efficiency of 66%. The primary pump operating performance is satisfactory.
- A detailed energy conservation option has been discussed for replacing the existing primary pump with new energy efficient pump.

5.5 Performance Assessment of Evaporative Condensers:

The service blocks chillers are equipped with evaporative condensers to dissipate the heat to atmosphere. During the field studies it is observed that the discharge gas temperature is in the range of 88 to 95 ^{0}C .It is suggested to recover the waste heat by placing a stage –I heat recovery system to generate hot water which can be used.The evaporative condensers were normally used to reduce water consumption in the plant.

The performance assessment of few running evaporative condensers was evaluated for effectiveness and operating TR.

Evaporator Reference US-HDL-9/-15ºC/158TR

Parameter Reference	US-HDL-9/-15ºC/158TR
CT Inlet Temp. ºC	33.9
CT Outlet Temp. ºC	30.9
Ambient Temp. ºC	35.9
Wet BulbTemp. ºC	29
Range ºC	3.0
Approach ºC	1.9
Effectiveness = Range/(Range + Approach)	61.22
Air inlet condition	
DBT, ºC	35.9
RH, %	65
Enthalpy, kCal/kg	23.7
Air flow rate, m^3/hr	73589
Air flow rate, kg/hr	78043.71
Air outlet condition	
DBT, ºC	37
RH, %	70
Enthalpy, kCal/kg	28.56
Enthalpy difference, kCal/kg	4.9
TR	137.77

Table 246:Performance of Evaporator Condenser US-HDL-9/-15ºC/158TR

Observations and findings:

- The operating range of the above evaporative condenser is 3.0^{0}C and approach is 1.9^{0}C.
- The operating effectiveness is to the tune of 61.22%.
- The TR rejected to atmosphere of the above evaporative condenser is 137.77 TR.
- The performance of the above evaporative condenser is satisfactory.

5.6 Energy Conservation Options (ENCON):

Encon 1:Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference US-HDL-09/-15^{o}C/158TR

Present Condition:

During the field studies a production block, production process log sheets were studied and observed that the temperature required at end user for -15^{o}C chiller is in the range of -8 to -12^{o}C. Even though production requirements changes from batch to batch as each reactor will be having a supply of +5^{o}C,- 5^{o}C,- 15^{o}C ,- 20^{o}C & -40^{o}C.It is suggested to optimize evaporator temperature for considerable energy savings

Currently -15^{o}C chiller of capacity 158TR is running with a set point of -8^{o}C to -12^{o}C. The compressor will be in OFF condition once reaches -12^{o}C and compressor will be ON once the temperature reaches -8^{o}C.As the power consumption of the compressor is directly proportional to the evaporator temperature by increasing the set point of compressor settings, a substantial amount of energy can be saved.

Proposed Condition:

It is proposed to increase the set point by 3^{o}C to 5^{o}C i.e., keeping set point at -7^{o}C. For every 5.5^{o}C raise in evaporator temperature there will be power savings of 20% - 25%.By increasing the set point there will be envisaged annual savings of 1.4 Lakh kWh with an annual monetary savings of Rs.8.4 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference US-HDL-09/-15°C/158TR		
Description	**Units**	**Value**
Chiller Ref		**US-HDL-09/-15°C/158TR**
Normal operating inlet temperatures of Water	°C	2.20
Normal operating outlet temperatures of Water	°C	0.8
Present set point	°C	-8 to -12
Suggested to increase the set point	°C	-5 to -7
Increase in set point	°C	3 to 5
Present power consumption	kW	260
Percentage reduction in power consumption of compressor	kW	31.2
Number of hours of Operation	Hrs	15
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	1.40
Envisaged annual Monetary savings	Lakhs Rs	8.4
Investment	Lakhs Rs	Nil
Payback period	Months	Immediate
Action to be taken		Operational adjustments
Note: For every 5.5⁰Ccentigrade raise in evaporator temperature the power consumption will reduce by 20-25%		

Table 247: Optimization of chiller Evaporator temperature by adjusting the existing set point of 158TR chiller with reference US-HDL-09/-15oC/158TR

Encon 2:Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Present Condition:

It is observed during the field studies the hot well tank and cold well tank of various chillers are connected with a inter connecting wall for any operational exigency. Normally this wall should be closed condition but during field studies it is observed that all the hot well and cold well inter connecting are in open condition which will increase the temperature of cold well which in turn increases the power consumption of the compressor.

Proposed Condition:

It is proposed to close the valve between hot well and cold well tanks. For arriving at energy savings 250m3 per shift is considered with estimated temperature rise of 1°C. By closing the valve the envisaged annual savings of 4.46 Lakh kWh with an annual monetary savings of Rs.26.7 Lakhs and the investment required for the above suggestion is nil. The above suggestion requires only an operational adjustments. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers		
Description	**Units**	**Value**
HLL-09/service block-03		**Common for all tanks**
Volume of chilled water mixed from hot to cold tanks	m^3/shift	250
Estimated Temperature raise due to mixing of hot and cold water tanks	°C	**1**
Loss in refrigeration effect	TR/Shift	82.67
Average kW/TR generated of chillers	kW/TR	1.50
Number of Shift	no's	3
Number of Tanks in Service block 1	no's	4
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	4.46
Envisaged annual Monetary savings	Lakhs Rs	26.79
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments

Table 248: Energy Savings Due to closing Valve between Hot well and cold well tanks of chillers

Encon 3:Energy Savings by changing operating breathing air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for breathing requirements of the production blocks. The existing pressure settings for the air compressors were 5 – 5.5 kg/cm$^{2.}$ .i.e. at 5.5 the compressor will be in OFF condition and at 5 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3 - 3.5kg/cm^2.

Proposed Condition:

It is proposed to change the pressure settings to 3 - 3.5kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.04 Lakh kWh savings with an annual monetary savings of Rs.0.23 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating breathing air compressor pressure settings		
Description	**Units**	**Value**
HLL-09/service block-06		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	5.5
Existing compressor pressure settings-on	kg/cm^2	5
Existing capacity of air Compressor	CFM	40
Power consumption of air Compressor	kW	6
Existing compressor pressure settings-off	kg/cm3	3.5
Existing compressor pressure settings-on	kg/cm2	3
Estimated Power consumption for proposed power consumption	kW	5.13
Reduction in power consumption	kW	0.8
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.04
Envisaged annual Monetary savings	Lakhs Rs	0.23
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 249: Energy Savings by changing operating breathing air compressor pressure settings

Encon 4: Energy savings by replacing existing (+5 °C) old inefficient chiller with new energy efficient chiller system

Present Condition:

It is observed during the field studies that the existing +5°C chiller of capacity 173 TR is not giving any chilling effect and the output from the chiller is almost 35°C.Whereas the chiller is consuming 85Kw power, without giving any useful output. It is very much urgent to go for either going for immediate maintenance activity or it is suggested to replace the existing chiller with new energy efficient chiller.

Proposed Condition:

It is proposed to change the existing inefficient +5**°C** chiller with new energy efficient chiller immediately. The above ENCON will lead to 62.28 Lakh kWh savings with an annual monetary savings of Rs.373.68 Lakhs with any investment of Rs 34.6 Lakhs with a payback period of 1.1 months. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by replacing existing (+5 °C) old inefficient chiller with new energy efficient chiller system		
Description	**UNITS**	**ACTUAL**
Capacity of Existing (+5°C) Chiller	**TR**	**173.0**
Existing Power Consumption of (+5°C)	kW/TR	5.41
Proposed Chiller Power Consumption (+5°C)	kW/TR	0.91
Excess Power Consumed	kW/TR	4.50
Total Excess Power Consumption	kW	**778.5**
Operating Hours per Annum	Hrs	8000
Total Power Savings Per annum	Kwh/annum(in Lakhs)	62.28
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	373.68
Investment	Lakhs Rs.	34.6
Simple payback period	Months	1.1

Table 250: Energy savings by replacing existing (+5 °C) old inefficient chiller with new energy efficient chiller system

Encon 5: Energy savings by replacement of primary Pump of (+5°C) 173TR with New Energy Efficient Pump

Present Condition:

It is observed during the field studies that the existing efficiency of the primary pump of 173 TR chiller (+5 °C) is 34.76% as against to the design efficiency of 66%, which is low and can be replaced with a new energy efficient pump.

Proposed Condition:

It is proposed to install a five-star rated new energy efficient pump of rated efficiency 75% in the place of existing old inefficient pump. The above proposed option will save 0.39 Lakh kWh of electricity per annum and equivalent annual monetary savings of Rs.2.35 Lakhs with a payback period of 2.0 months. The detailed encon rationale is presented below.

Encon Rationale:

Replacement of Primary Pump of (+5 °C) 173TR with New Energy Efficient Pump		
Description	**UNITS**	**ACTUAL**
Date		
Efficiency of Existing Pump	**%**	**34.8**
Proposed Efficiency of Pump	**%**	75.00
Average Operating Load of Primary Pump	kW	9.14
Proposed energy Consumption	kW	4.24
Expected Savings by Installation of New Pumps	kW	4.90
Operating Hours per Annum	Hrs	**8000**
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.39
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	2.35
Investment	Lakhs Rs.	0.40
Simple payback period	Months	2.0

Table 251: Energy savings by replacement of primary Pump of (+5°C) 173TR with New Energy Efficient Pump

6.0 HONOUR LAB

- Honour Labs Established in 2012, Honour Lab Limited is engaged in the manufacturing of Bulk Drug Intermediates and Active Pharmaceutical Ingredients (APIs). Honour Lab Limited has 6 state-of-the-art manufacturing facilities located in Hyderabad, Visakhapatnam and Pune. The company has been recognized for its sophisticated manufacturing infrastructure, advanced quality control systems, extensive market insights, in-depth R&D expertise and exemplary customer care.
- Honour Labs has 2blocks A & B.The power requirements for honour labs is met through HLL-09 and steam requirements is met through captive power plant. The chiller water requirements is met through 2 service blocks in HLL-09 i.e., service block 2 and service block 4.
- The performance assessment of chillers has been discussed in HLL-09 service blocks performances.
- Honour Labs has one nitrogen plant and one compressed air compressor for meeting batch micronizes of pharma unit and breathing air compressors for individual blocks.
- Production block A has one cooling tower where RO reject water is used as makeup water.
- Production block B cooling tower will be met from service block-3 of HLL-09.
- The honour labs is having a instrument air compressor to meet instrument air requirements of 2 blocks.
- The utilities installed in Honour lab is given below.

S.NO	DISCRIPTION	LOCATOIN	CAPACITY	HP/KW
1	Instrument Air Compressor	N2 Plant	143 CFM	22KW
2	Air Compressor for Nitrogen	N2 Plant	425CFM	75KW
3	Breathing Air Compressor	N2 Plant	50CFM	11KW
4	Process Air Compressor	H6 Block	150 CFM	30KW

Table 252:Equipment list of Honour Lab

- The average steam requirements ranges from 2 to 3Tons per day depending on process demand. There is no condensate recovery and most of the condensate is sent to ETP. Some part of the condensate is sent to gardening. A detailed energy conservation option is discussed in Encon chapter.
- Most of the equipment's in production blocks in A & B are pretty new.
- The detailed power measurements for all the equipment's are measured with portable power analyser and the details of power measurements were attached in Annexure.

- During the field observations it is observed that the breathing air requirements are met by 50CFM capacity air compressor with 11KW.The pressure settings for the above compressor is 6.5 kg/Cm2 to 5 kg/cm2.During discussion with plant people the actual requirements for breathing air is not more than 2.5 kg/cm2.It is suggested to optimize the pressure settings of the breathing air compressor and a detailed energy conservation option has been discussed in energy conservation chapter.
- It is observed that the instrument air requirements are met by 143CFM capacity air compressor with 22KW.The pressure settings for the above compressor is 6.5kg/Cm2 to 7 kg/cm2.Normally the instrument air requirements in any process industry will be in the range of 5 to 5.5 kg/cm2.It is suggested to optimize the pressure settings of the breathing air compressor and a detailed energy conservation option has been discussed in energy conservation chapter.
- It is observed that the process air requirements are met by 150CFM capacity air compressor with 30KW.The pressure settings for the above compressor is 6.5kg/Cm2 to 7 kg/cm2.Normally the process air requirements in any process industry will be in the range of 5 to 5.5 kg/cm2.It is suggested to optimize the pressure settings of the breathing air compressor and a detailed energy conservation option has been discussed in energy conservation chapter.

Energy Conservation Options (ENCON):

Encon 1: Energy Savings by changing operating breathing air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for breathing air requirements. The existing pressure settings for the air compressors were 5 – 6.5 kg/cm$^{2.}$ .i.e. at 6.5 the compressor will be in OFF condition and at 5 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 3 - 3.5 kg/cm^2.

Proposed Condition:

It is proposed to change the pressure settings to 3 - 3.5 kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.06 Lakh kWh savings with an annual monetary savings of Rs.0.33 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating breathing air compressor pressure settings		
Description	**Units**	**Value**
Honour Lab		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	6.5
Existing compressor pressure settings-on	kg/cm^2	5
Existing capacity of air Compressor	CFM	50
Power consumption of air Compressor	kW	8.8
Existing compressor pressure settings-off	kg/cm3	3.5
Existing compressor pressure settings-on	kg/cm2	3
Estimated Power consumption for proposed power consumption	kW	7.56
Reduction in power consumption	kW	1.2
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.06
Envisaged annual Monetary savings	Lakhs Rs	0.33
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 253: Energy Savings by changing operating breathing air compressor pressure settings

Encon 2: Energy Savings by changing operating instrument air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for instrument air requirements. The existing pressure settings for the air compressors were 6.5 - 7 kg/cm$^{2.}$ .i.e. at 7 the compressor will be in OFF condition and at 6.5 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 5 - 5.5 kg/cm^2.

Proposed Condition:

It is proposed to change the pressure settings to 5 - 5.5 kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.01 Lakh kWh savings with an annual monetary savings of Rs.0.67 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating instrument air compressor pressure settings		
Description	**Units**	**Value**
Honour Lab		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	7
Existing compressor pressure settings-on	kg/cm^2	6.5
Existing capacity of air Compressor	CFM	143
Power consumption of air Compressor	kW	17.6
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	15.13
Reduction in power consumption	kW	2.5
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.01
Envisaged annual Monetary savings	Lakhs Rs	0.67
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 254: Energy Savings by changing operating instrument air compressor pressure settings

Encon 3: Energy Savings by changing operating process air compressor pressure settings

Present Condition:

It is observed during the field studies that the air compressor is used for process air requirements. The existing pressure settings for the air compressors were 6.5 - 7 kg/cm$^{2.}$ .i.e. at 7 the compressor will be in OFF condition and at 6.5 the compressor will be in ON condition. A detailed discussion with the engineers in the production block concludes the pressure requirements at the end user is between 5 - 5.5 kg/cm^2.

Proposed Condition:

It is proposed to change the pressure settings to 5 - 5.5 kg/cm^{2}for breathing air compressors. The above operational adjustment will lead to 0.15 Lakh kWh savings with an annual monetary savings of Rs.0.91 Lakhs without any investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by changing operating process air compressor pressure settings		
Description	**Units**	**Value**
Honour Lab		**Compressors**
Existing compressor pressure settings-off	kg/cm^2	7
Existing compressor pressure settings-on	kg/cm^2	6.5
Existing capacity of air Compressor	CFM	150
Power consumption of air Compressor	kW	24
Existing compressor pressure settings-off	kg/cm3	5.5
Existing compressor pressure settings-on	kg/cm2	5
Estimated Power consumption for proposed power consumption	kW	20.64
Reduction in power consumption	kW	3.4
Number of hours of Operation	hrs/day	15.0
Number of days of Operation	days	300
Envisaged annual Energy savings	Lakh Kwh	0.15
Envisaged annual Monetary savings	Lakhs Rs	0.91
Investment	Months	Immediate
Payback period		Immediate
Action to be taken		Operational adjustments
Note:For every 1kg/cm2 decrease of compressor pressure reduces 9% compressor power consumption		

Table 255: Energy Savings by changing operating process air compressor pressure settings

Encon 4: Energy Savings by recovering condensate in honour lab otherwise sent to ETP and Gardening.

Present Condition:

It is observed during the field studies that the steam after used in the process the condensate quantity around 3 tonnes is not recovered and drained to ETP and used for gardening. A detailed discussion with the plant personnel concludes that as there is no provision to recover the condensate they are draining out. It is not only the energy but also the water which is DM water and costlier.

Proposed Condition:

It is proposed to recover the complete condensate by having proper system. The above energy conservation option will lead to 13500kgs of coal savings,18 lakhs worth of DM water and with an annual monetary savings of Rs18.5 Lakhs with any investment of Rs 3.0 Lakhs. The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by recovering the condensate in Honour lab		
Description	**Units**	**Value**
Amount of condensate drained	kgs/day	3000
Temperature of condensate	ºC	80
Amount of heat that can be recovered	Kcals	135000.00
Envisaged annual amount of heat lost	kcals/annum	40500000.0
Calorific value of coal	kcals/kg	3000.0
Amount of coal saved	kgs/annum	13500
Envisaged annual monetary savings through coal	LakhRs/annum	0.41
Envisaged annual monetary savings through water savings	Lakhs Rs/annum	18.0
Total savings	Lakhs Rs/annum	18.4
Investment for piping and constriction of condensate recovery tank	Rs Lakhs	3
Pay back period		2.0

Table 256: Energy Savings by recovering condensate in honour lab

7.0 CAPTIVE POWER PLANT

Hetero Labs Limited has installed 6.1MW extraction back pressure turbine to meet the steam as well as power requirements of the complete plant. The power plant is not connected to grid and the complete power generated from captive power plant is utilized indigenously. The excess power required is taken from the grid. A detailed performance assessment of all the utilities of the plant is conducted during the field studies.

During the field studies the as run measurements were measured with portable instruments and hourly data of individual utilities has been captured for more than 10days.The major sub systems of the power plant that were studied during the field studies are:

1. Boiler System
2. Turbine and its accessories
3. Boiler Feed Water System
4. Ash Handling System
5. Fuel handling system
6. Steam System
7. Draught System
8. Combustion System

The overview of individual sub systems is been presented below along with the design details.

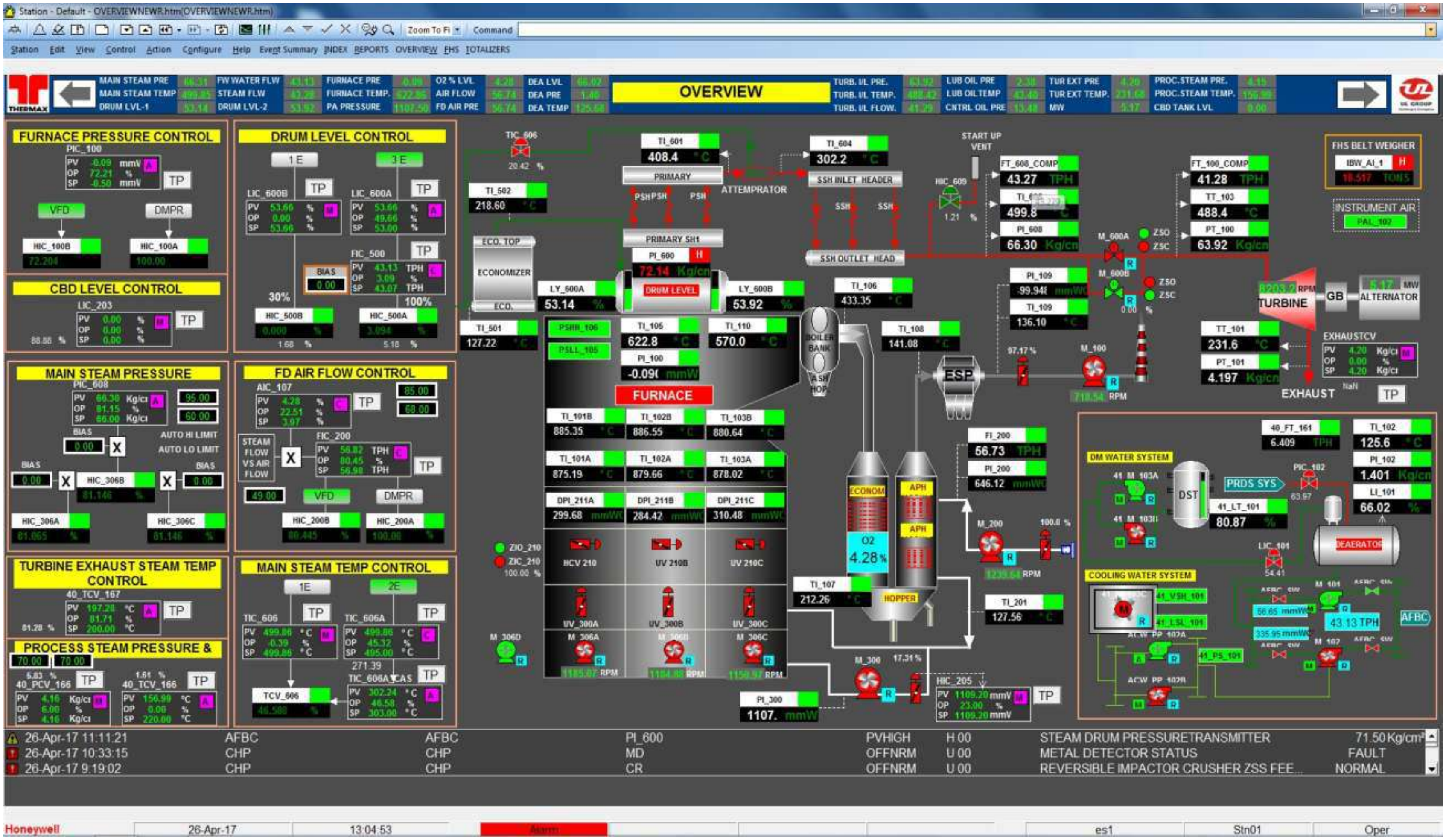


Figure 18:Overview of Power Plant

Boiler system

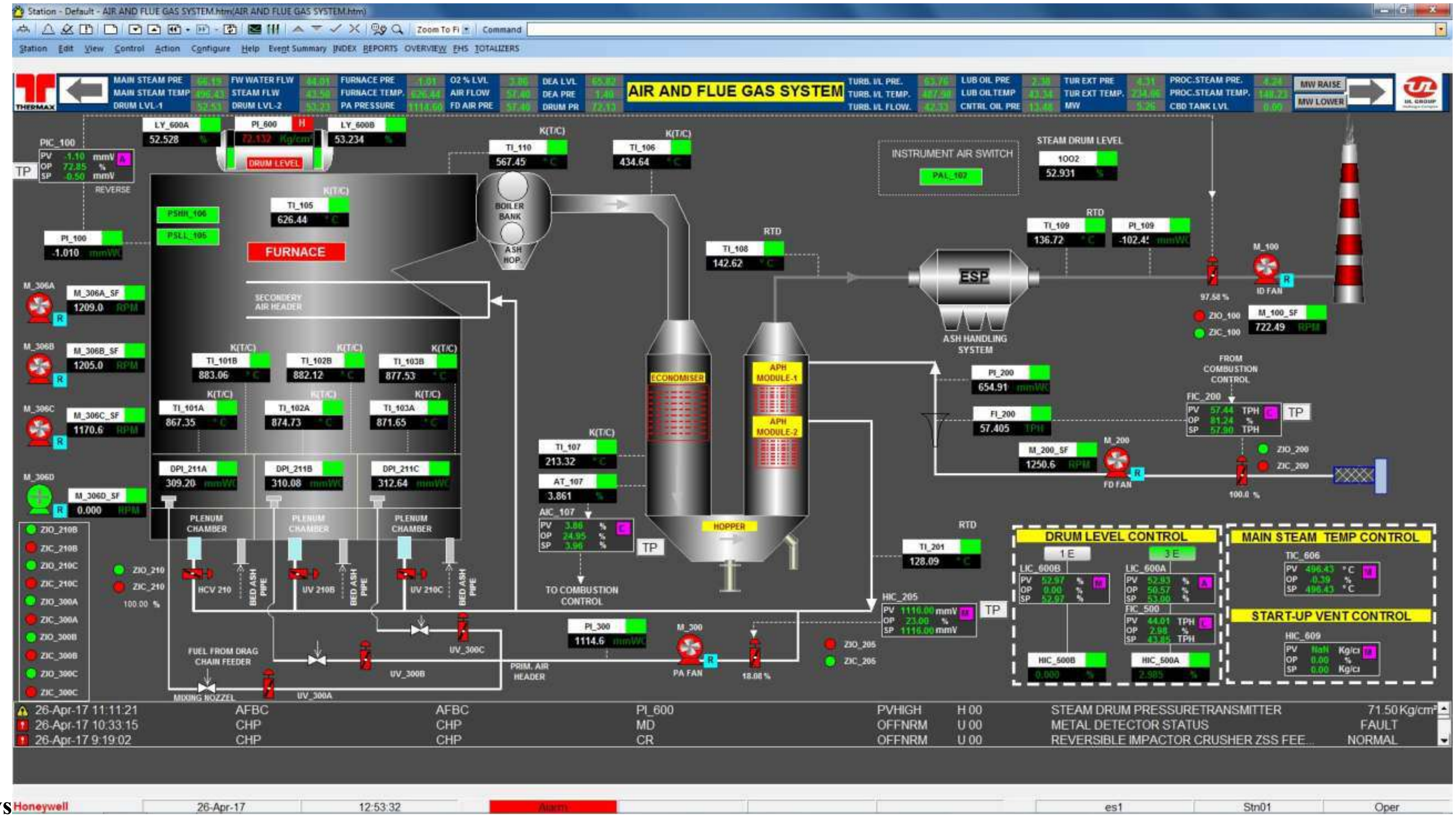


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Figure 19:Boiler System

Design Details of Boiler System

General Information		
Sl.No.	**Title of Test**	**Performance Guarantee Test**
1	Date of Test	03.12.2014
2	Owner	POWER DIVISION A/C HETERO DRUGS LTD
3	Steam Generator Manufacturer	Thermax Ltd. Pune.
4	Steam Generator Capacity	45 TPH; 66 kgfcm2 (g); 490 ± 5 deg c

Table 257: Design Details of Boiler System

PROCESS DATA		
Basic Data		
Number of Boilers	Qty	1.00
Boiler Capacity	TPH	45.00
Boiler Outlet Temperature	oC	490.00
Boiler Outlet Pressure	kg/cm2g	66.00
Feed Water Temperature @ Economiser Inlet	oC	130.00
Design Ambient Dry Bulb Temperature	oC	45.00
Design Relative Humidity	%	60.00
Imported coal consumption at MCR condition	kg/hr	11900.00
Steam generator thermal efficiency on 100% Imported coal (on GCV)	%	79.50
Flue Gas Temperatures		
Bed	°C	900 - 950
Furnace Exit	°C	860 - 920
Superheater Outlet	°C	500 - 550
Boiler Bank Outlet	°C	380 - 400
Economiser Outlet	°C	200 - 250
APH Outlet	°C	140.00
Steam Temperatures		
Primary super heater inlet	°C	285 - 290
Primary super heater outlet	°C	385 - 400
Secondary super heater inlet	°C	375 - 390
Secondary super heater outlet	°C	490+/-5
Water Temperatures		
Feed water inlet temperature deaerator	°C	130.00
Economiser inlet	°C	130.00
Economiser outlet	°C	195 - 210
Air Temperatures		
Air preheater inlet	°C	45.00

Air preheater outlet	°C	170 - 180
Air Pressure Profile		
Fan outlet	mmWC	750.00
Air preheater	mmWC	50.00
Ducting / dampers	mmWC	25.00
Aerofoil	mmWC	25.00
Bubble caps	mmWC	200.00
Fluidised bed	mmWC	450.00
Gas Pressure Profile		
Furnace	mmWC	5.00
Superheater	mmWC	5.00
Bank tubes	mmWC	25.00
Economiser	mmWC	25.00
Air preheater	mmWC	20.00
ESP	mmWC	25.00
Ducting / dampers	mmWC	30.00
PRESSURE PART DATA		
Furnace - Membrane Panel		
Tube Outside Diameter	mm	63.50
Tube Thickness	mm	4.06
Pitch	mm	120.00
Tube Material	---	SA210 Gr.A1
Heat Transfer Area	m2	120.00
Furnace dimension	mm	4000 x 6000
Header size	mm	219.1 x 23
MOC of header	mm	SA 106 Gr.B
Superheater		
Location	---	Furnace Exit
Tube Outside Diameter	mm	38.1/44.45
Tube Thickness	mm	4.06
Tube Material	---	SA210 Gr.A1
Tube Arrangement	---	Pendant, non-drainable
Heat Transfer Area	m2	675.00
Header size	mm	219.1 x 23
MOC of header	mm	SA 106 Gr.B / SA335P11
Steam Drum (SD)		
Inside Diameter	mm	1375.00
Length Tan-To-Tan	mm	5000.00
Plate Thickness	mm	63.00
Material	---	SA516 Gr.70
Drum internals	---	Two stage cyclone seperator
Drum internals material	---	Carbon steel
Water Drum (WD)		
Inside Diameter	mm	960.00

Length Tan-To-Tan	mm	5000.00
Plate Thickness	mm	40.00
Material	---	SA516 Gr.70
Type of dished end	---	Semi ellipsoidal
Dished end thickness	mm	40.00
Boiler Bank (BB)		
Location	---	Downstream of SH
Tube Outside Diameter	mm	50.80
Tube Thickness	mm	3.66
Tube Material	---	SA210 Gr.A1
Flow	---	Cross
Tube Arrangement	---	In Line
Heat Transfer Area	m2	345.00
Economiser (ECO)		
Location	---	Downstream of Boiler Bank
Tube Outside Diameter	mm	38.1/44.45
Tube Thickness	mm	3.66
Tube Material	---	SA210 Gr.A1
Flow	---	Counter
Tube Arrangement	---	In Line
Heat Transfer Area	m2	505.00
AIR PRE HEATER DATA		
APH		
Type	---	Tubular
Orientation	---	Vertical
Location	---	Downstream of Economiser
Tube Outside Diameter	mm	63.50
Tube Thickness	mm	2.03
Tube Material	---	BS 6323 ERW CS
Flow	---	Cross
Tube Arrangement	---	In Line
Tube Side Fluid	---	Flue Gas
Tube Sheet Material	---	IS2062 / Equi.
Heat Transfer Area	m2	925.00
FAN DATA		
FD Fans		
Number of Fans per Boiler	Qty	1.00
Capacity per Fan	%	100.00
Flow Rate - Test Block	m3/s	19.00
Head - Test Block	mmWC	825.00
Drive (Motor)	---	VFD Suitable
PA Fans		

Number of Fans per Boiler	Qty	1.00
Capacity per Fan	%	100.00
Flow Rate - Test Block	m3/s	1.50
Head - Test Block	mmWC	830.00
Drive (Motor)	---	Const. Speed
ID Fans		
Number of Fans per Boiler	Qty	1.00
Capacity per Fan	%	100.00
Flow Rate - Test Block	m3/s	32.00
Head - Test Block	mmWC	180.00
Drive (Motor)	---	VFD Suitable
DUCT DATA		
Cold Air Ducts		
Thickness	mm	4.00
Allowable Velocity	m/s	14.00
Hot Air Ducts		
Thickness	mm	4.00
Allowable Velocity	m/s	18.00
Flue gas Ducts		
Thickness	mm	5.00
Allowable Velocity	m/s	18.00
SAMPLE COOLER DATA		
Sample Coolers		
Number of Sample Coolers	Qty	4.00
FLUE GAS VELOCITIES		
Fluidised bed	m/s	2 - 3
Furnace	m/s	2 - 3
Superheater	m/s	6 - 8
Economiser	m/s	10 - 12
Airpreheater	m/s	11 - 14
FEED WATER QUALITY		
General Appearance		Clear & Colourless
TDS		0.1 PPM(Max)
Conductivity at 25 oC		0.2 micro Siemens/cm(Max)
pH at 25 oC		8.5 - 9.5
O2		0.007 PPM
Free CO2		Nil

Total Iron (Fe)		0.01 ppm
Total Copper (Cu)		0.005 ppm
Silica (SiO2)		< 0.02 ppm
Hydrazine		0.02 ppm(Max)
Total Carbonic Acid		Nil
Hardness		Nil
KMnO4		Nil
Oil		Nil
BOILER WATER QUALITY		
Silica		< 2.7 ppm
Phosphate as PO4		7 ppm
TDS		100 PPM
pH		10.8 – 11.2
Conductivity		200 micro Siemens/cm
DEAERATOR		
Deaeration Principal		Spray Cum Tray Type
Deaeration capacity	TPH	45.00
Storage Tank Capacity	m3	12.00
Operating Pressure	kg/cm2g	1.75
Operating Temperature	oC	130.00
Tray Material of construction	---	SS
Nozzle Material of construction	---	SS
Shell Material of construction	---	SA516Gr70
DOSING SYSTEM DATA		
HP Dosing System		
Number of Tanks	Qty	1.00
Capacity of Tank	Litres	300.00
Tank Material	---	SS304
Type of Agitator	---	Propeller Type
Number of Agitator	Qty	1.00
Number of Pumps	Qty	2.00
Type of Pumps	---	Plunger Type
Capacity of Pump	lit/hr	7.50
Pump Discharge Pressure	kg/cm2g	79.00
Pump Material (Wetted Parts)	---	SS316
LP Dosing System		
Number of Tanks	Qty	1.00
Capacity of Tank	Litres	150.00

Table 258:Process Details of Captive Power Plant

Turbine System:

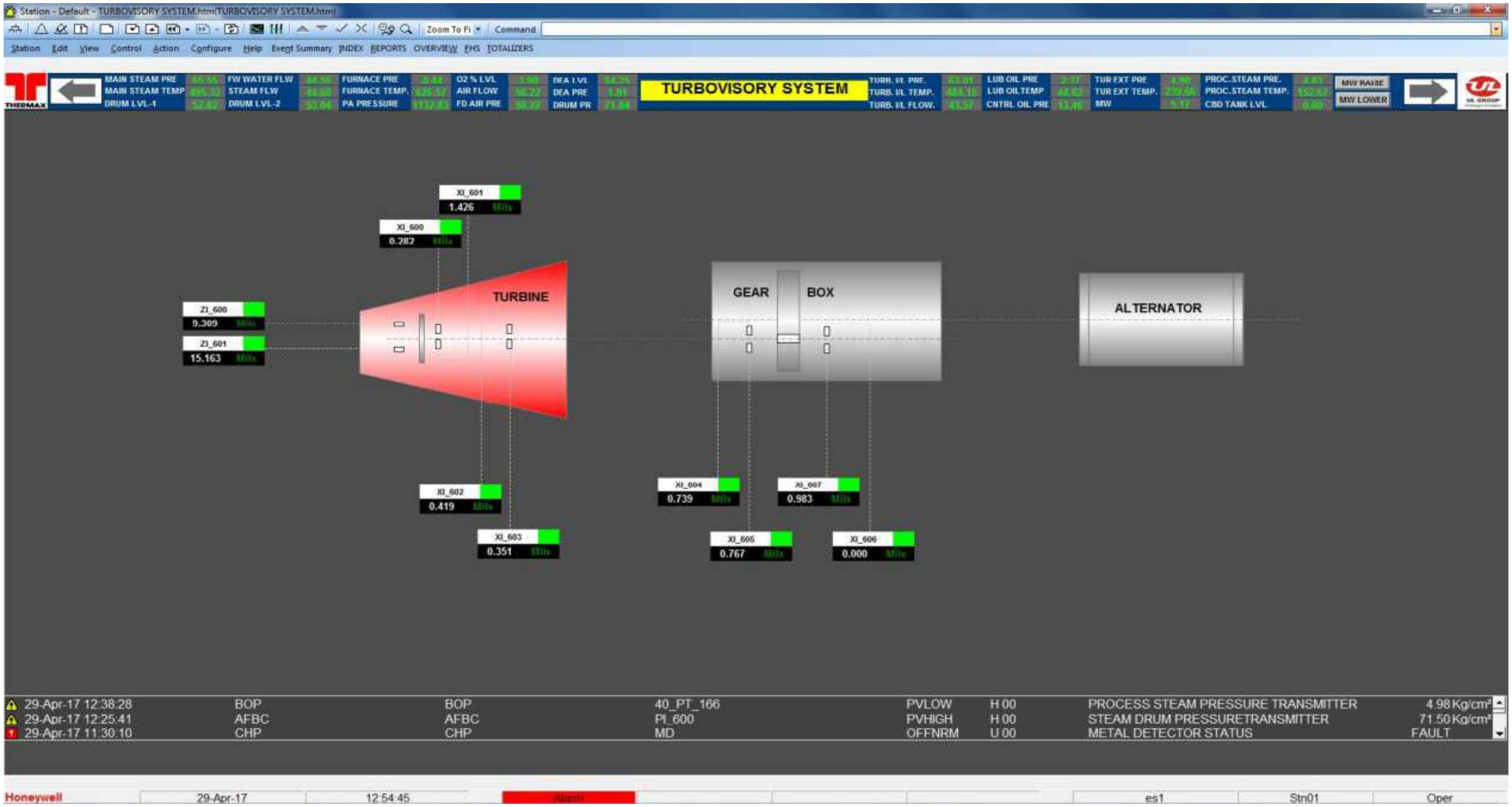


Figure 20:Turbine System

Turbine Design Details			
S.No	**Parameters**	**Units**	**Design**
1	Unit Load	MW	6.1
2	Boiler Efficiency	%	80
3	GCV of Fuel	kCal/kg	3500
	Inlet Steam Condition		
4	Main Steam Flow	TPH	45
5	Main Steam Temperature	^oC	490
6	Main Steam Pressure	kg/cm^2	66
7	Main Steam Enthalpy	kCal/kg	810
	Outlet Steam Condition		
8	Outlet Steam Condition-Back pressure	TPH	45
9	Back Pressure Steam Temperature	^oC	202
10	Back Pressure Steam Pressure	kg/cm^2	5
11	Back Pressure Steam Enthalpy	kCal/kg	681
	Feed Water		
12	Feed water Flow	TPH	45
13	Feed Water Temperature	^oC	130
14	Feed water Pressure	kg/cm^2	100
15	Feed water enthalpy	kCal/kg	130
16	Makeup water temperature	^oC	60
17	Makeup water Enthalpy	kCal	60
18	Mechanical Efficiency of Turbine	%	
19	Transmission Efficiency	%	
20	Generator Efficiency	%	97

Table 259:Turbine Design Details

Boiler Feed Water Pumps:

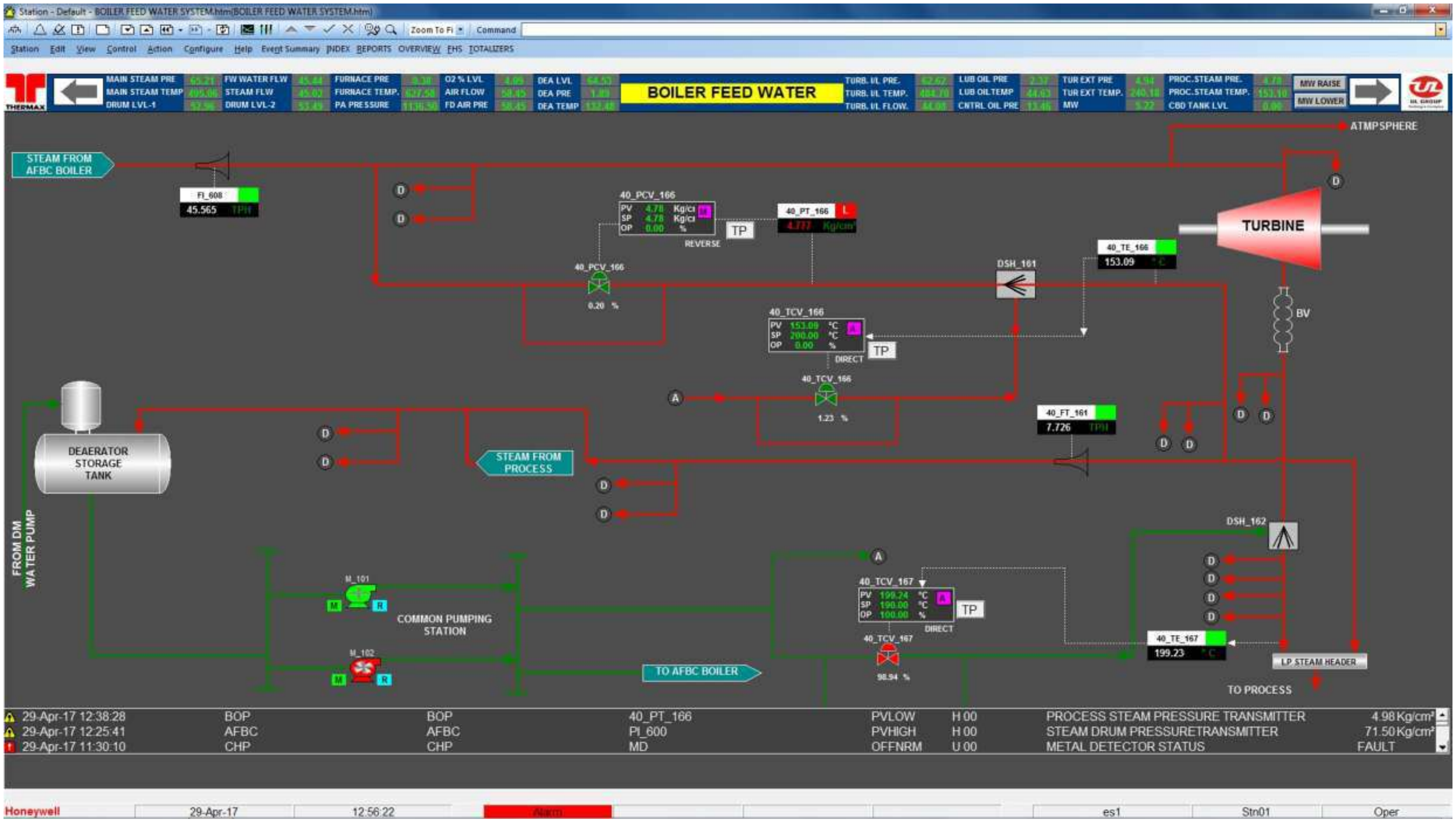


Figure 21:Boiler Feed Water Pumps

Design Details of Boiler Feed Water Pump			
Sno	**Parameter**	**Units**	**Deign**
1	Unit Load	MW	6.1
2	Flow	TPH	57
3	Temperature		130
4	Suction Pressure	kg/cm2 (g)	2.7
5	Discharge Pressure	kg/cm2 (g)	96
6	Pump Head	m	1005
7	Liquid Density	kg/m3	0.9346
8	Hydraulic Power	kW	
9	Motor output power	kW	222
10	Motor Power Input	kW	250
11	Motor Efficiency	%	94.2
12	Pump Efficiency	%	66
13	Combined Efficiency	%	

Table 260:Design Details of Boiler Feed Water Pumps

Draught System:

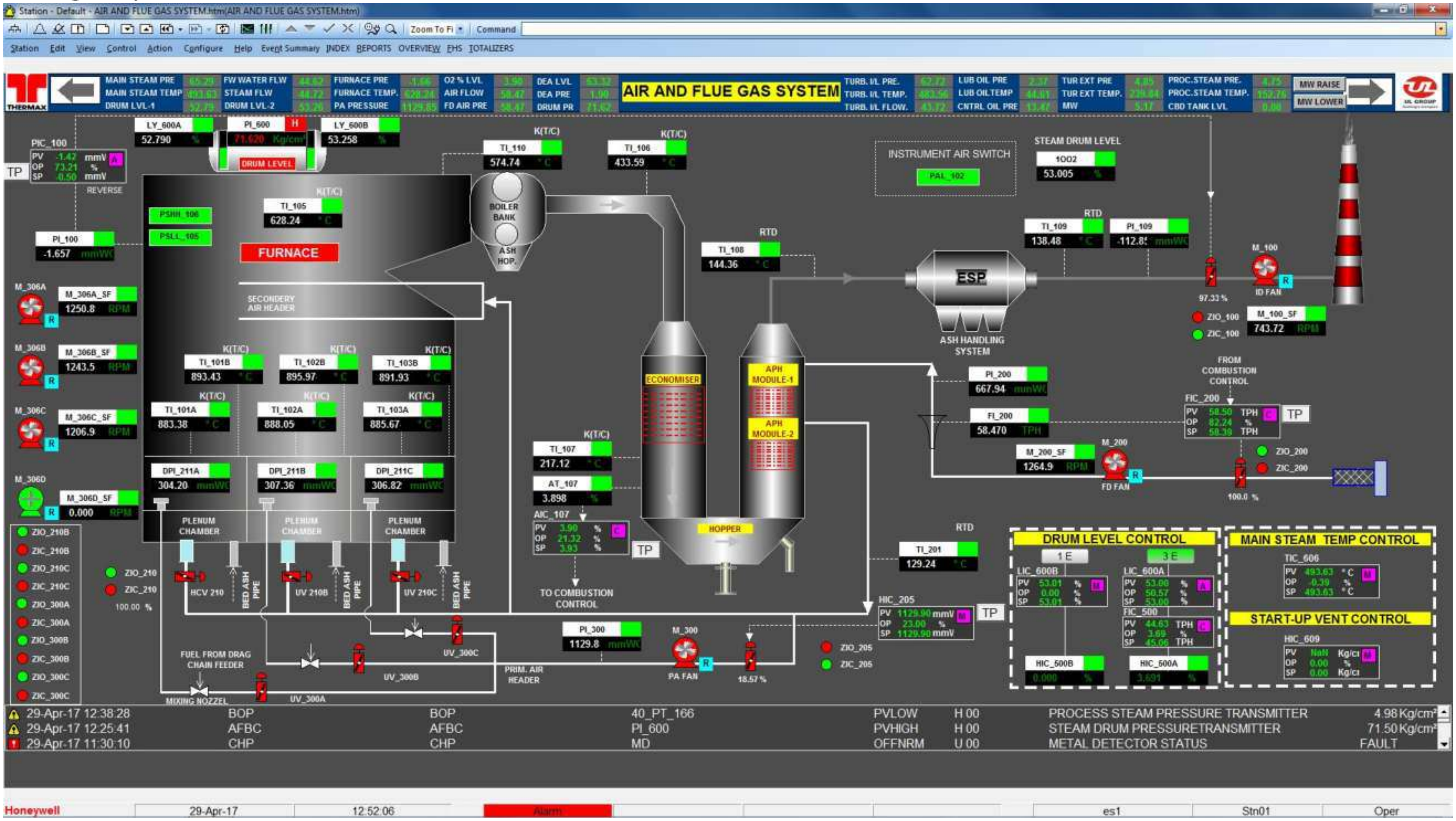


Figure 22:Draught System

FD Fan Design Details			
S.No	**Parameter reference**	**Units**	**Design**
1	Megawatt load	MW	6.1
2	Flow	m3/hr	68400
		TPH	70.46
3	Suction Pressure	$mmWC_G$	-
4	Discharge pressure	$mmWC_G$	-
5	Head developed	$mmWC_G$	825
6	FD air temperature	^oC	45
7	FD air density	kg/m^3	1.03
8	Motor Efficiency	%	92
9	Fan motor rated power	kW	250
10	Motor input Power	kW	271.74
11	Air KW *(Fan hydraulic power)*	kW	153.49
13	Overall Efficiency (Fan and Motor)	%	56.48
14	Fan Efficiency	%	61.40

Table 261:Design Details of FD Fan

ID Fan Design Details			
S.No	**Parameter reference**	**Units**	**Design**
1	Megawatt load	MW	6.1
2	Flow	m3/hr	115200
		TPH	98.54
3	Suction Pressure	$mmWC_G$	-
4	Discharge pressure	$mmWC_G$	-
5	Head developed	$mmWC_G$	180
6	FD air temperature	^oC	110
7	FD air density	kg/m^3	0.86
8	Motor Efficiency	%	92
9	Fan motor rated power	kW	110
10	Motor input Power	kW	119.6
11	Air KW *(Fan hydraulic power)*	kW	56.40
13	Overall Efficiency (Fan and Motor)	%	47.2
14	Fan Efficiency	%	51.3

Table 262:Design Details of ID Fan

Combustion System:

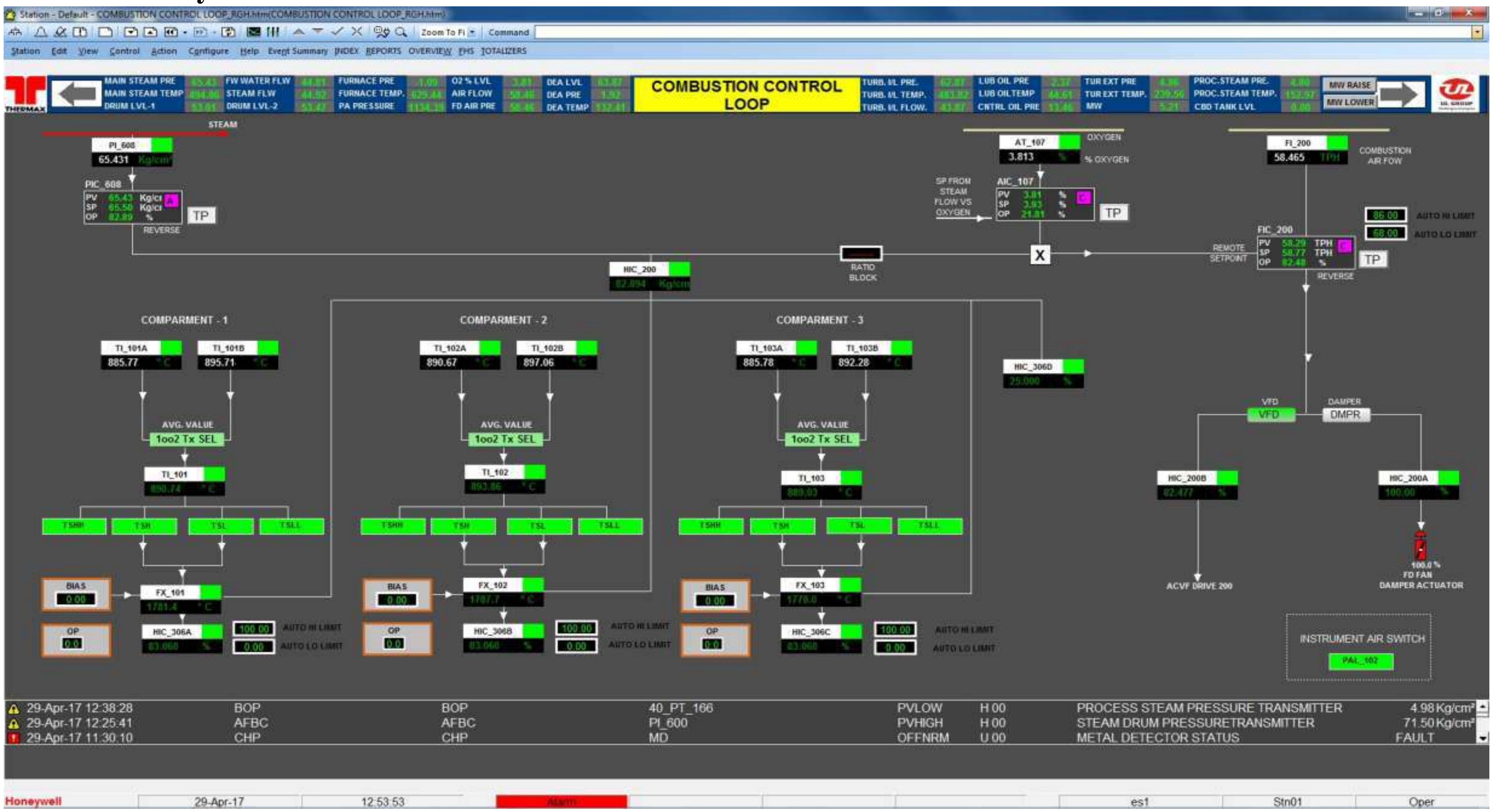


Figure 23:Combustion System

Design Fuel Analysis:

CONTRACT (DESIGN) FUEL ANALYSIS		
Sl. NO.	**Parameter**	**100% Imported Coal**
1	C	37.1
2	S	0.35
3	H2	3.1
4	H20	35
5	N2	1.21
6	O2	13.5
7	Ash	9.74
8	GCV (Kcal/kg) As received basis	3400

Table 263:Design Fuel Analysis

Steam System:

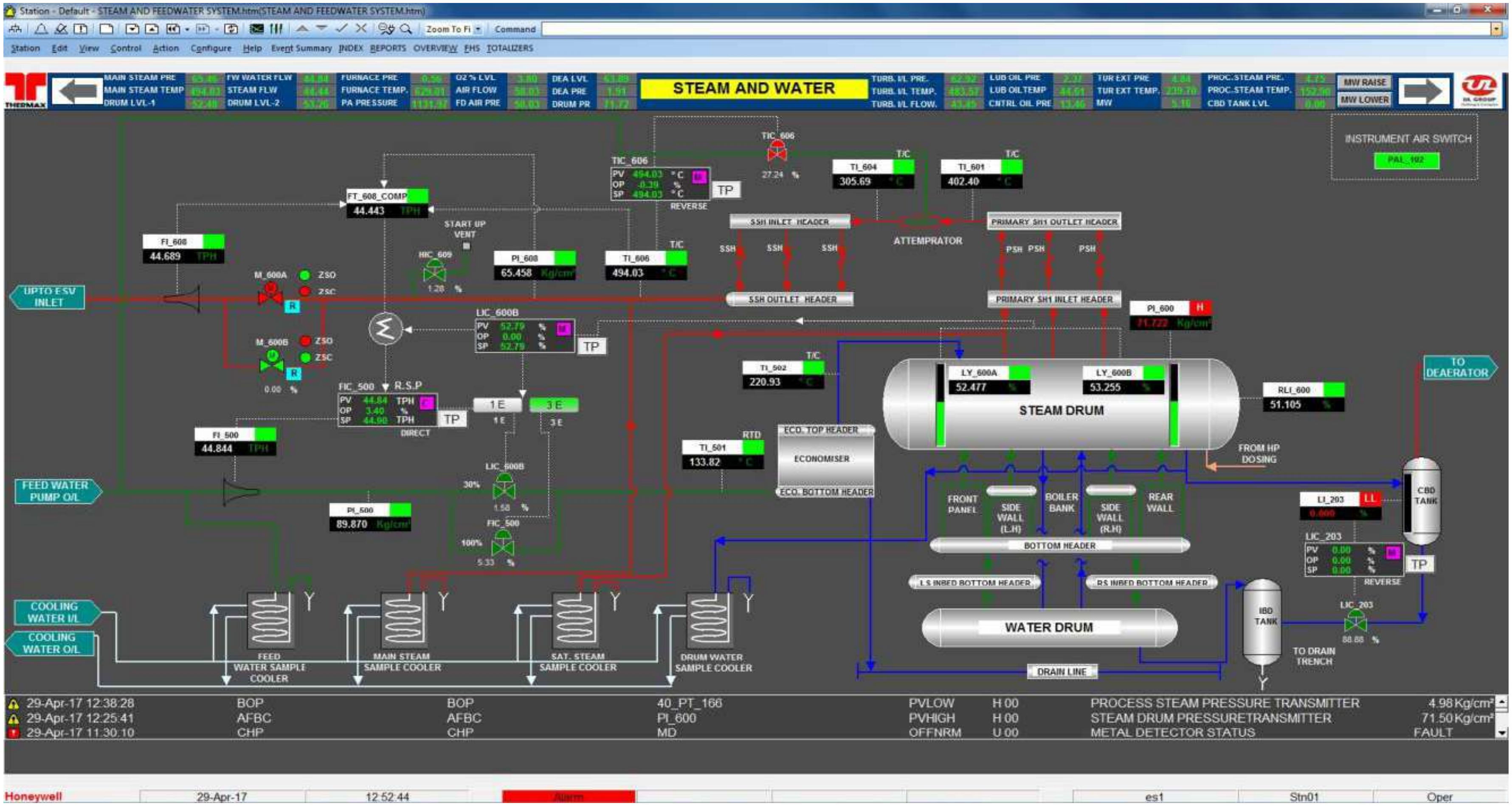


Figure 24:Steam System

Boiler Efficiency by Indirect Method:

A boiler efficiency trail has been conducted on 10 March 2017 & 26 April 2017.The efficiency test was conducted for 6-8 hours were hourly parameters from control room has been collected and measurements with portable instruments has been taken to evaluate boiler efficiency by indirect method. During field studies on 10th March 2017 it has been observed that boiler pre heater tubes got punctured and primary air was bypassed from APH. The efficiency test was conducted on 26th April after pre heater tubes was replaced.

Basic data collected

Item	Value	Units
Date	**26.04.2017**	
Boiler Reference		
Mean Sea level	45	m
Barometric pressure	10110	mmWC
Ambient air temperature	35.6	ºC
Avg Steam Flow	38.729	TPH
Steam Pressure operated at	65.433	kg/cm2(g)
Temperature	497.185	ºC
Enthalpy of Steam	814.489	kCal/kg
Flue gas outlet temperature after APH	145	ºC
Gross Calorific Value of fuel (as fired basis)	3462.00	kCal/kg
Avg coal feed rate	0	TPH
Carbon monoxide (Economizer O/L)	88	ppm
Temp. (Economizer Out)	226	ºC
Oxygen (APH O/L)	5	%
Carbon monoxide (APH O/L)	67	ppm
Temp. (APH Out)	145	ºC
Oxygen (ID O/L)	6.5	%
Carbon monoxide (ID O/L)	61	ppm
Temp. (ID Out)	135	ºC
Atmospheric Air:		
DBT	35.6	ºC
WBT	27.16	ºC
Abs. Humidity	0.0198	kg of moisture/kgof air
Dew point	24.6	ºC
Fuel firing rate	0.00	TPH
Feed Water:		
Temp. (Before Economiser)	129.78	ºC
Temp. (After Economiser)	214.52	ºC

Table 264:Data Collected from Plant for Boiler Efficiency

Fuel Analysis:

Coal Analysis-Ultimate:		Values	
Carbon Content	C	36.44	%
Hydrogen Content	H	2.07	%
Nitrogen Content	N	1.53	%
Oxygen Content	O	12.93	%
Sulphur Content	S	0.43	%
Ash Content	A	8.15	%
Moisture Content	M	38.45	%
GCV of Coal		3462.00	kCal/kg
Ash Analysis:			
Unburnt in Bottom Ash		0	%
Unburnt in Fly ash		30.25	%
GCV		3065.00	
Distribution of Ash:			
Bottom Ash	% of total ash	0.00	%
Fly ash	% of total ash	100.00	%
Total Ash Distribution Quantity:			
Bottom ash		0.0000	kg/kgcoal
Fly ash (100% of the total ash)		0.0815	kg/kgcoal
Oxygen (Economizer O/L)		2.84	%

Table 265:Fuel Analysis

Boiler Performance Evaluation:

Efficiency By Indirect Method:

Theoretical Air Requirement For complete combustion — $Air_{(theo.)}$ — $((11.6 \times C) + (34.8 \times (H_2 - O_2/8)) + 4.35 \times S))/100$

4.40 kg / kg of Coal

Excess Air Supplied (EA) — EA — $\frac{O_2 \% \times 100}{21 - O_2\%}$

Where O_2 % is oxygen % at Economizer outlet — 31.25 %

Actual Mass of Air Supplied (AAS) — AAS — (1 + EA/100) X Theoretical Air

5.78 kg / kg of Coal

Mass of Dry Flue Gas — $M_{dry\ Flue\ Gas}$ — AAS + (1-Total ash)

6.70 kg / kg of Coal

% Heat Loss in Dry Flue Gas — L1 — $\frac{m \times C_p \times (T_f - T_a) \times 100}{GCV\ of\ Fuel}$

Efficiency By Indirect Method:

Where T_f is flue gas exit temp		5.08	%
% Heat Loss due to H_2 in Fuel	L2	$\frac{9 \times H_2 \times (584 + Cp\,(T_f - T_a)) \times 100}{\text{GCV of Fuel}}$	
		3.41	%
% Heat Loss due to Moisture in fuel	L3	$\frac{M \times (584 + Cp\,(Tf - Ta)) \times 100}{\text{GCV of Fuel}}$	
		7.03	%
% Heat Loss due to Moisture in Air	L4	$\frac{AAS \times Humidity \times Cp \times (Tf - Ta)) \times 100}{\text{GCV of Fuel}}$	
		0.16	%
%Unaccounted and Heat Loss due Radiation and Convection from boiler surfaces Ts=Boiler surface temp [^{0}C] Ta= Ambient Temp [^{0}C] Hs=Heat Loss [kCal/hr] A = Surface Area [m2}	L5	[10+(Ts-Ta)/20]*(Ts-Ta)*A*100/GCV of Fuel	
		2.00	%
% Heat Loss due to Unburnt in Bottom Ash		$\frac{\text{Total Ash Collected in Blr bed/ kg of Fuel Burnt} \times \text{\% Unburnt} \times GCV \times 100}{\text{GCV of Fuel}}$	
		0.00	%
% Heat Loss due to Unburnt in fly ash		$\frac{\text{Total Fly Ash Collected/ kg of Fuel Burnt} \times \text{\% Unburnt in Fly ash} \times GCV \times 100}{\text{GCV of Fuel}}$	
		7.22	%
% Heat Loss due to Unburnt in Total Ash	L6	a+b	
		7.22	%
% Heat loss due to sensible heat of Ash		m*Cp*(Tash-Tamb)*100	

Efficiency By Indirect Method:

		GCV coal		
Bottom Ash			0.00	%
Fly ash			0.05	%
% Total sensible heat loss due to Ash residue	L7	a+b		
			0.0546	%
% Heat Loss due to Unburnts (CO) in Flue Gas	L8	CO(in ppm)*28*5654 / 10^6*GCV coal		
			0.40	%
			74.64	**%**
Coal Consumption			9.53	
Evaporation ratio			4.06	

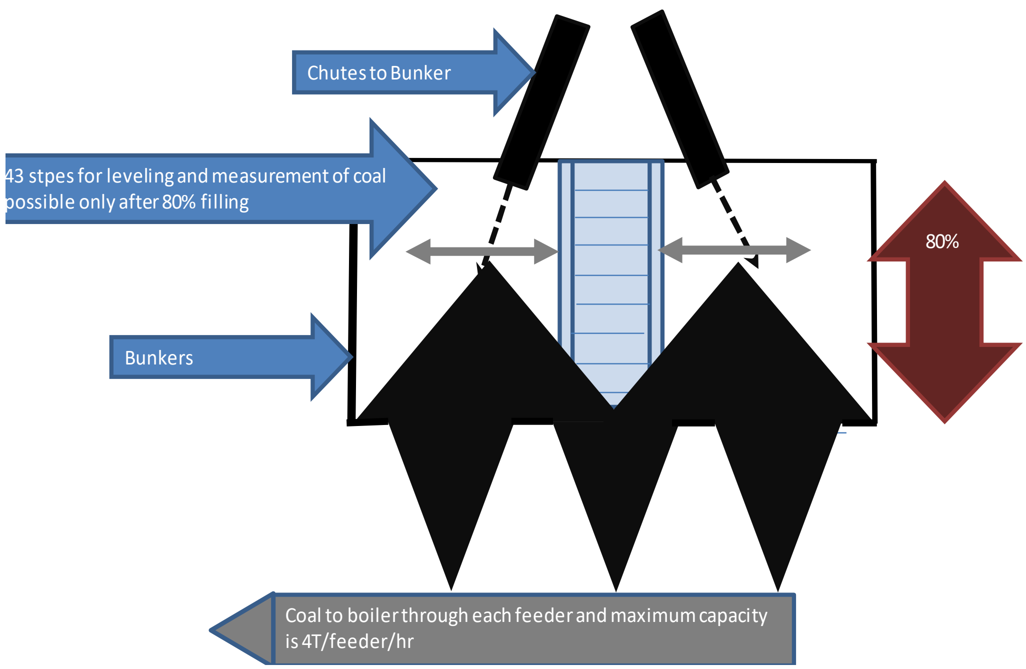
Boiler Efficiency by Indirect Method Summary			
% Loss		**Value**	
Heat Loss in Dry Flue Gas	L1	5.08	%
Heat Loss due to H2 in Fuel	L2	3.41	%
Heat Loss due to Moisture in fuel	L3	7.03	%
Heat Loss due to Moisture in Air	L4	0.16	%
Heat Loss due to Unburnt in Bottom Ash'	L5	0.00	%
Heat Loss due to Unburnt in fly ash	L6	7.22	%
Total sensible heat loss due to Ash residue	L7	0.05	%
Heat Loss due to Unburnt (CO) in Flue Gas	L8	0.40	%
Radiation ,Surface and Unaccounted Loss	L9	2.00	%
Net Boiler Efficiency		74.64	%

Table 266:Various Heat Losses

Observations & findings:

- The boiler trail done on 27th April 2017 was presented in annexure.
- It has been observed during the 1st boiler test trial on 10th March 2017 that the oxygen before APH 2.8% and after APH 13%, which clearly indicates that there is a tube failure in the APH. This issue has been already discussed with the management for the corrective action to arrest the air leakages in the APH tube.
- Management of Hetero Labs has immediately attended the above leakage and replace all the tubes in the month of April 2017.
- It has also been observed that the coal is having high amount of fines. During the boiler test fly ash at different points from bank zone, economizer, APH and ESP was collected and sent to two different labs for loss of ignition and calorific value of ash.
- The report from two different labs estimates that unburnt carbon after APH point is 32% with a calorific value of 2320 kCal/kg and the unburnt carbon after economizer is 28.5% with a calorific value of 2100kCal/kg.(The reports from two different labs i.e./s Vitro Labs and M/s Lucid labs is annexed for reference).
- This resulted as one of the major loss i.e., 7.2% while evaluating boiler efficiency.
- The management of hetero drugs quickly called for a meeting with all coal suppliers and power plant operation people on 2nd May 2017 to bring down the losses by adopting best practices at purchase end and also by operational practices.

- If the percentage of fines in the coal is very high, wetting of coal can decrease the percentage of unburnt carbon and the excess air level required to be supplied for combustion to an extent.
- Roughly, the extent of wetting for the fine of about 30%, the surface moisture to be maintained at around 7-8%. If the extent of wetting is too high the heat loss due to moisture in fuel will be high. The heat loss due to moisture in fuel in our case is high at 7.03 % and unburnt loss is high at 7.2 %. Hence it is recommended to use the properly sized coal for the FBC boiler the recommend size of the coal for the FBC boiler is 8 to 10 mm.
- It has been observed that the coal measurement in the plant was not proper and the measuring instrument near feeder conveyor that is available is showing error. Hence it is recommended to use weighing feeder at the bottom of the bunker to exactly monitor the coal consumption of the boiler.
- It is observed during the field studies the coal consumption is estimated by direct method which is a rough estimation. The estimation is based on a level of bunker which is again a very difficult to assess. It is suggested to conduct indirect method of boiler efficiency test for arriving at consumption of coal.



- It has been observed that the boiler efficiency is about 74.64%, ER is 4.06 with coal consumption as per indirect efficiency calculation works out to be 9.53 TPH. The ER worked out by the management is very low at around 3 to 3.3 because they take the coal consumption as received basis which includes all other losses like carpet losses, vintage losses and moisture losses etc.
- Due to high excess air because of Failure of tube in APH results in increased power consumption of ID fans and results increase of APC of captive power plant.By arresting air leakages in APH tubes resulted considerable coal savings and detailed energy conservation option has been discussed in Energy Conservation Option (ENCON) chapter.
- Due to high excess unburnt in ash because of high percentage of fines in purchased coal resulted considerable coal losses and detailed energy conservation option has been discussed in Energy Conservation Option(ENCON) chapter.
- Due to high moisture in purchased coal resulted considerable coal losses and detailed energy conservation option has been discussed in Energy Conservation Option (ENCON) chapter. A detailed presentation with management of hetero drugs and coal suppliers on 2nd May 2017 on moisture and fines in purchased coal and effect on efficiency of boiler was presented.
- During the field studies it has been observed that CPP is generating 4.45 MW whereas the CPP is designed for 6.1MW.Discussion with operation personnel reveals that the steam requirement is the single deciding parameter for power generation. As steam requirement is low the power generation is also low.When compared to grid power CPP power is always reliable and financially viable. It is suggested to increase the steam consumption by having VAM operation in service blocks and increase the generation capacity. A detailed energy conservation option has been discussed in Energy Conservation Option (ENCON) chapter.

Performance of Turbine:

A turbine performance evaluation has been evaluated by collecting online data from control room and the performance parameters like Heat to power ratio, steam to power ration has been evaluated. The following table compares the actual performance of turbine with design parameters.

Turbine Performance				
S.No	**Parameters**	**Units**	**Design**	**Unit**
1	Unit Load	MW	6.1	4.22
2	Boiler Efficiency	%	82.5	74.64
3	GCV of Fuel	kCal/kg	3400	3462.00
	Inlet Steam Condition			
4	Main Steam Flow	TPH	45	38.73
5	Main Steam Temperature	ºC	485	487.185
6	Main Steam Pressure	kg/cm^2	64	65.433
7	Main Steam Enthalpy	kCal/kg	808.12	809
	Outlet Steam Condition			
8	Outlet Steam Condition-Back pressure	TPH	45	39
9	Back Pressure Steam Temperature	ºC	202	220
10	Back Pressure Steam Pressure	kg/cm^2	6	4.3
11	Back Pressure Steam Enthalpy	kCal/kg	681.84	693
	Feed Water			
12	Feed water Flow	TPH	45	40
13	Feed Water Temperature	ºC	131	129.78
14	Feed water Pressure	kg/cm^2	64	65.4
15	Feed water enthalpy	kCal/kg	133.1	129.78
16	Makeup water temperature	ºC	35	35
17	Makeup water Enthalpy	kCals	35	35
18	Mechanical Efficiency of Turbine	%	96	93
19	Transmission Efficiency	%	98	92
20	Generator Efficiency	%	98	94
21	Enthalpy Drop	kCals/kg	126.28	117
22	Power Generated from Turbine	MW	6.09	4.22
23	**Heat to Power ratio**	**kW_{th}/kWe**	**6.94**	**8.64**
24	**Steam to Power Ratio**	**kg/kWh**	**7.39**	**9.18**

Table 267:Turbine Performance

Observation & Findings:

- It is observed that heat to power ratio is 8.6 kW_{th}/kWe vis-à-vis the design value of 6.94kW_{th}/kWe. The heat to power ratio is low when compared to design value low generation when compared to design.
- It is observed that CPP is generating 4.45MW when compared to design capacity of 6.1MW.
- The calorific value of the fuel is 3460 kCal/kg when compared to the design GCV 3500 kCal/kg.
- The main steam flow rate is 38.73 TPH when compared to the design flow rate of 45 TPH.
- The steam to power ratio i.e., kg of steam required to generate 1kWh of electricity is 9.18 kg/kWh when compared to the design steam to power ratio of 7.39 kg/kWh.

Performance of Air preheater:

APH performance has been evaluated by collecting online data from control room and from field measurements by using NPC portable instruments and performance parameters like Heat pickup across the APH, effectiveness has been evaluated. The following table gives the design details of APH.

Performance of Air preheater			
Sno	**Parameter**	**Units**	**Design**
1	Flue Gas Temperature inlet to Air preheater	°C	250
2	Flue gas Temperature outlet	°C	140
3	Flue gas Flow rate	TPH	98.54
4	Temperature Rise	°C	110
4	Air flow to Air preheater	TPH	70.46
5	Air temperature at inlet	°C	45
6	Air temperature at outlet	°C	180
7	Temperature Rise	°C	135
8	Effectiveness	%	65.854
9	Heat Pickup across heater	M kCals	2.28

Table 268:Design Details of Air Preheater

The as run details along with the design details has been given in the following table.

Sno	Parameter	Units	Design	Asrun data
1	Flue Gas Temperature inlet to Air preheater	°C	250	216.09
2	Flue gas Temperature outlet	°C	140	124.742
3	Flue gas Flow rate	TPH	98.54	117.98
4	Temperature Rise	°C	110	91.4
4	Air flow to Air preheater	TPH	70.46	57.21
5	Air temperature at inlet	°C	45	45
6	Air temperature at outlet	°C	180	70
7	Temperature Rise	°C	135	25.0
8	Effectiveness	%	65.854	31.4
9	Heat Pickup across heater	M kCals	2.28	1.430

Table 269:Performance of Air Preheater

Observation & Findings:

- It is observed that the effectiveness of APH is 31.4 vis-à-vis the design value of 65.85. The effectiveness has been measured when preheater tubes were failed. The same has been immediately rectified by management of hetero drugs.

- The performance of APH is not satisfactory.
- The heat pickup is 1.43 M kCal as against to the design value of 2.28 M kcal.
- The temperature rise is only 25 ^{0}C as against to the design value of 135 ^{0}C.

Performance of Economizer:

Economizer performance has been evaluated by collecting online data from control room and from field measurements by using NPC portable instruments and performance parameters like Heat pickup across the economizer, effectiveness has been evaluated. The following table gives the design details of economizer.

Performance of Economizer			
Sno	**Parameter**	**Units**	**Design**
1	Flue Gas Temperature inlet to Economizer	ºC	400
2	Flue gas Temperature outlet	ºC	250
3	Flue gas Flow rate	TPH	98.54
4	Temperature Rise	ºC	150
4	Water flow to Economizer	TPH	45.00
5	Water temperature at inlet	ºC	130
6	Water temperature at outlet	ºC	210
7	Temperature Rise	ºC	80
8	Effectiveness	%	29.630
9	Heat Pickup across heater	M kCals	0.86

Table 270:Design Details of Economizer

The as run details along with the design details has been given in the following table.

Sno	Parameter	Units	Design	As run data
1	Flue Gas Temperature inlet to Economizer	ºC	400	497.19
2	Flue gas Temperature outlet	ºC	250	216.09
3	Flue gas Flow rate	TPH	98.54	117.98
4	Temperature Rise	ºC	150	281.09
4	Water flow to Economizer	TPH	45.00	40
5	Water temperature at inlet	ºC	130	129.78
6	Water temperature at outlet	ºC	210	214.52
7	Temperature Rise	ºC	80	84.7
8	Effectiveness	%	29.63	23.06
9	Heat Pickup across heater	M kCals	0.86	0.81

Table 271:Performance of Economizer

Observation & Findings:

- It is observed that the effectiveness of economizer is 23.06 vis-à-vis the design value of 29.63.
- The performance of economizer is satisfactory.

- The heat pickup is 0.81 M kCal as against to the design value of 0.86 M kcal.
- The temperature rise is 84.7^{0}C as against to the design value of 80 ^{0}C.

Performance of Forced Draft Fan:

Performance of the forced draft fan has been evaluated by collecting online data from control room and from field measurements by using NPC portable instruments and performance parameters like air kW, Fan efficiency and overall Efficiency has been evaluated. The following table gives the design details of Forced draft fan.

Performance of Forced Draft Fan			
S.No	**Parameter reference**	**Units**	**Design**
1	Megawatt load	MW	6.5
2	Flow	m3/hr	68400
		TPH	70.46
5	Head developed	$mmWC_G$	825
6	FD air temperature	^oC	45
7	FD air density	kg/m^3	1.03
8	Motor Efficiency	%	92
9	Fan motor rated power	kW	250
10	Motor input Power	kW	271.74
11	Air KW *(Fan hydraulic power)*	kW	153.49
12	Overall Efficiency (Fan and Motor)	%	56.48
13	Fan Efficiency	%	61.40

Table 272:Design Details of Forced Draft Fan

The as run details along with the design details has been given in the following table.

S.No	Parameter reference	Units	Design	FD
1	Megawatt load	MW	6.5	6.1
2	Flow	m3/hr	68400	55533.2
		TPH	70.46	57.21
3	Suction Pressure	$mmWC_G$	-	-
4	Discharge pressure	$mmWC_G$	-	-
5	Head developed	$mmWC_G$	825	825.0
6	FD air temperature	°C	45	45
7	FD air density	kg/m^3	1.03	1.03
8	Motor Efficiency	%	92	92
9	Fan motor rated power	kW	250	224.48
10	Motor input Power	kW	271.74	244.0
11	Air KW *(Fan hydraulic power)*	kW	153.49	124.62
12	Overall Efficiency (Fan and Motor)	%	56.48	51.07
13	Fan Efficiency	%	61.40	55.51

Table 273: Performance of Forced Draft Fan

Observation & Findings:

- It is observed from the above table the air kW for the forced draft fan is 124.62 kW vis-à-vis the design value of 153.49 kW
- The fan efficiency is 51.07% as against to the design value of 51.07%
- The overall efficiency of the fan and motor is 55.51% as against to the design value of 56.48%.
- The performance of forced draft fan is satisfactory.

Performance of Induced Draft Fan:

Performance of the induced draft fan has been evaluated by collecting online data from control room and from field measurements by using NPC portable instruments and performance parameters like air kW, Fan efficiency and overall Efficiency has been evaluated. The following table gives the design details of induced draft fan.

Performance of Induced Draft Fan			
S.No	**Parameter reference**	**Units**	**Design**
1	Megawatt load	MW	6.5
2	Flow	m3/hr	115200
		TPH	98.54
5	Head developed	$mmWC_G$	180
6	Gas temperature	^oC	110
7	Gas density	kg/m^3	0.86
8	Motor Efficiency	%	92
9	Fan motor rated power	kW	110
10	Motor input Power	kW	119.6
11	Air KW *(Fan hydraulic power)*	kW	56.40
12	combined Efficiency	%	47.2
13	Fan Efficiency	%	51.3
14	SEC of ID fan	kW/TPH	1.21

Table 274:Design Details of ID Fan

The as run details along with the design details has been given in the following table.

S.No	Parameter reference	Units	Design	ID 1A
1	Megawatt load	MW	6.5	6.1
2	Flow	m3/hr	115200	138292
		TPH	98.54	118.0
5	Head developed	$mmWC_G$	180	140.0
6	Gas temperature	^oC	110	111
7	Gas density	kg/m^3	0.86	0.85
8	Motor Efficiency	%	92	92
9	Fan motor rated power	kW	110	101
10	Motor input Power	kW	119.6	110.0
11	Air KW *(Fan hydraulic power)*	kW	56.40	52.66
12	combined Efficiency	%	47.2	47.9
13	Fan Efficiency	%	51.3	52.0
14	SEC of ID fan	kW/TPH	1.21	0.93

Table 275:Performance of ID Fan

Observation & Findings:

- It is observed from the above table the air kW for the forced draft fan is 52.66 kW vis-à-vis the design value of 56.40 kW
- The fan efficiency is 52% as against to the design value of 51.3%
- The overall efficiency of the fan and motor is 47.9% as against to the design value of 47.9%.
- The performance of induced draft fan is satisfactory.

Performance of Primary air Fan:

Performance of the primary air fan has been evaluated by collecting online data from control room and from field measurements by using NPC portable instruments and performance parameters like air kW, Fan efficiency and overall Efficiency has been evaluated. The as run details of the primary air fan has been given in the following table.

Performance of Primary air Fan			
S.No	**Parameter reference**	**Units**	**PA**
1	Megawatt load	MW	6.5
2	Flow	m3/hr	11979.8
		TPH	11.44
3	Suction Pressure	$mmWC_G$	-
4	Discharge pressure	$mmWC_G$	-
5	Head developed	$mmWC_G$	830.0
6	PA air temperature	°C	70
7	PA air density	kg/m^3	0.96
8	Motor Efficiency	%	92
9	Fan motor rated power	kW	44.16
10	Motor input Power	kW	48.0
11	Air KW *(Fan hydraulic power)*	kW	27.05
12	Overall Efficiency (Fan and Motor)	%	56.35
13	Fan Efficiency	%	61.24

Table 276: Performance of PA Fan

Observation & Findings:

- It is observed from the above table the air kW for the primary air fan is 27.05 kW.
- The fan efficiency is 61.24% and the overall efficiency of the fan and motor is 56.35%.
- The performance of primary air fan is satisfactory.

Performance of Boiler Feed Pump (BFP):

Performance of the Boiler feed Pump has been evaluated by collecting online data from control room and from field measurements by using NPC portable instruments and performance parameters like Hydraulic power(kW), pump efficiency and overall Efficiency has been evaluated. The following table gives the design details of induced draft fan.

Performance of Boiler Feed Pump			
S. no	**Parameter**	**Units**	**Design**
1	Unit Load		6.1
2	Flow	TPH	57
3	Temperature		130
4	Suction Pressure	kg/cm2 (g)	2.7
5	Discharge Pressure	kg/cm2 (g)	96
6	Pump Head	m	1005
7	Liquid Density	kg/m3	1000
8	Hydraulic Power	kW	156.1
9	Motor output power	kW	222
10	Motor Power Input	kW	250
11	Motor Efficiency (assumed)	%	94.2
12	Pump Efficiency	%	66
13	Combined Efficiency	%	62

Table 277: Design Details of Boiler Feed Pump

The as run details along with the design details has been given in the following table.

S. no	Parameter	Units	Design	As Run parameters
1	Unit Load		6.1	4.45
2	Flow	TPH	57	40
3	Temperature		130	129.78
4	Suction Pressure	kg/cm2 (g)	2.7	1.75
5	Discharge Pressure	kg/cm2 (g)	96	92.667
6	Pump Head	m	1005	909.17
7	Liquid Density	kg/m3	1000	1000
8	Hydraulic Power	kW	156.1	98.9
9	Motor output power	KW	222	229
10	Motor Power Input	kW	250	243
11	Motor Efficiency (assumed)	%	94.2	94.2
12	Pump Efficiency	%	66	43
13	Combined Efficiency	%	62	41

Table 278: Performance of Boiler Feed Pump

Observation & Findings:

- It is observed from the above table the hydraulic power for the boiler feed Pump is 98.9 kW vis-à-vis the design value of 156.1 kW
- The pump efficiency is 43% as against to the design value of 66%.The as-run efficiency is less when compared to design due to less mass flow rate and less head.
- The overall efficiency of the Pump and motor is 41% as against to the design value of 62%.
- The performance of boiler feed water pump is satisfactory.

Energy Conservation Options

Encon1: Energy Savings by arresting Air Leakage in APH tube leakage

Present Condition:

The primary air from ambient condition passes through the tubes and exchanges heat with hot flue gas from boiler. The hot ambient air from air preheater outlet is send to boiler for combustion. It is observed during the field studies that the air preheater tubes got damaged and air preheater has been bypassed. This resulted in loss of heat from hot flue gas which is vented to atmosphere and the additional coal has been fired in boiler to preheat the air.

Proposed Condition:

It is proposed to immediately attend the above leakage and arrest the preheater tubes to recover the heat from flue gas side. Management of Hetero drugs has immediately attended the above problem and arrested the leakage from tube side. The envisaged annual coal savings of 5360 TPH with an annual monetary savings of Rs.160.28 Lakhs and the investment required for the above suggestion is Rs 30 Lakhs and with a simple payback period of 2-3 months.The detailed encon rationale is presented below.

Encon Rationale:

Energy Savings by arresting Air Leakage in APH tube leakage		
Description	**Units**	**Boiler**
Before Replacement of air preheater tubes		
Air temperature	ºC	70.00
% oxygen leakage	%	13
Actual Air supplied	kg/kg of coal	11.37
Mass flow rate of flue gas	TPH	117.98
Excess air percentage	%	162.50
Coal Consumption	TPH	10.93
After Replacement of air preheater tubes		
Air temperature	ºC	70.00
% oxygen leakage	%	5
Actual Air supplied	kg/kg of coal	5.78
Air Leakage after air preheater tube replacement	%	5
Flue gas flow	TPH	46.75
Excess air percentage	%	31.25
Coal Consumption	TPH	10.26
Reduction in coal consumption	TPH	0.67
Envisaged annual coal savings	TPA	5360
Landed cost of coal	Rs/Ton	3000
Coal Saving by reduction of air ingress by arresting air preheater tube leakages	Lakh Rs/yr	160.80
Investment made for arresting air preheater leakage	Lakh Rs/yr	30
Simple payback period	Months	2.24

Table 279: Energy Savings by arresting Air Leakage in APH tube leakage

Encon 2: Energy Savings by Reducing load on ID fan by arresting air preheater leakage

Present Condition:

As discussed in energy conservation option-1 the preheater tube damage will also add additional load on ID fan in terms increase in oxygen levels after air preheater (APH), electrostatic precipitator (ESP) and Induced draft (ID) fan. This leakage will result in additional power consumption of ID fan. The ID fan being one of the major contributors of auxiliary power consumption (APC) will in turn increase the APC consumption of the captive power plant.

Proposed Condition:

With the immediate response of the management of Hetero drugs in response to the damage of the preheater tubes the envisaged annual power savings of 5.31 Lakh kWh with an annual monetary savings of Rs.31.88 Lakhs and the investment required for the above suggestion is NIL .The detailed encon rationale is presented below

Encon Rationale:

Energy Savings by Reducing Load on ID fan by arresting air preheater leakage		
Description	**Units**	**Boiler**
Existing Condition		
Flow	TPH	117.98
Specific Energy Consumption of ID fan	kW/TPH	0.93
After Replacement of air preheater tubes		
Flow	TPH	46.75
Reduction in Flow	TPH	71.23
Envisaged Power savings	kWh	66.41
Envisaged annual Power savings	Lakhs kWh	5.31
Cost of Power	Rs/kW	6
Annual Monetary savings	Lakh Rs/yr	31.88
Investment made for arresting air preheater leakage	Lakh Rs/yr	NIL
Simple payback period	Months	Immediate

Table 280: Energy Savings by Reducing Load on ID fan by arresting air preheater leakage

Encon 3: Energy Savings by Reducing Loss due to unburnt in ash in coal

Present Condition:

During field studies the quality of coal has seen visually and observation says the coal has lot of fines and the boiler being fluidized bed combustion boiler (FBC), the same has been validated during boiler performance test by indirect method the ash samples from bank zone, economizer and air preheater has been collected and send for loss of Ignition (LOI) and calorific value of the ash (kCals/kg).The samples has been send to two different labs for analysis.The report from two different labs estimates that unburnt carbon after APH point is 32% with a calorific value of 2320 kCal/kg and the unburnt carbon after economizer is 28.5% with a calorific value of 2100kCal/kg. This resulted in loss due to unburnt carbon in ash is 7.20%.

Proposed Condition:

It proposed to carefully select the coal supplier during procurement as the more fines will lead to increase in loss due to unburnt carbon in ash and the envisaged annual cost savings by reducing the unburnts in fly ash to 2 % will give annual monetary savings of Rs.165.60 Lakhs and the investment required for the above suggestion is NIL .The detailed encon rationale is presented below

Encon Rationale:

Energy Savings by Reducing Loss due to unburnt in ash in coal		
Description	**Units**	**Boiler**
Percentage loss due Unburnt carbon in ash	%	7.20
Recommended percentage reduction	%	2.00
Reduction in loss due to unburnt	%	5.20
Reduction in coal consumption	TPH	0.69
Envisaged annual Coal savings	TPA	5520
Landed cost of coal	Rs/Ton	3000
Annual Cost savings by reducing unburnt in ash	Lakh Rs/yr	165.60
Investment made by reducing unburnt in ash	Lakh Rs/yr	Negligible
Simple payback period	Months	Immediate

Table 281: Energy Savings by Reducing Loss due to unburnt in ash in coal

Encon 4: Energy Savings by Reducing Loss due to Moisture in coal

Present Condition:

During field studies the quality of coal has seen visually and observation says the coal has lot moisture, the same has been validated during boiler performance test by indirect method the coal samples from coal yard, at bunker level has been collected and send for ultimate analysis and calorific value of the fuel (kCals/kg).The samples has been send to two different labs for analysis.The loss due to moisture in fuel resulted in 7.03%.

Proposed Condition:

It proposed to carefully select the coal supplier during procurement as the coal has very high moisture and will lead to increase in loss due to moisture in fuel and the envisaged annual cost savings by reducing the moisture in fuel to 6.50 % from 7.03% will give annual monetary savings of Rs.16.80 Lakhs and the investment required for the above suggestion is NIL .The detailed encon rationale is presented below

Encon Rationale:

Energy Savings by Reducing Loss due to Moisture in coal		
Description	**Units**	**Boiler**
Percentage loss due Moisture in fuel	%	7.03
Recommended percentage reduction of moisture as per design	%	6.50
Reduction in loss due to unburnt	%	0.53
Reduction in coal consumption	TPH	0.07
Envisaged annual Coal savings	TPA	560.00
Landed cost of coal	Rs/Ton	3000
Annual Cost savings by reducing unburnts in ash	Lakh Rs/yr	16.80
Investment made by reducing unburnts in ash	Lakh Rs/yr	Negligible
Simple payback period	Months	Immediate

Table 282: Energy Savings by Reducing Loss due to Moisture in coal

Encon 5: Monetary Savings by by increasing power output from captive power plant (CPP)

Present Condition:

During field studies it has observed that the generation from the captive power plant is 4.45 MW and the design capacity is 6.10 MW. There is a gap between design generation and the actual generation, when discussed with plant personnel it was find out that the steam requirement is the deciding factor for power generation being back pressure turbine. As the steam requirement is not their and hence the power generated is less. As a know fact that the cost of power from captive power is always less and reliable when compared to grid power.

Proposed Condition:

It proposed to increase the steam requirement by having additional Vapour adsorption Machine (VAM) with double effect as it will have more COP in service blocks rather than having Vapour compression refrigeration (VCR).A detailed cost benefit analysis was done and the envisaged annual cost savings by increasing the steam requirement Rs.1060 Lakhs and the investment required for the above suggestion is Rs 462 lakhs with a payback period of 5.23 months. The detailed encon rationale is presented below

Encon Rationale:

Monetary Savings by increasing power output from captive power plant (CPP		
Description	**Units**	**Boiler**
Existing generation through captive power plant	MW	4.45
Increase the power generation to the installed capacity	MW	6.10
Increase in power Generation	MW	1.65
Cost of power Through captive power plant	Rs/kWh	2.00
Cost of Power Through APCPDCL	Rs/kWh	6.00
Savings due to decrease in APCPDCL power	Rs/kWh	4.00
Annual Cost savings by reducing APCPDCL	Lakh Rs/yr	528.00
Increased Steam Generation	kCal	4344692.82
Specific energy consumption of single effect VAM	kCal/TR	4700.00
Refrigeration effect that can be generated from the additional steam	TR	924.40
Specific energy consumption of compressor refrigeration system	kWh/TR	1.20
Reduction in power consumption due to installation of VAM	kW	1109.28
Envisaged annual electricity savings	Lakhs kWh	88.74
Annual Cost savings	Lakh Rs/yr	532.46
Total annual cost savings	Lakh Rs/yr	1060.46
Investment required for installation of VAM	Lakhs Rs	462
Simple payback period	Months	5.23

Table 283: Monetary Savings by increasing power output from captive power plant (CPP)

8.0 PROCESS EQUIPMENT

Process Cooling Towers

General Observation

- Process Cooling Towers were present in each service block of all the plants. The basic purpose of process cooling tower is to circulate RT water to the reactors for better solvent recovery.
- During the field studies the performance of process cooling towers in terms of their range, approach and effectiveness need to be analysed.
- It was observed during field studies in HLL-03 most of the cooling towers were not getting even minimum range during operation and quality of water is not good.
- Even cooling tower fan is not working in most of the cooling towers in HLL-03.
- This indicates instead of RT water which is around 20 – 25^{o}C.The process requirements were met by +5, -5 & -15 ^{o}C. This leads to higher energy consumption as the load on respective chiller will increase.
- It is suggested to immediately take appropriate cleaning action of Cooling towers and replace water with fresh makeup water otherwise the RT water will affect the life of reactors.
- Process cooling towers in HLL-09 is better in operation when compared to HLL-03.
- A detailed energy conservation option is discussed below for utilizing chilled water in the place of RT water.
- It is observed that during the field studies that all the process reactors and reactors at solvent recovery system were having variable frequency drives(VFD).

Performance Assessment of Cooling Towers –HLL-09

Performance of Cooling Tower for Production Block-D/CT-01		
Description	Units	Value
Inlet Water Temperature	^0C	**32.6**
Outlet Water Temperature	^0C	**31.1**
Wet bulb temperature	^0C	**28**
Circulating Water Flow	m3/hr	**206**
Range	^0C	**1.5**
Approach	^0C	**3**
Effectiveness	%	**33**
Cooling Tower Capacity	TR	**102**
Input power	kW	20.49
Input power to CT fan	kW	4.5

Comments:

- The design capacity of the above cooling tower is 500TR and the TR delivered is 102TR.The TR delivered is low is mainly because of low range and low circulating water flow.
- The main circulating water pumps installed were four in number whereas during field studies only 2 pumps are in operation.
- It is suggested to clean the fills of cooling tower during regular maintenance to improve delta T.

Performance of Cooling Tower for Production Block-B/CT-01		
Description	Units	Value
Inlet Water Temperature	^0C	43.3
Outlet Water Temperature	^0C	41.7
Wet bulb temperature	^0C	29.5
Circulating Water Flow	m3/hr	90.6
Range	^0C	**1.6**
Approach	^0C	**12.2**
Effectiveness	%	**12**
Cooling Tower Capacity	TR	**48**
Input power	kW	7.62
Input power to CT fan	kW	-

Comments:

- The design capacity of the above cooling tower is 500TR and the TR delivered is 48TR.The TR delivered is low is mainly because of low circulating water flow as well as low range.
- The main circulating water pumps installed were three in number whereas during field studies only 1 pump is in operation.
- It is suggested to clean the fills of cooling tower during regular maintenance to further improve delta T.

Performance of Cooling Tower for Production Block-H12/CT-01		
Description	Units	Value
Inlet Water Temperature	^0C	34.1
Outlet Water Temperature	^0C	32.5
Wet bulb temperature	^0C	30.1
Circulating Water Flow	m3/hr	270
Range	^0C	**1.6**
Approach	^0C	**2.4**
Effectiveness	%	**40**
Cooling Tower Capacity	TR	**143**
Input power	kW	21.36
Input power to CT fan	kW	-

Comments:

- he design capacity of the above cooling tower is 500TR and the TR delivered is143TR.The TR delivered is low is mainly because of low circulating water flow & range.
- It is suggested to clean the fills of cooling tower during regular maintenance to further improve delta T.

Performance of Cooling Tower for Production Block-SRS-I/CT-01		
Description	Units	Value
Inlet Water Temperature	^0C	33.9
Outlet Water Temperature	^0C	32.2
Wet bulb temperature	^0C	29.8
Circulating Water Flow	m3/hr	349
Range	^0C	**1.7**
Approach	^0C	**2.4**
Effectiveness	%	**41**
Cooling Tower Capacity	TR	**196**
Input power	kW	27.34
Input power to CT fan	kW	14.81

Comments:

- They are 3 cooling towers installed for SRS-I with capacities 800TR 2 No's and 500TR 1 No.During field studies only 1 cooling tower of 800TR is in operation.
- The design capacity of the above cooling tower is 800TR and the TR delivered is196TR.The TR delivered is low is mainly because of low range.
- It is suggested to clean the fills of cooling tower during regular maintenance to improve delta T.

Performance of Cooling Tower for Production Block-SRS-2/CT-01		
Description	Units	Value
Inlet Water Temperature	^0C	38.2
Outlet Water Temperature	^0C	34
Wet bulb temperature	^0C	29
Circulating Water Flow*	m3/hr	500
Range	^0C	**4.2**
Approach	^0C	**5.0**
Effectiveness	%	**46**
Cooling Tower Capacity	TR	**694**
Input power	kW	
Input power to CT fan	kW	17.36

Comments:

- The design capacity of the above cooling tower is 2500TR and the TR delivered is 694TR.The TR delivered is low is mainly because of low circulating water flow.
- There are totally four pumps running during field visit for the two cells out of 6 pumps per cell.
- Flow for the above cooling tower is estimated from design flow as portalok ultra sonic flow meter is unable to detect the flow.

Performance of Cooling Tower for Production Block-MEE-I		
Description	Units	Value
Inlet Water Temperature	^0C	40.9
Outlet Water Temperature	^0C	37.2
Wet bulb temperature	^0C	29.5
Circulating Water Flow*	m3/hr	193
Range	^0C	**3.7**
Approach	^0C	**7.7**
Effectiveness	%	**32**
Cooling Tower Capacity	TR	**236**
Input power	kW	-
Input power to CT fan	kW	-

Comments:

- The TR delivered is 236 with a range of 3.7oC and with a circulating water flow of 193m3/hr.
- The approach is high which means the delta T can be still improved and there is scope for improving TR.
- It is suggested to clean the fills of cooling tower during regular maintenance to improve delta T.

Performance of Cooling Tower for Production Block-MEE-II		
Description	Units	Value
Inlet Water Temperature	^{0}C	41.2
Outlet Water Temperature	^{0}C	36.8
Wet bulb temperature	^{0}C	29.5
Circulating Water Flow*	m3/hr	435
Range	^{0}C	**4.4**
Approach	^{0}C	**7.3**
Effectiveness	%	**38**
Cooling Tower Capacity	TR	**633**
Input power	kW	-
Input power to CT fan	kW	-

Comments:

- The TR delivered is 633 with a range of 4.4oC and with a circulating water flow of 435m3/hr.
- The approach is high which means the delta T can be still improved and there is scope for improving TR.
- It is suggested to clean the fills of cooling tower during regular maintenance to improve delta T.

Status of Cooling Towers during field Visit for HDL-09

HDL-09					
S.No	**Production Block**	**TR**	**Flow Rate**	**Delta T**	**Comments**
1	A B C	500	315	4.8	Not working during field studies
2	D	250	150	5.0	1.No Circulating water flow but pump is in running condition. 2.CT fan is not working. 3.A detailed energy conservation option is discussed in encon chapter.

Energy Conservation Option

Encon 1: Energy Savings by utilizing RT water in the place of chilled water in HLL-03

Present Condition:

It is observed during the field studies in HLL-03 the process cooling towers which circulates RT water i.e., room temperature water is not in operation. The basic requirement of RT water is to circulate the RT water to heat-exchangers for recovery solvent. The basic function of cooling tower operation has been stopped and this infers the higher utilization low temperature chilled water. Even the condition of RT water is not good and an immediate action to replace the existing RT water with fresh makeup water needs tobe initiated.

Proposed Condition:

It is proposed to operate the existing process cooling towers in HLL-03 to optimize the load on chilled water utilization. The above energy conservation measure will lead to 7.6 Lakh kWh savings with an annual monetary savings of Rs.45.6 Lakhs with nil investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy savings by Utilising RT water in the place of Chilled water		
Description	**UNITS**	**ACTUAL**
Base capacity for process cooling towers	**TR**	**100.0**
Existing Power Consumption of (+5°C)	kW/TR	1.00
Power Consumption of RT water from Process Cooling Tower (for CT fan and Pump the power consumption is 0.05 Kw/TR)	kW/TR	0.05
Excess Power Consumed	kW/TR	0.95
Total Excess Power Consumption	kW	**95.0**
Operating Hours per Annum	Hrs	8000
Total Power Savings Per annum	Kwh/annum (in Lakhs)	7.6
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	45.60
Investment	Lakhs Rs.	NIL
Simple payback period	Months	Immediate

Table 284: Energy Savings by having -5°C energy efficient chiller in service block-2

Encon 2: Energy Wastage by Idle running of Circulating Water Pump in Production Block-D

Present Condition:

It is observed during the field studies in HDL-09 production block D circulating water pump is running continuously where the cooling water is not working. It is also observed that the discharge from the circulating water pump is neglible.

Proposed Condition:

It is proposed not to operate the circulating water pump when the cooling tower is not required in production block. There can be auto control arrangement to operate circulating water pumps. The above energy conservation measure will lead to 0.4476 Lakh kWh savings with an annual monetary savings of Rs.2.69 Lakhs with nil investment. The detailed encon rationale is presented below.

Encon Rationale:

Energy Wastage by Idle running of Circulating Water Pump in Production Block-D		
Description	**UNITS**	**ACTUAL**
Power Consumption of Circulating Water Pump	**Kw**	**5.6**
Operating Hours per Annum	Hrs	8000
Total Power Savings Per annum	Kwh/annum(in Lakhs)	0.4476
Cost of Power	Rs./kWh	6
Total Annual Savings	Lakhs Rs.	2.69
Investment	Lakhs Rs.	NIL
Simple payback period	Months	Immediate

Heat Exchangers

- Basically, each reactor is equipped with heat exchangers which are predominantly condenser type.
- The condenser type heat exchanger basically transfers latent heat of vaporization at saturation temperature.
- For estimation of effectiveness of heat exchanger, the flow rates of both streams i.e., gas and liquid are required and during field studies at EPAVARINZ Stage-I Block H3 an attempt was made to find out the flow rates of both streams with the help of process personnel. Even plant process personnel has no idea of the exact flow rates. Hence performance could not be ascertained. The temperature drop of cold stream was in the range of 4-5 °C.

Process Equipment & Insulation

- The process equipment's like reactors and centrifuges are basically used in batch process and to evaluate the performance of such systems is difficult.
- Some of the Process equipment needs insulation. The outer surface of the vessel is directly exposed to atmosphere resulting in heat loss. The vessel jacket is sometimes heated to 120 °C and then cooled down to 10-20 oC based on the process requirements. Hence the loss of heat in form of both Heat gain and Heat loss is taking place. All the process vessel needs proper insulation wherever required.
- In some of the cases, -40 °C chilled water is circulated for cooling the jacket to 10 to 15 °C. For example, in the Main reactor cap (10KL), THE solvent of 600 L along with NaoH of 210 kg is added and the solution is maintained at 10 to 15 °C for 4 hrs by circulating -40 °C chilled water. This is one such instance, where such practice is being followed. It is recommended to circulate +5 chilled water instead of -40 to reduce the load on -40 chillers and thus reduce the energy consumption. The same reasoning can be applied in primary and secondary condensers for using appropriate cooling medium (+5/-5/-40 and RT).

Hot Water System

- 5 KL hot water insulated tank is used for hot water generation (Indirect heating). There is a control for steam control based on the temperature set point. Steam trap was found to be in working condition for this hot water system. Condensate is being collected in the common condensate tank. The set point during audit was 65 °C.
- During the field studies in each service blocks single stage hot water generation system was suggested for recovering heat from hot refrigerant gas and generate hot water. These systems will help to eliminate the steam requirements in hot water systems.

Desalination Pumps:

The performance assessment of working desalination pumps was assessed and presented below.

Desalination Plant				
		RO Feed Pump A (Plant IV)		RO Inlet HP Water Plant-III
Description	**UNITS**	RATED	ACTUAL	ACTUAL
Flow	**m^3/hr**	220	180	220
Suction Head	**m**	-	3.5	45
Discharge Head	**m**	-	49	400
Total Head	**m**	43.5	45.5	355
Hydraulic power	**kW**	26.05	22.30	212.61
Electrical Input power	**kW**	35	33	297
Motor Efficiency	**%**	90.00	90.00	90
Pump Input power	**kW**	32.9	31.02	279
Pump Efficiency	**%**	**79**	**72**	**76**

Table 285: Performance of Desalination Pumps

Motor Loading:

A motor loading survey was also conducted for running motors in various service blocks and the details were given below:

S.No	Motor Ref	Rated (KW)	Measured (KW)	% Loading	Remarks
1	US-1/RFS 001/+5oC/173TR	160	105	65.6	No Comments
2	US-1/RFS 002/-5oC/120TR	160	121.5	75.9	No Comments
3	US-1/RFS 004/-15oC/186TR	320	298	93.1	No Comments
4	US-1/RFS 006/+5oC/400TR	350	105.6	30.2	Unloaded
5	PRIMARY +5 400 TR	20.56	19.1	92.9	No Comments
6	US-2/RFS 007/+5oC/173TR	160	146	91.3	No Comments
7	US-2/RFS 002/+5oC/173TR	160	125	78.1	No Comments
8	US-2/RFS 003/-20oC/120TR	264	94.13	35.7	Unloaded
9	US-2/RFS 009/-15oC/186TR	320	206.22	64.4	No Comments
10	US-2/RFS 005/-40oC/50TR	167	164	98.2	No Comments
11	US-4/RFS 003/-15oC/450TR	800	161	20.1	Unloaded
12	US-4/RFS 004/-20oC/450TR	815	100.7	12.4	Unloaded
13	SB-08/+5oC/395TR	320	313.3	97.9	No Comments
14	SB-04/-15oC/158TR	264	217	82.2	No Comments
15	SB-02/005/-40oC/52TR	188	174	92.6	No Comments
16	SB-2/+5oC/362TR	315	105	33.3	Unloaded
17	SB-3/+5oC/395TR/Comp-02	360	277	76.9	No Comments
18	SB-3/+5oC/395TR/Comp-01	360	138	38.3	Unloaded
19	SB-3/-15oC/ Comp-4/450TR	670	309	46.1	Unloaded
20	SB-3/-40oC/150TR	584	207	35.4	Unloaded
21	SB-4/AM Comp-002/-15oC/450TR	710	221	31.1	Unloaded
22	SB-4/AM Comp-001/-15oC/450TR	710	307	43.2	Unloaded
23	SB-4/AM Comp-003/-40oC/150TR	510	293.9	57.6	No Comments
24	SB-6/FN Comp-001/+5oC/350TR	339.6	212	62.4	No Comments
25	SB-6/FN Comp-002/+5oC/350TR	339.6	247	72.7	No Comments
26	US-HDL-9/-15oC/158TR	264	260	98.5	No Comments
27	US-HDL_9/+5ºC/175TR	160	85	53.1	No Comments
28	FD Fan	271.44	244	89.9	No Comments
29	ID Fan 1A	119.6	110	92.0	No Comments
30	BFP	250	243	97.2	No Comments
31	PRIMARY +5 173 TR	11	9.72	88.4	No Comments
32	PRIMARY +5 400 TR	18.5	17.19	92.9	No Comments
33	PRIMARY -5 120 TR	7.5	10.62	141.6	Overloaded
34	PRIMARY -15 186 TR	14.92	6.98	46.8	Unloaded
35	PRIMARY +5 oC 173 TR	11	9.27	84.3	No Comments
36	PRIMARY -20oC 120 TR	11	4.86	44.2	Unloaded

S.No	Motor Ref	Rated (KW)	Measured (KW)	% Loading	Remarks
37	Primary Pump US-2/RFS 009/-15oC/186TR	11.19	9	80.4	No Comments
38	PRIMARY -40oC 50TR	5.5	5.81	105.6	Overloaded
39	Primary Pumps US-2/RFS 002/+5oC/175TR	11	9.27	84.3	No Comments
40	Primary Pump RFS 002/+5oC/395TR	29.84	21.49	72.0	No Comments
41	Primary Pump RFS 001/+5oC/395TR	29.84	22.39	75.0	No Comments
42	Primary Pump RFS 003/-15oC/450TRR	37.3	19.35	51.9	No Comments
43	Primary Pump RFS 004/-20oC/450TR	37.3	23.13	62.0	No Comments
44	Primary Pump SB 008/+5oC/395TR	29.8	18	60.4	No Comments
45	Primary Pump SB-2/+5oC/362TR	22	9.72	44.2	Unloaded
46	Primary Pump SB-3/+5oC/395TR/Comp-02	37	26.46	71.5	No Comments
47	Primary Pump SB-3/+5oC/395TR/Comp-03	37	25.2	68.1	No Comments
48	Primary Pump SB-3/+5oC/395TR/Comp-04	37	34.29	92.7	No Comments
49	Primary Pump SB-3/-40oC/150TR	30	19.8	66.0	No Comments
50	Primary Pump SB-4/AM Comp-002/-15oC/450TR	37.3	27.9	74.8	No Comments
51	Primary Pump SB-4/AM Comp-003/-40oC/150TR	22	19.8	90.0	No Comments
52	Primary Pump SB-5/VAM -001/+5oC/300TR	18.65	17.19	92.2	No Comments
53	Primary Pump SB-5/VAM -002/+5oC/300TR	18.65	15.93	85.4	No Comments
54	Cooling Water Pumps (+5) VAM -001/300TR	44.76	34.74	77.6	No Comments
55	Cooling Water Pumps (+5) VAM -002/300TR	44.76	35.01	78.2	No Comments
56	Primary Pump SB-6/FN Comp-001/+5oC/350TR	37.3	23.4	62.7	No Comments
57	Primary Pump SB-6/FN Comp-002/+5oC/350TR	37.3	25.2	67.6	No Comments
58	Primary Pump US-HDL-9/-15oC/158TR	11	12.03	109.4	Overloaded
59	Primary Pump US-HDL-9/+5oC/173TR	11	4.81	43.7	Unloaded

Table 286:Motor Loading

AHU Performance of HLL-09:

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	-	-	**H2/AHU-003**	**H2/AHU-002**	**H4/AHU-003**	**H4/AHU-002**
Usage area			**Crystallizer-III**	**Crystallizer-III**	**Crystallizer-III**	**Crystallizer-III**
Rated details						
Rated Capacity	CFM		19500	19500	19500	19500
Measurements						
Relative Humidity inlet air	%	Measured value	75.0	75.0	72	76
Temperature of inlet air (T_i)	ºC	Measured value	36.0	36.0	35	27.5
Dew point of inlet air (T_{dwi})	ºC	Measured value	31.8	29.6	29.1	22.8
Relative Humidity outlet air	%	Measured value	87.0	85.0	83	85
Temperature of outlet air (T_o)	ºC	Measured value	32.0	31.0	31	24
Dew point of outlet air (T_{dwo})	ºC	Measured value	29.5	28.1	27.13	21.3
Power Input to AC	kW	Measured value	10.00	12.00	7.00	6.50
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	26.24	24.77	24.31	17.44
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	23.92	22.34	22.00	15.50
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.14	1.14	1.14	1.17
Air Flow	**m/s**		**1.4**	**1.5**	**1.09**	**1.0**
Volume flow rate at outlet(V_o)	m^3/hr	v * A	10080.00	10800.00	7848.00	7320.00
Volume flow rate at outlet(V_o)	CFM	-	5929.41	6352.94	4616.47	4305.88
Mass flow rate at outlet (m_o)	kg/hr	$V * \rho$	11488.26	12308.85	8973.47	8578.65

Parameter Reference	**Units**	**Formula**	**Values**	**Values**	**Values**	**Values**
Equipment reference	**-**	**-**	**H7/AHU-001**	**H7/AHU-002**	**AHU-001**	**AHU-006**
Usage area					Pharma Area-III	Pharma Area-I
Rated Capacity	CFM		16000	16000	19000	9000
Relative Humidity inlet air	%	Measured value	72.0	75	72	75
Temperature of inlet air (T_i)	ºC	Measured value	33.0	30	27	25
Dew point of inlet air (T_{dwi})	ºC	Measured value	27.2	25	21.5	19.39
Relative Humidity outlet air	%	Measured value	81.0	83	87	82
Temperature of outlet air (T_o)	ºC	Measured value	29.0	27	24	22
Dew point of outlet air (T_{dwo})	ºC	Measured value	25.4	23.8	21.7	18.8
Power Input to AC	kW	Measured value	15.5	9.2	14.0	6.8
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	22.1	19.5	16.4	14.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	19.5	17.9	15.7	13.5
Density of Inlet air (ρ_o)	kg/m^3	1.29 * (273)/(273+T_o)	1.15	1.16	1.17	1.18
Air Flow	**m/s**		1.15	1.10	4.20	1.90
Volume flow rate at outlet(V_o)	m^3/hr	v * A	8280.00	7920.00	30240.00	13680.00
Volume flow rate at outlet(V_o)	CFM	-	4870.59	4658.82	17788.24	8047.06
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	9529.3	9205.2	35498.7	16166.7

Parameter Reference	**Units**	**Formula**	**Values**	**Values**	**Values**
Equipment reference	**-**	**-**	**AHU-004**	**AHU-002**	**AHU-001**
Usage area			Pharma Area-II	Production Block-A	Production Block-B
Rated Capacity	CFM		8000	12000	11000
Relative Humidity inlet air	%	Measured value	68	70	68
Temperature of inlet air (T_i)	ºC	Measured value	27	33	32
Dew point of inlet air (T_{dwi})	ºC	Measured value	20.6	26.7	25.3
Relative Humidity outlet air	%	Measured value	78	81	78
Temperature of outlet air (T_o)	ºC	Measured value	24	29	29.2
Dew point of outlet air (T_{dwo})	ºC	Measured value	19.9	25.4	24.9
Power Input to AC	kW	Measured value	8.7	12.6	13.3
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	15.8	21.7	20.5
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	14.7	19.6	19.3
Density of Inlet air (ρ_o)	kg/m^3	1.29 * (273)/(273+T_o)	1.17	1.15	1.15
Air Flow	**m/s**		1.75	1.90	2.90
Volume flow rate at outlet(V_o)	m^3/hr	v * A	12600.00	13680.00	20880.00
Volume flow rate at outlet(V_o)	CFM	-	7411.76	8047.06	12282.35
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	14791.1	15744.1	24109.2

AHU Performance of HDL-09:

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**PA/AHU-03**	**PA/AHU-06**	**PA/AHU-08**	**PA/AHU-09**
Usage area			Section-2	Section-5	Section-7	Section-8
Rated Capacity	CFM		6000	6000	6000	6000
Relative Humidity inlet air	%	Measured value	69.8	Difficult to measure the outlet conditions as the block is having powder and issue of opening the outlet door for measurement	70	76
Temperature of inlet air (T_i)	ºC	Measured value	30.0		30.4	27.5
Dew point of inlet air (T_{dwi})	ºC	Measured value	23.4		24.3	22.8
Relative Humidity outlet air	%	Measured value	76.0		77	85
Temperature of outlet air (T_o)	ºC	Measured value	28.0		27	24
Dew point of outlet air (T_{dwo})	ºC	Measured value	23.3		22.6	21.3
Power Input to AC	kW	Measured value	4.50		6.20	6.50
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	18.34		19.08	17.44
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	17.82		17.06	15.50
Density of Inlet air (ρ_o)	kg/m^3	1.29 * (273)/(273+T_o)	1.16		1.16	1.17
Air Flow	**m/s**		**1.5**		**0.97**	**1.0**
Volume flow rate at outlet(V_o)	m^3/hr	v * A	9809.96		6389.63	6687.19
Volume flow rate at outlet(V_o)	CFM		5770.57		3758.61	3933.64
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	11401.89		7416.73	7837.03

Parameter Reference	Units	Formula	Values	Values
Equipment reference	**-**	**-**	**PA/AHU-012**	**PA/AHU-013**
Usage area			Section-11	Section-12
Rated Capacity	CFM		6000	6000
Relative Humidity inlet air	%	Measured value	75.7	66
Temperature of inlet air (T_i)	ºC	Measured value	25.6	25.8
Dew point of inlet air (T_{dwi})	ºC	Measured value	21.0	19
Relative Humidity outlet air	%	Measured value	83.8	81.8
Temperature of outlet air (T_o)	ºC	Measured value	23.5	22.2
Dew point of outlet air (T_{dwo})	ºC	Measured value	20.6	18.9
Power Input to AC	kW	Measured value	5.0	4.5
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	15.7	14.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	14.9	13.7
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.18	1.18
Air Flow	**m/s**		1.30	1.10
Volume flow rate at outlet(V_o)	m^3/hr	$v * A$	8550.83	7235.32
Volume flow rate at outlet(V_o)	CFM		5029.90	4256.07
Mass flow rate at outlet (m_o)	kg/hr	$V * \rho$	10084.9	8527.6

AHU Performance of Honour Lab:

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**AHU-24**	**AHU-11**	**AHU-22**	**AHU-14**
Usage area			Pharma-VIII	Pharma-IV	PharmaVI	Pharma-V
Rated Capacity	CFM		5500	5500	5500	5500
Relative Humidity inlet air	%	Measured value	74.0	N/W	76.4	70
Temperature of inlet air (T_i)	ºC	Measured value	27.0		26.4	25.9
Dew point of inlet air (T_{dwi})	ºC	Measured value	22.0		21.9	20
Relative Humidity outlet air	%	Measured value	81.5		82.6	85
Temperature of outlet air (T_o)	ºC	Measured value	23.8		23.9	22
Dew point of outlet air (T_{dwo})	ºC	Measured value	20.3		20.7	19.38
Power Input to AC	kW	Measured value	5.00		4.85	5.10
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	16.66		16.46	15.19
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	14.92		15.13	13.87
Density of Inlet air (ρ_o)	kg/m^3	1.29 * (273)/(273+T_o)	1.17		1.18	1.18
Air Flow	**m/s**		**2.6**		2.81	2.90
Volume flow rate at outlet(V_o)	m^3/hr	v * A	8970.21		9524.30	9823.00
Volume flow rate at outlet(V_o)	CFM	-	5276.59		5602.53	5778.23
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	10530.13		11202.99	11573.65

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**AHU-16**	**AHU-10**	**AHU-004**	**AHU-18**
Usage area			Crystallizer-VI	Crystallizer-III	Crystallizer-II	Crystallizer-IV
Rated Capacity	CFM		3000	4000	4000	5000
Relative Humidity inlet air	%	Measured value		75.8		75
Temperature of inlet air (T_i)	ºC	Measured value		29.1		29
Dew point of inlet air (T_{dwi})	ºC	Measured value		28.8		24.1
Relative Humidity outlet air	%	Measured value		81.5		78.8
Temperature of outlet air (T_o)	ºC	Measured value		26.8		27.6
Dew point of outlet air (T_{dwo})	ºC	Measured value		23.3		23.6
Power Input to AC	kW	Measured value		2.7		2.7
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	Not Working	18.3	Not working	18.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart		17.5		17.8
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$		1.17		1.17
Air Flow	**m/s**			2.23		2.30
Volume flow rate at outlet(V_o)	m^3/hr	v * A		6502.68		8280.00
Volume flow rate at outlet(V_o)	CFM	-		3825.11		4870.59
Mass flow rate at outlet (m_o)	kg/hr	V * ρ		7580.4		9655.5

Parameter Reference	Units	Formula	Values	Values	Values
Equipment reference	**-**	**-**	**AHU-13**	**AHU-23**	**AHU-08**
Usage area			Crystallizer-V	Pharma-VII	Pharma-III
Rated Capacity	CFM		4500	5500	5500
Relative Humidity inlet air	%	Measured value	Not working	75.9	73.2
Temperature of inlet air (T_i)	ºC	Measured value		28.5	27.1
Dew point of inlet air (T_{dwi})	ºC	Measured value		23.8	21.9
Relative Humidity outlet air	%	Measured value		85.3	82.6
Temperature of outlet air (T_o)	ºC	Measured value		25	23.9
Dew point of outlet air (T_{dwo})	ºC	Measured value		22.3	20.7
Power Input to AC	kW	Measured value		4.8	6.3
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart		18.3	16.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart		16.4	15.1
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$		1.18	1.17
Air Flow	**m/s**			2.30	1.93
Volume flow rate at outlet(V_o)	m^3/hr	v * A		7617.60	8706.54
Volume flow rate at outlet(V_o)	CFM	-		4480.94	5121.49
Mass flow rate at outlet (m_o)	kg/hr	V * ρ		9002.3	10217.2

9.0 STEAM DISTRIBUTION

Steam Distribution Network in HLL-03

The steam generated from the captive power plant is utilized in various production blocks and other utilities. The average plant steam demand is 38.72TPHat 4-5 kg/cm^2**.** Steam from the boiler is routed to the process plant. Expansion loop with drain lines are provided at regular intervals to take care of pipe expansion and line condensate load. But in most of the cases, the steam trap is not provided at the drip legs. Steam pressure is reduced to required pressure at the user point with the help of pressure reducing stations.Steam pressure is further reduced using manual throttling valve at the point of utilization based on the process temperature requirement.

The steam from the power plant is distributed the following areas in HLL-03 Plant:

S.No	Production Block
1.	SRS-1
2.	SRS-2
3.	SRS Columns
4.	Q-Block
5.	M- Block
6.	Pharma Area
7.	Solvent Storage
8.	A-Block
9.	B- Block
10.	H-Block
11.	G-Block
12.	K-Block
13.	Canteen
14.	J-Block
15.	H-12 Block
16.	H-10 Block

Table 287:Steam Distribution in HLL-03

PRV working status

During the audit totally 17 no's pressure reducing stations were identified in the plant. The following table shows the actual working status of installed PRVs.

S. No	Location	Inlet Pr. (kg/cm^2)	Outlet Pr. (kg/cm^2)	Moisture Separator (MS)	Safety Valve	Remark	Working Status
1	K-Block	-	-	Yes	Yes	Flange leak observed. Safety Relief valve passing.	Pressure gauge not available at Upstream and Downstream.
2	L-Block	4.2	-	Yes	Yes	Steam leak- Moisture drainer line without the steam trap.	Pressure gauge not available at upstream.
3	Between (Q & T Block)	-	3.9	Yes	Yes	Flange leak in the relief valve and downstream steam leak.	-
4	Front of Q block	-	-	Yes	Yes	Valve leak at the outlet.	-
5	M-Block -I	-	-	Yes	Yes	No pressure gauges	-
6	M-Block-II	Not running					
7	M-Block-III	4.8	-	Yes	Yes	No pressure gauge at Downstream	-
8	Block-A	-	-	Yes	Yes	Float trap is working. No pressure gauge at both ends	-
9	Block-B	3.8	-	Yes	Yes	No pressure gauge at downstream. Two TD traps working. Isolation valve not insulated.	-
10	G-Block	4	-	Yes	Yes	Safety Relief valve flange leak. Moisture separator TD trap and downstream float trap working	-
11	Near H-Block	4	-	Yes	Yes	Two TD traps at moisture separator	-

S. No	Location	Inlet Pr. (kg/cm^2)	Outlet Pr. (kg/cm^2)	Moisture Separator (MS)	Safety Valve	Remark	Working Status
						and downstream are working. Steam leak near inlet Isolation valve and pressure relief valve flange leak	
12	SRS	3.8	2	Yes	Yes	Total 3 TD traps. Two nos. (Outlet and drip leg) working fine and one in cold condition	Yes
13	C-Block Opp.	3.6	-	Yes	Yes	Steam leak at valve discharge. TD trap at moisture separator in cold condition	-
14	Pharma	-	-	Yes	Yes	Isolation valve not insulated. No pressure at both ends. Moisture separator TD trap is working. TD trap at discharge in cold condition	-
15	Canteen	5.8	1.5	Yes	Yes	Isolation valve inlet leak. All trap at PRS working	Yes
16	N-Block	5.2	-	Yes	Yes	Flange leak at pressure gauge inlet side. Flange leak at inlet line to PRS and discharge side isolation valve leak. Two Float traps available. One at inlet side is working fine and other at discharge is plugged condition.	-
17	I-Block	4.5	4	Yes	Yes	TD trap at inlet is working. Direct steam leak at moisture separator	Yes

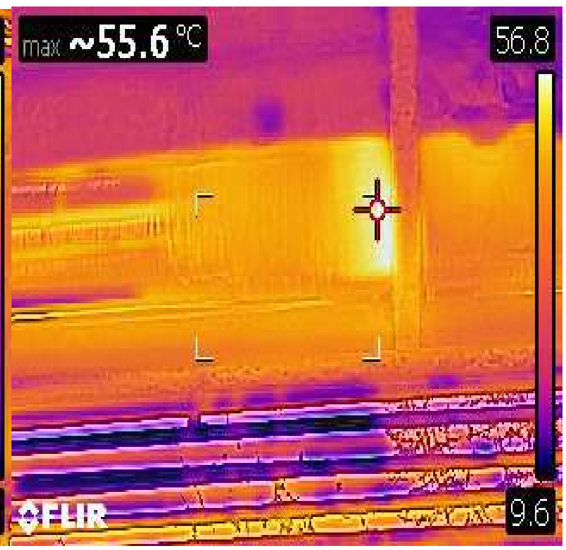
Table 288:Steam Survey in HLL-03

It is seen from the above table that in most of the PRS, pressure gauge is not available at the Upstream and downstream. In some of the locations, Steam traps are found in cold conditions and many steam leaks were observed. Hence it is suggested to replace or repair not working steam traps and arrest steam leakages.

Steam Line Insulation

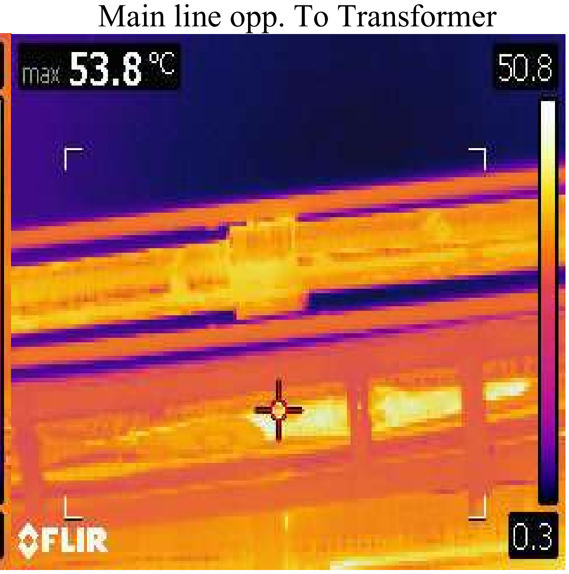
During the audit it was observed that the steam distribution lines are properly insulated, surface temperature found to be normal ranging 45 – 50 ˚C. However some of the valves and other pipeline auxiliary insulation need to be reviewed.

Steam line opposite to DG sets (K-Block)



Main line opp. To Transformer

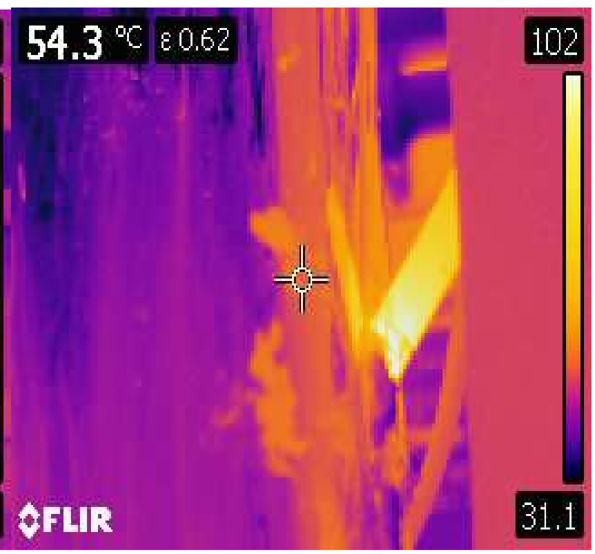
Steam line surface temperature in Q block PRS



Steam line between Prod Block A & B

Pharma Block-PRV Isolation Valve Not insulated

Main steam line near D2 building



Steam line Opp. Service block 1 6" main line

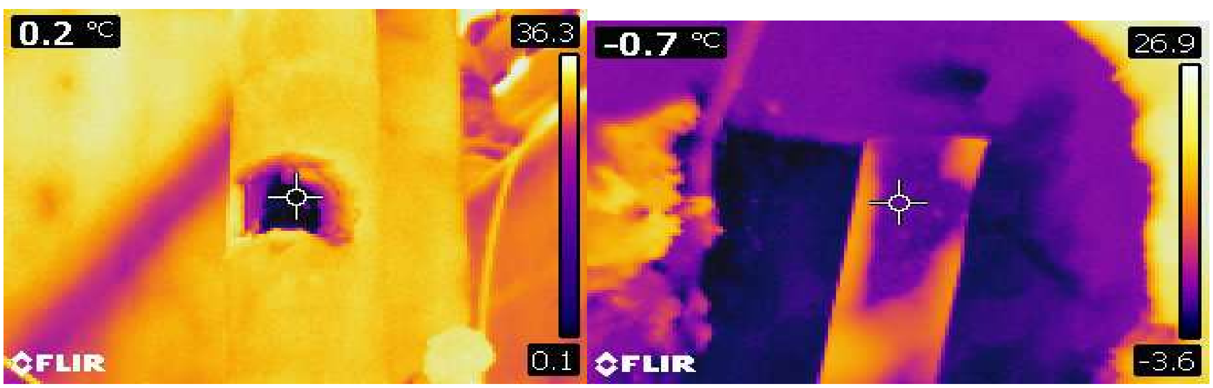
Steam line in SRS PRS

G-Block Skin Temp of uninsulated valve at Main Line (6 inch)

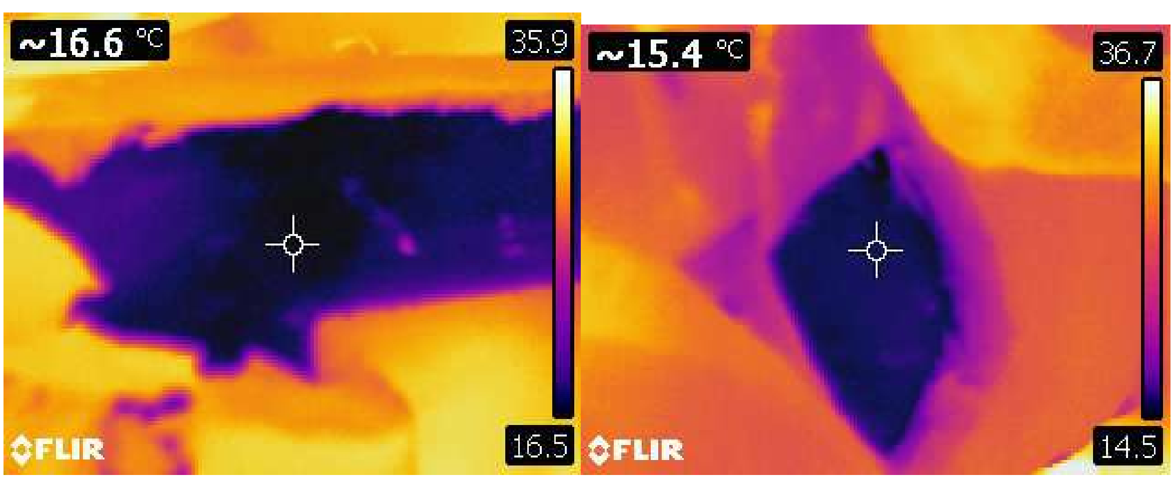
Cold Line Insulation

During the audit it was observed that the steam distribution lines are properly insulated, surface temperature found to be normal. The cold lines of different chillers i.e. +5, -15 from Service block- 1 were studied during the audit. The surface temperature were taken at different point's i.e at generation points, distribution points and utilization points (Block G and H).

The skin temperature is found to be within the recommended limits and there is no significant temperature raise between the generation points and utilization point. The overall energy loss is negligible as there was no significant temperature difference across the generation and distribution observed during the thermography survey. Moreover as the chilled water temperature is at very low as compared to ambient, it is therefore recommended to measure the chilled water temperature using online high precession contact type thermocouple to measure the actual temperature drop between the source and distribution.



The above two images refers to -15 chiller line at generation (1st form left) and utilization



a) Return line temperature at prod block (utilization) and b) return line at generation

Steam Leaks

During the audit, the steam leak survey brought to notice many locations where considerable amount of steam was leaking. The major leaks were from the flanges, glands etc. The leakages in the plant need to be reviewed, as they are the source of energy loss.

All leakages have to be plugged as soon as they are identified. Refer steam leak list below:

SL.NO	Location	Type of Leak	Plume length (m)	Steam loss (kg/hr)
1	PRS- K-Block	Flange Leak	0.1	1.2
2	PRS- K-Block	PRS Passing	0.1	1.2
3	PRS 1 Block	Moisture Sep without trap	0.2	1.5
4	PRS between (Q&T Block)	Flange Leak at Relief Valve	0.05	1.1
5	PRS between (Q&T Block)	Outlet Leak	0.03	1.1
6	PRS Q block	Valve Leak	0.05	1.1
7	PRS-G-Block	Valve Leak	0.06	1.1
8	PRS-G-Block	Releif Valve Flange Leak	0.1	1.2
9	PRS-H-Block	Inlet Isolation Valve Leak	0.07	1.2
10	PRS-H-Block	relief valve flange leak	0.03	1.1
11	PRS-C Block-Opp	Discharge Leak	0.02	1.1
12	PRS-Canteen	Isolation Valve Leak	0.1	1.2
13	PRS-N-Block	Flange Leak	0.05	1.1
14	PRS-N-Block	Flange Leak at Inlet to PRS	0.1	1.2
15	PRS-I-block	Direct Steam Leak from Moisture Separator	0.06	1.1
16	Drip Leg-J-Block-(No Steam Trap)	Direct Steam Leak from Drip Leg. Steam Vented out due to Non availability of trap	0.35	1.9
17	Q-Block	Flange Leak (6inch line)	0.15	1.3
18	Q-Block near Expansion Loop	Direct Leak	0.1	1.2
	Total Steam loss			**22.2**

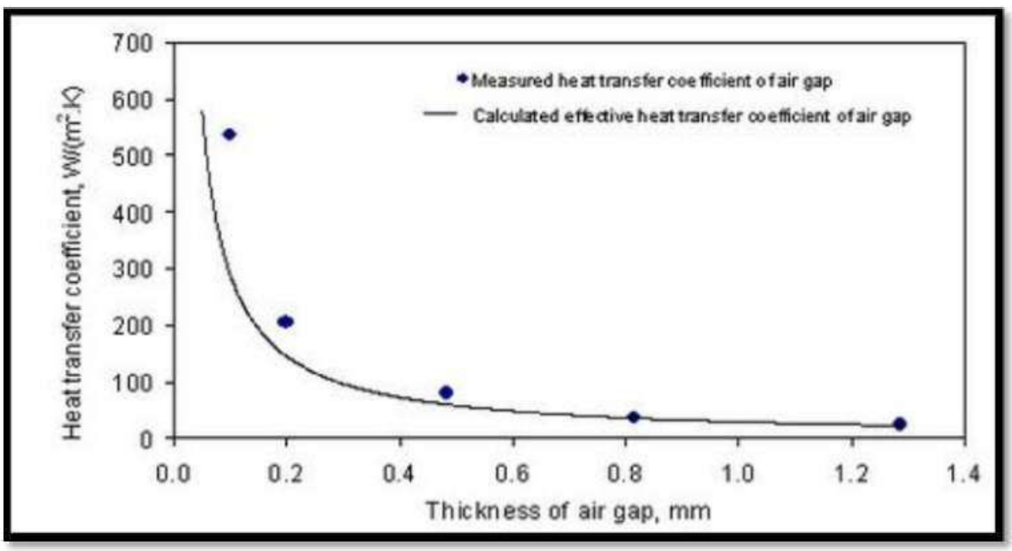
Energy Conservation Options (ENCON)

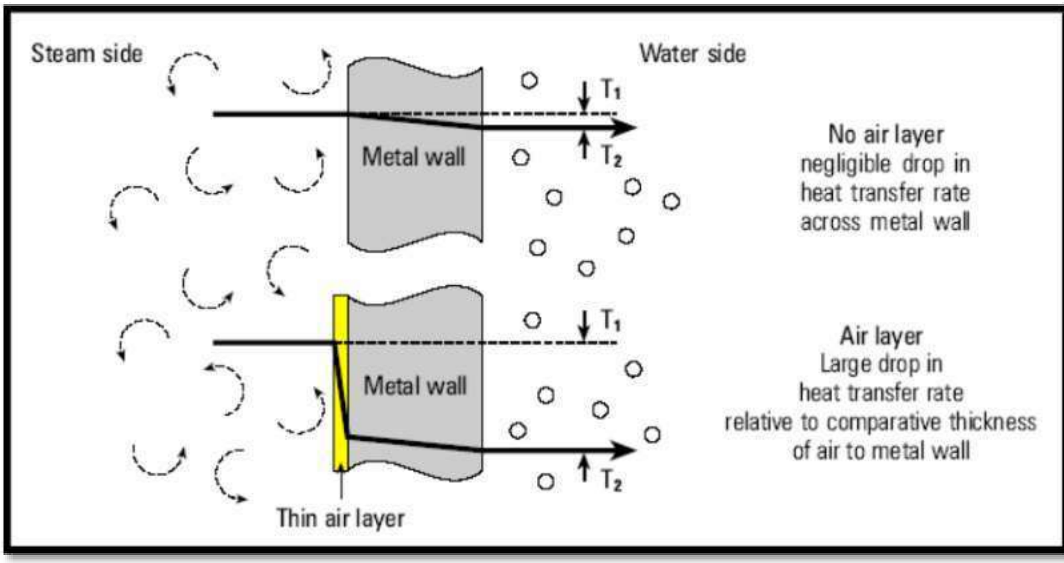
ENCON 1: Installation of air vents in identified locations
Present Condition:

It was observed during field studies no automatic air vents were installed on the main steam line or process equipment. However it is important to have air vent on batch steamed jacketed vessels and dead ends, especially for batch operated plant. All processes in the plant are batch type.

Proposed Condition:

In a batch process steam will be supplied for certain duration and steam valve will be closed once utility of steam is not required. During such batch operations when steam is allowed into pipeline usually pipeline will be filled with air. The air and non-condensable gases along with steam will accumulate within the pipe and in the steam spaces of the heat exchangers. Air being a bad conductor of heat and it reduces heat transfer efficiency of the equipment.





EFFECT OF AIR

It is too often overlooked that when steam is first admitted to a line after a period of shut down, the pipe will usually be full of air. Further amounts of air and other non-condensable gases will enter with the steam, although the proportions of these gases is normally very small compared to the steam. Nevertheless, these gases will accumulate within the pipe, and in the steam spaces of the heat exchangers, when the steam condenses, unless steps are taken to discharge them.

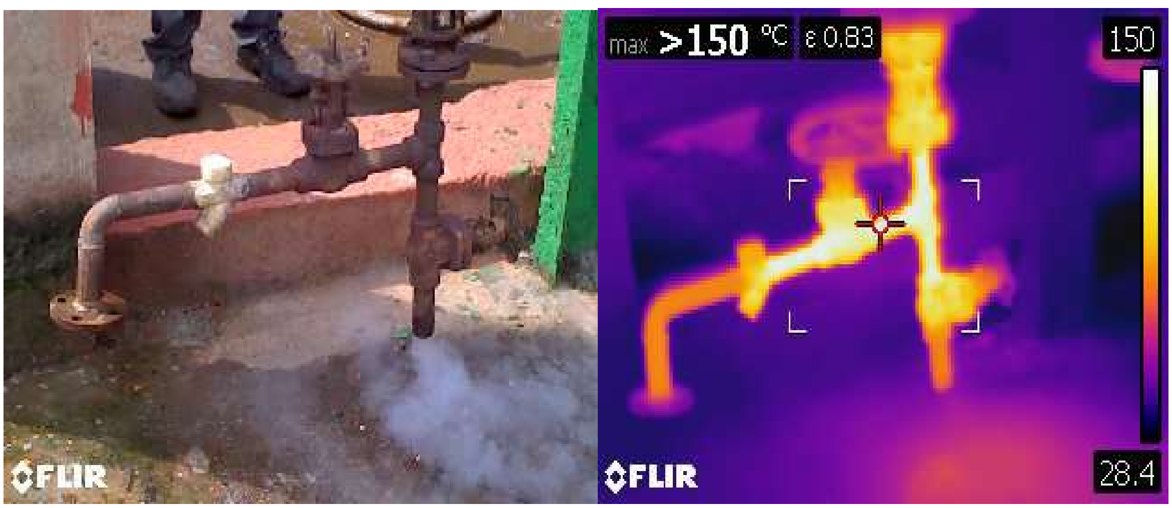
Recommended Optimization

It is necessary to remove air as soon as it forms hence recommended to provide automatic air vents at all the steam lines preferably at the ends of the pipes and steam header.

ENCON 2: Replace/Repair the main line traps which were found in plugged, cold and leaking condition

Present Condition:

During the field studies, it was observed that steam traps were not installed in the majority of the Main distribution lines. Steam traps are located only in few locations mainly in the Pressure Reducing Stations (PRS). The details of the same are given in the PRS survey table. In most of the drip legs on the main line, the drip leg valves are either in opened or closed condition. In case of valve being closed, the condensate gets accumulated inside the steam lines and causes water hammer. In case of valve being opened to remove the accumulated condensate, the steam also escapes along with the condensate and results in steam loss. The drip leg should be fitted with steam trap to drain the condensate.



A drip leg on the Main line, the bypass drain valve is kept open and steam is vented out

Proposed Condition:

As the steam flows through pipe an invariably steam will form condensate and this has to be removed from the main line so as to avoid the water hammer for inline steam accessories.

Irrespective of the quality and thickness of insulation there is always a heat loss arising due to radiation losses, which will cause the steam to condense. Condensate, unless removed, will accumulate and lead to problems such as corrosion, erosion, and water hammer. In addition, the steam will become wet as it picks up water droplets, which reduces its heat transfer potential. If water is allowed to accumulate, the overall effective cross sectional area of the pipe is reduced, and steam velocity can increase above the recommended limits.

Steam distribution systems link boilers and the equipment actually using steam, transporting it to any location in the plant where its heat energy is needed. The three primary components of steam distribution systems are boiler headers, steam mains and branch lines. Each fulfils certain requirements of the system and, together with steam separators and steam traps, contributes to efficient steam use.

Recommended optimization:

It is recommended to replace present traps which were found in cold/plugged condition.

Steam Distribution Network of HLL-09 and HDL-09

The steam generated from the captive power plant is utilized in various production blocks and other utilities. The average plant steam demand is 38.72TPHat 4-5 kg/cm^2**.** Steam from the boiler is routed to the process plant. Expansion loop with drain lines are provided at regular intervals to take care of pipe expansion and line condensate load. The superheated steam is then de-superheated in de-superheating station installed and distributed to the process areas. It was observed during the audit that in some of the areas, the De-superheating stations were not functional. De-superheating stations are functional only in SRS-I &SRS-II.Steam pressure is further reduced using manual throttling valve at the point of utilization based on the process temperature requirement.

There are quite a few reasons why superheated steam is not as suitable for process heating as saturated steam:

Superheated steam has to cool to saturation temperature before it can condense to release its enthalpy of evaporation. The amount of heat given up by the superheated steam as it cools to saturation temperature is relatively small in comparison to its enthalpy of evaporation.

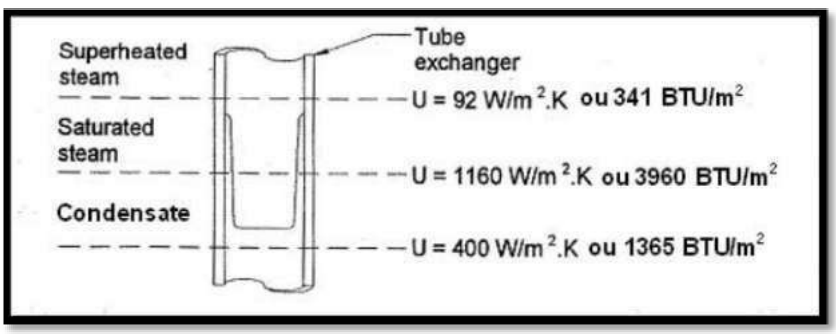
If the steam has only a few degrees of superheat, this small amount of heat is quickly given up before it condenses. However, if the steam has a large degree of superheat, it may take a relatively long time to cool, during which time the steam is releasing very little energy. Unlike saturated steam, the temperature of superheated steam is not uniform. Superheated steam has to cool to give up heat, whilst saturated steam changes phase. This means that temperature gradients over the heat transfer surface may occur with superheated steam.

In a heat exchanger, use of superheated steam can lead to the formation of a dry wall boiling zone, close to the tube sheet. This dry wall area can quickly become scaled or fouled, and the resulting high temperature of the tube wall may cause tube failure.

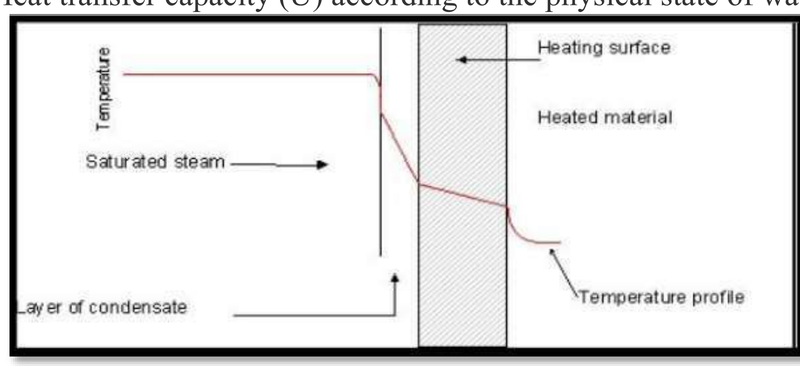
This clearly shows that in heat transfer applications, steam with a large degree of superheat is of little use because it:

- Gives up little heat until it has cooled to saturation temperature.
- Creates temperature gradients over the heat transfer surface as it cools to saturation temperature.
- Provides lower rates of heat transfer whilst the steam is superheated.
- Requires larger heat transfer areas.

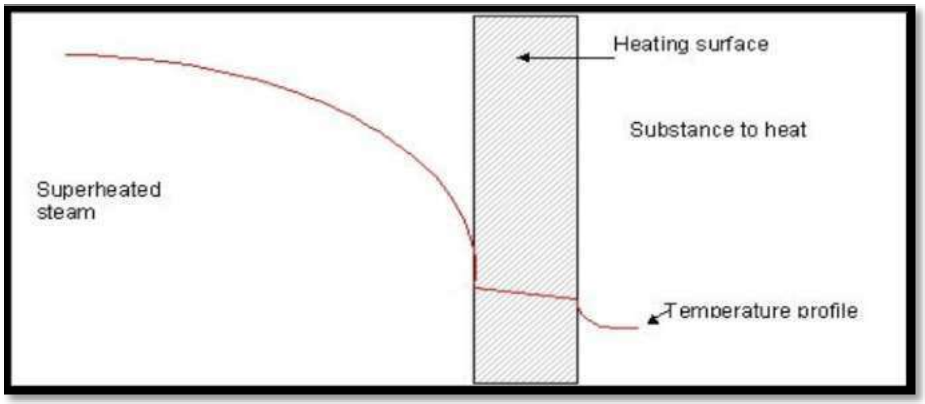
Figure shows the heat transfer capacity according to the source of steam used. We can see that the heat transfer capacity of saturated steam is much higher than that of water or superheated steam.



Heat transfer capacity (U) according to the physical state of water



Temperature profile near the surface of a heat exchanger using superheated steam



Temperature profile near the surface of a heat exchanger using saturated steam

PRV working status

During the audit totally 12 no's pressure reducing stations were identified in the plant. The following table shows the actual working status of installed PRVs.

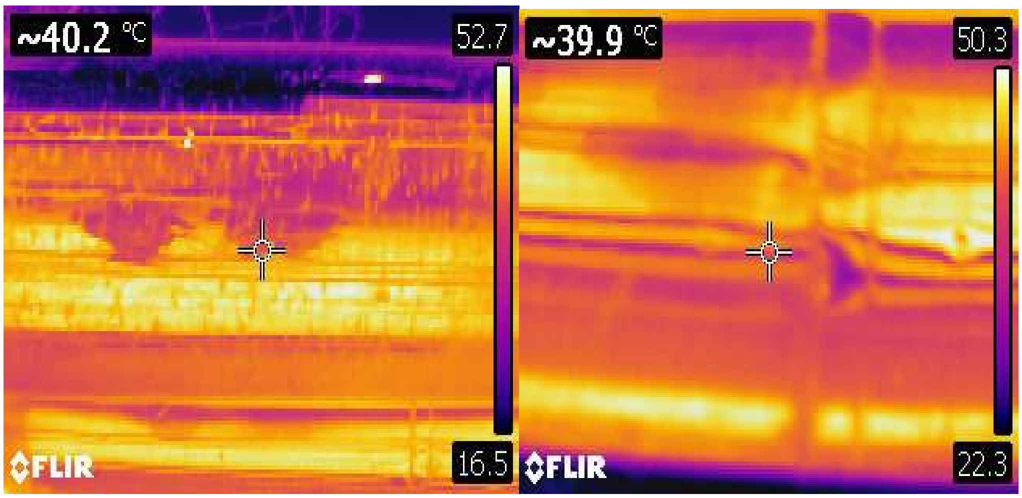
S. No	Location	Inlet Pr. (kg/cm^2)	Outlet Pr. (kg/cm^2)	Moisture Separator (MS)	Safety Valve	Remark	Working Status
1	SRS-II	3.4	2.8	YES	YES	Inlet TD trap cold condition	YES
2	PRS-1 Column SRS-1	5	2.5	NO	NO	Inlet Isolation valve Throttled (85%). Two TD traps working. One at Inlet and an another at discharge	NO
3	PRS-2 SRS-II	Closed					
4	PRS-3 Process SRS-III	5.2	1.4	YES	YES	Outlet Isolation valve throttled (20%). TD Trap at moisture separator in cold condition.	YES
5	PRS-1 ETP (MEE-2)	5.2	1.25	YES	YES	Flange plume length-5 cm	YES
6	PRS-2 (MEE-1)	5	1.1	YES	YES	TD trap in moisture separator working	YES
7	PRS-3 (Stripper-1)	4	1.3	YES	YES	TD trap in moisture separator working	YES
8	PRS-H12	4	4	YES	YES	TD trap at moisture separator and TD trap at inlet drain point are working fine	YES
9	PRS-H10	3.5	2.5	YES	YES	TD and Float traps are working fine. Isolation valve leak found	YES
10	PRS- H4	5.2	3	YES	YES	TD and Float traps are working fine. Steam leak at top near PRS (H4 Bent)	YES
11	PRS- H2	5	-	YES	YES	TD and Float traps are working fine. Downstream pressure gauge not available	-
12	PRS-H3	5	-	YES	YES	TD and Float traps are working fine. Downstream pressure gauge not available	-

Table 289:Steam Survey in HLL-03 & HDL-09

It is seen from the above table, in most of the places Pressure Reducing Stations (PRSs) are working fine. In some location steam leaks were observed. Hence it is suggested to arrest steam leakages and repair the faulty PRS near SRS-I.

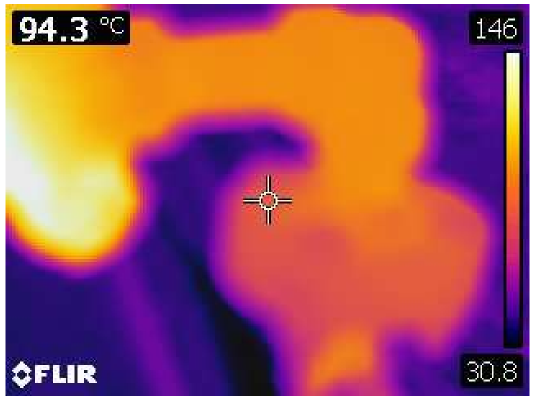
Steam Line Insulation

During the audit it was observed that the steam distribution lines are properly insulated, surface temperature found to be normal ranging 45 ˚C. – 50 ˚C. However some of the valves and other pipeline auxiliary insulation need to be reviewed.

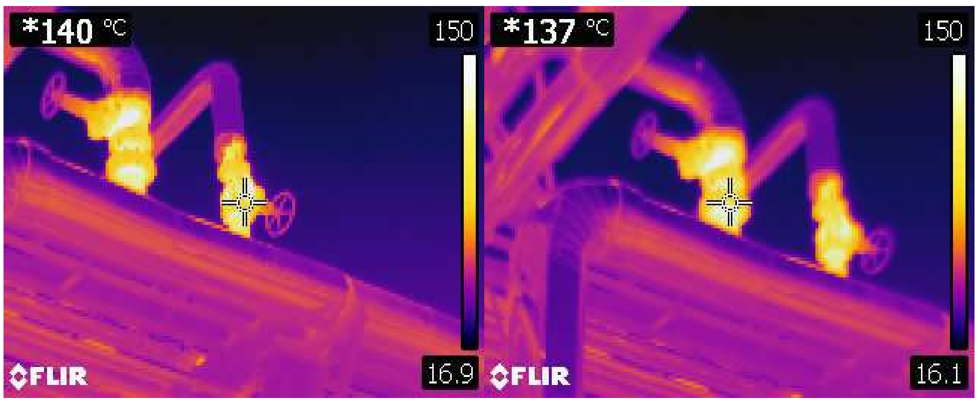


Two lines from boiler going to HLL-9 (12 inch and 10 inch)

HLL-9 10” Line TD trap failed due to rapidcycling (after boiler areas near bridge)

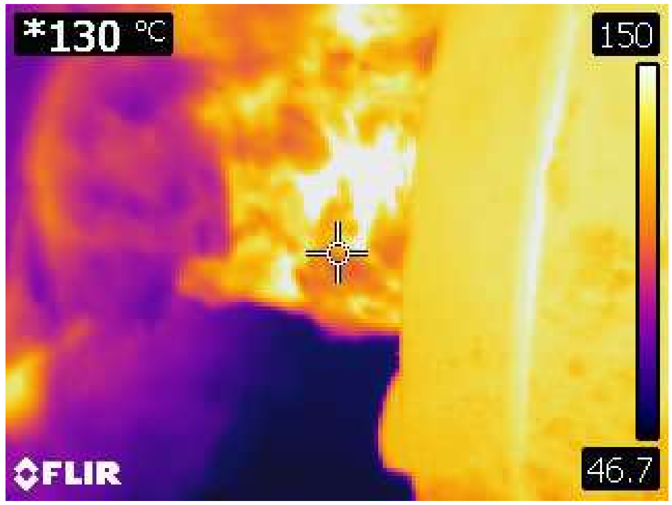


TD trap failed due to rapid cycling on 12” Line near Second expansion loop



Uninsulated Valves opp. SRS_1 (10” and 12” lines)

Near Honour lab entrance 10 inch line (Hot spot on the line)

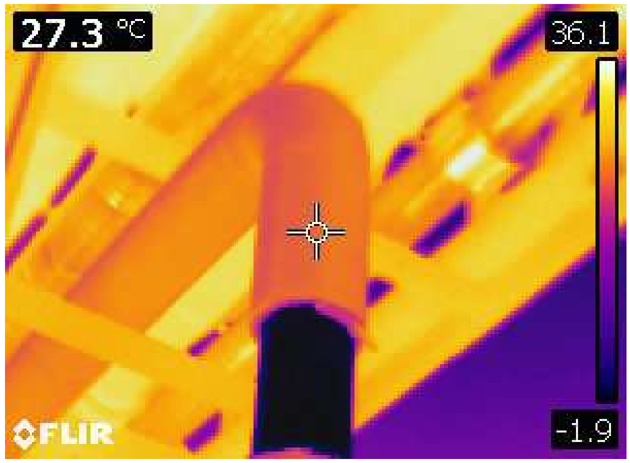


Prod-D PRS valve uninsulated

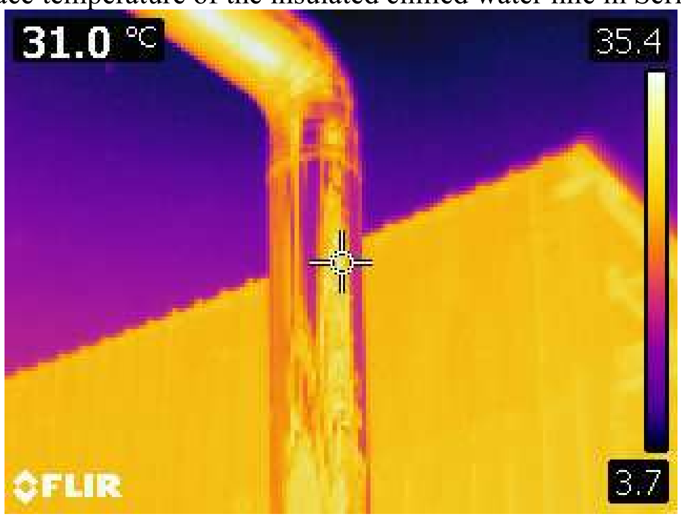
Cold Line Insulation

During the audit it was observed that the steam distribution lines are properly insulated, surface temperature found to be normal. The cold lines of different chillers i.e. +5, -15 of Service Block- A were studied during the audit. The surface temperature was taken at different point's i.e at generation points, distribution points and utilization points (Block H). The skin temperature is found to be within the recommended limits and there is no significant temperature raise between the generation points and utilization point.

The skin temperature is found to be within the recommended limits and there is no significant temperature raise between the generation points and utilization point. The overall energy loss is negligible as there was no significant temperature difference across the generation and distribution observed during the thermography survey. Moreover as the chilled water temperature is at very low as compared to ambient, it is therefore recommended to measure the chilled water temperature using online high precession contact type thermocouple to measure the actual temperature drop between the source and distribution.



The surface temperature of the insulated chilled water line in Serice Block



The surface temperature of insulated secondary pump chilled water line in Service Block

Steam Leaks

During the audit, the steam leak survey brought to notice some locations where considerable amount of steam was leaking. The major leaks were from the flanges, glands etc. The leakages in the plant need to be reviewed, as they are the source of energy loss.

All leakages have to be plugged as soon as they are identified. Refer steam leak list below:

S.No	Location	Type of Leak	Plume length (m)	Steam loss (kg/hr)
1	PRS K-Block	Flange leak	0.1	1.2
2	H_-Block	Flange leak	0.1	1.2
3	PRS-H4 Block	Top line bent direct leak	0.12	1.3
4	PRS-H10	Isolation valve leak	0.1	1.2
5	HDL-9	Gland leak	0.07	1.2
6	PRS-1 (MEE-2)	Leak in upstream	0.05	1.1
	Total Steam loss			**7.2**

Table 290:Steam Losses

Description	Unit	Value
Steam loss	kg/hr	7.2
Steam loss	Tons/annum	51.84
Present steam cost	Rs/kg	6
Estimated monetary savings	Lacs/annum	3.1
Investment	Rs	1
Payback period	Months	3.86

Table 291:Steam Loss Calculation

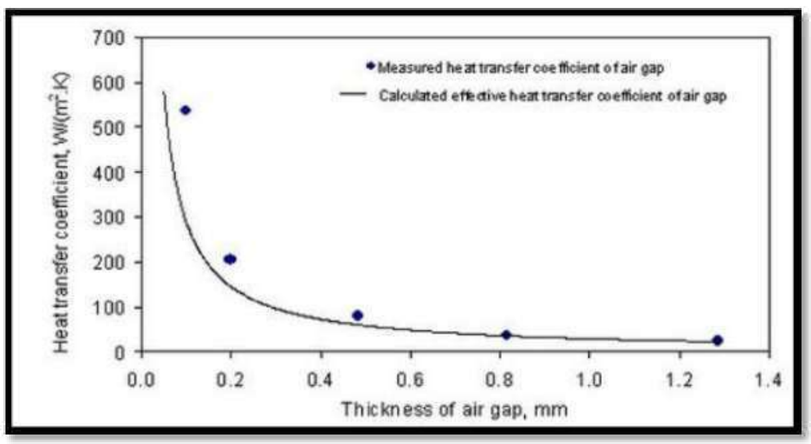
Energy Conservation Options (ENCON)

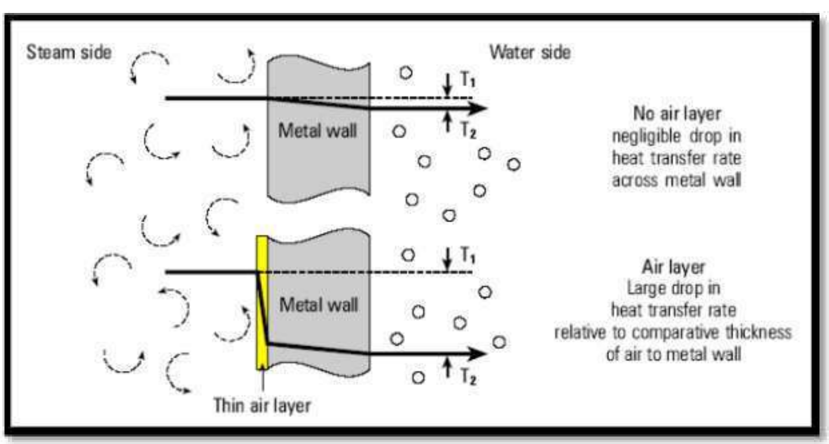
ENCON 1: Installation of air vents in identified locations
Present Condition:

It was observed during field studies no automatic air vents were installed on the main steam line or process equipment. However it is important to have air vent on batch steamed jacketed vessels and dead ends, especially for batch operated plant. All processes in the plant are batch type.

Proposed Condition:

In a batch process steam will be supplied for certain duration and steam valve will be closed once utility of steam is not required. During such batch operations when steam is allowed into pipeline usually pipeline will be filled with air. The air and non-condensable gases along with steam will accumulate within the pipe and in the steam spaces of the heat exchangers. Air being a bad conductor of heat and it reduces heat transfer efficiency of the equipment.





EFFECT OF AIR

It is too often overlooked that when steam is first admitted to a line after a period of shut down, the pipe will usually be full of air. Further amounts of air and other non-condensable gases will enter with the steam, although the proportions of these gases is normally very small compared to the steam. Nevertheless, these gases will accumulate within the pipe, and in the steam spaces of the heat exchangers, when the steam condenses, unless steps are taken to discharge them.

Recommended Optimization

It is necessary to remove air as soon as it forms hence recommended to provide automatic air vents at all the steam lines preferably at the ends of the pipes and steam header.

10.0 SOLVENT RECOVERY SYSTEM I & II

Hetero Labs Limited, Nakapally unit has three solvent recovery systems i.e.,SRS-I,SRS-II & H-12 with 32 columns. In these units, solvent used in various processes are distilled and recovered from the mother liquor and used in the process again. Considering the increasing cost of solvents used, it becomes vital to have maximum recovery.

S.No	Recovery Block	No of Columns	Remarks
1	Solvent Recovery System-1(SRS-1)	12	-
2	Solvent Recovery System-2(SRS-2)	14	-
3	H-12	6	-

Table 292:Solvent Recovery System

For each solvent there will be 5 tanks where 2 tanks for mixed solvents,2 tanks for recovered solvents and 1 tank for mixed solvent. Some of the few solvents being recovered in SRS-I and II are DMS, Methanol, IPA, Ethanol, Cyclo-Hexane, Butanol, Toluene, Ethyl acetate, Acetone etc.

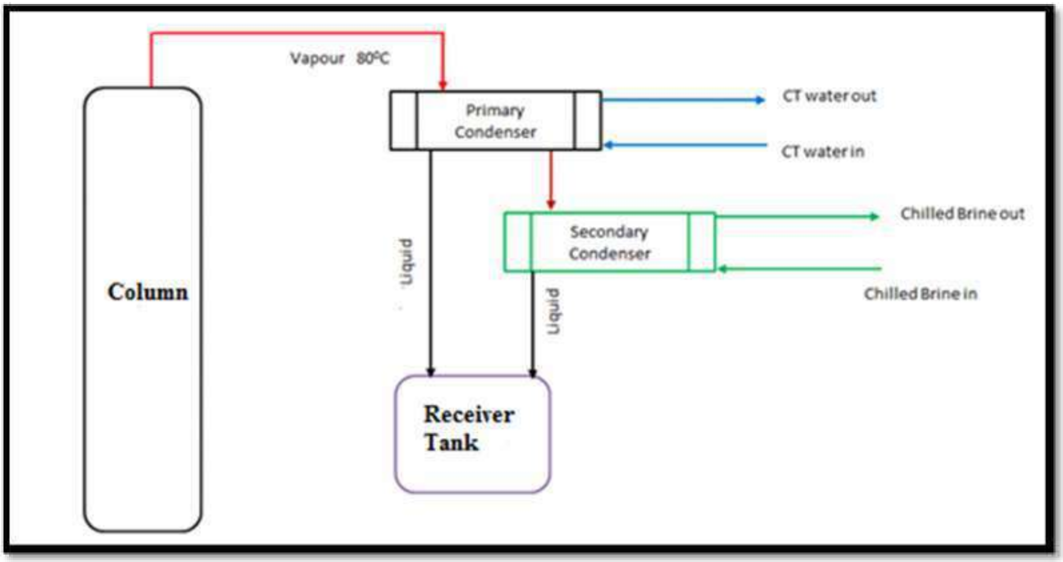
The average production capacity of SRS-1 and SRS-II is 140T/day.

Field Observations

- During the audit, for the reactors running, process steam traps (Float traps) were checked and found working.
- All the condensate are recovered and pumped back to boiler
- During the audit, process steam traps (Float traps) for the process which were running, were tested and found to be working satisfactorily.

Overview of SRS Condensation Process:

There are 12 columns in SRS-I for the recovery of majorly DMS, Methanol, IPA and Ethanol. Process vapour is generated in these columns at the temperature of around 80^0C. This process vapour is cooled down with two shell and tube heat exchangers with the help of cooling tower water (primary condenser) and Chilled brine (secondary condenser). Main function of primary condenser is to absorb all the available latent heat in the solvent vapour and convert its phase from vapour to liquid form. Hence heat removal is quite high in primary condenser. The remaining trace of these solvent vapours coming out from primary condenser is cooled down by secondary condenser. The following SLD shows the present system:



Comments

- Primary condenser is supplied with cooling tower water through 8" line.
- The flow rate was measured and found to be around 340 m^3/hr.
- During the study temperature difference was measured as 40^0C-50^0C in the cooling tower water across primary condenser
- It is very clear that huge amount of latent heat is removed in the primary condenser.
- The feasibility of boiler RO makeup pre heating with SRS vapours is done with RO water flow rate of 20 m^3/h at 30^0C and it is estimated that the RO water temperature at the outlet of primary condenser is 68^0C.

Energy Conservation Options (ENCON)

ENCON 1: Waste Heat Recovery from SRS vapours by preheating RO makeup water to boiler.

Present Condition:

Primary condenser from cooling tower with a flow rate of 340 m3/hr is cooling solvent vapours and the heat gained is dissipated to atmosphere in cooling tower. The temperature rise of primary condenser is 40^0C-50^0C

Proposed Condition:

It is recommended to recover the available latent heat from SRS vapours by installing heat recovery unit before primary condenser with the supply of boiler RO make-up water.

Advantages of ISP Vapour Heat Recovery

- Pre heating the boiler RO makeup would result in increased feed water temperature and reduced coal consumption in boiler.
- Heat recovery before primary condenser with boiler RO make-up would reduce the cooling tower water circulation rate in the primary condenser.
- Heat recovery before primary condenser would result in reduced power consumption of cooling water circulation pump as well as the cooling load of cooling tower.

The detailed Energy Conservation option along with ROI is depicted below:

Description	Unit	Value
Available process vapour from SRS column	kg/h	4000
Temperature of process vapour	^{0}C	80
Latent heat of process vapour	kcal/kg	120
Available heat energy from process vapour	kcal/h	384000
Quantity of Boiler RO makeup	m^3/h	20
Initial temperature of boiler RO makeup	^{0}C	30
Expected outlet temperature of boiler RO makeup	^{0}C	49
Equivalent coal reduction	kg/h	108
Annual operating hours	hours	6000
Annual coal savings	Tons/annum	648
Average coal cost	Rs./Ton	3000
Annual cost savings	Rs. Lakhs/annum	19.44
Investment	Rs.Lakhs	30
Simple payback period	Months	18.5185

Table 293: Waste Heat Recovery from SRS vapours by preheating RO makeup water to boiler.

11.0 EFFLUENT TREATMENT PLANT

During field studies the existing Effluent Treatment Plant (ETP) operation was reviewed during the audit. There are three treatment facility being carried out in the ETP plant viz. primary, secondary and tertiary. Effluents are segregated into High and Low COD at the source and treated separately in the ETP. The ETP consists of screen chambers, Oil & Grid chambers, Equalization and Neutralization tank, flash mixer, flocculate, Primary and secondary clarifier and filter press etc. the treated water is finally sent to sea from the guard pond under the supervision of State Pollution control board.

Steam is used in Multiple Effect Evaporator (MEE), Agitated Thin Film Dryer (ATFD) and Strippers concentrating the effluent in the ETP. Presently steam is distributed through 4 Pressure reducing stations at ETP. The steam is used at 1.1-1.3 kg/cm^2 pressure in the downstream of PRV's. The normal steam requirement is considered as 0.25 kg of steam for every 1kg of water to evaporate.

There are two sets of MEE with 5 effects of capacity 300KL & 200KL respectively and Stripper combination (3 no's) and one ATFD operating in the ETP. The condensate from all the equipment's are recovered and sent back to boiler. There are two cooling towers of 1000 TR operated to cool the RT water from the condenser units (ATFD, MEE and Strippers).

Field Observation

1. It was observed that PRV-II was bypassed and not operated. Due to which the steam valve was operated manually at the stripper column. The pressure recorded during the study was 4-5 kg/cm^2.
2. It was observed during the audit that the flash steam from the condensate is not properly utilized. This resulted in venting of steam to the atmosphere. Since the flash steam was not properly recovered, hammering effect was observed in the condensate tank.
3. The performance assessment of CT pumps were evaluated.

MEE-II Cooling Towers			
ETP Pumps		**MEE-I Cooling Tower**	**MEE-II Cooling Tower**
Description	**UNITS**	ACTUAL	ACTUAL
Flow	**m^3/hr**	345	450.00
Suction Head	**m**	1	1.00
Discharge Head	**m**	23	23.00
Total Head	**m**	24	22.00
Hydraulic power	**kW**	22.54	26.95
Electrical Input power	**kW**	23.00	23.00
Pump Input power	**kW**	40.00	40.00
Pump Efficiency	**%**	**56.35**	**67.38**

Table 294:Performance of Cooling Towers Pumps in MEE-II

Observations and findings:

- It is observed from the above table the hydraulic power for the 2 MEE cooling tower pumps is 22.54 and 26.95.
- The pump efficiencies are 56.35% & 67.38%.
- The performance of the two pumps is satisfactory.

Areas for Improvement and Recommendation

- Currently the steam is used at 7kg/cm^2 in the ATFD. The condensate is taken to common condensate tank. The flash steam from the condensate tank is vented out. Presuming, 0.5 kg/cm^2 pressure drop across the vessel, the condensate is available at 6.5 kg/cm^2.Therefore it is proposed to install a flash vessel at the discharge of ATFD and use the flash steam effectively in the stripper columns. While connecting the flash line with the downstream of the PRS, pressure setting at the PRV should be kept 0.5 bar less than the flash steam pressure.
- The temperature of vapour from the ATFD is around 90 deg C going to the condenser unit. The temperature of feed to the ATFD is around 60 deg C. The heat of condensation can be utilized for preheating the incoming feed to the ATFD. This will increase the incoming feed temperature and reduce the steam consumption in the ATFD.
- One of the cells of the cooling tower has to be made functional by replacing the fill material inside. This will not only increase the capacity of the cooling tower but also gives the potential to reduce the flow of water due to the fact that there will be an increase in the natural evaporative cooling. This will reduce the energy costs due to reduction in water flow.

12.0 LIGHTING SYSTEM

The share of energy consumption of lighting when compared to other utilities is very minimal and it is observed during the field studies most of the lighting fixtures are taken as per the production requirements. An improvement can be done in a phased manner in the area of street lighting by replacing the existing sodium vapour lamps with LED lighting. The detailed energy conservation option for HLL-09 and HLL-03 are discussed in the energy conservation option (ENCON).

Energy Conservation Options (ENCON):

ENCON 1:Energy Savings by replacing all sodium vapour street lights with LED Street Lights in HLL-03

Present Condition:

HLL-03 has Sodium Vapour Lamps of 250 W lamps for meeting the street lighting requirements. Now in the market energy efficient lamps such as LED lamps were available, which consumes less power and also has a life of more than 50000 hrs.

Proposed Condition:

It is suggested to replace the existing 250 nos. of Sodium Vapour lamps with equivalent wattage of LED lamps of 70W. This option would yield an energy savings of around 40-50%. The expected annual savings are around 229950 kWh per annum which amounts to 13.8 Lakhs. An investment of around Rs.15 Lakhs will be needed to incorporate this opportunity which will be paid back in a year.

Encon Rationale:

Energy Savings by replacing all sodium vapour street lights with LED street Lights in HLL-03		
Item Reference	**Units**	**Value**
Existing No of 250 watt Sodium vapour lamps street lighting	No's	250
Power consumption of existing street light including ballast	Watts	280
Suggested replace with LED Lamps	No's	250
Power Consumption of LED	W	70
Power Savings by replacing with LED street lights	W	210
Average operating hours/day	hours	12
No. of days of operation / year	days	365
Avg. cost of Electricity	Rs/kwh	6
Annual Electricity Savings	kwh	229950
Annual cost Savings	Rs. Lakhs	13.80
Cost of LED/Lamp	Rs	6000
Investment	Rs. Lakhs	15
Simple Payback period	years	1.087

Table 295: Energy Savings by replacing all sodium vapour street lights with LED street Lights in HLL-03

ENCON 2:Energy Savings by replacing all sodium vapour street lights with LED Street Lights in HLL-09

Present Condition:

HLL-09 has Sodium Vapour Lamps of 250 W lamps for meeting the street lighting requirements. Now in the market energy efficient lamps such as LED lamps were available, which consumes less power and also has a life of more than 50000 hrs.

Proposed Condition:

It is suggested to replace the existing 60 nos. of Sodium Vapour lamps with equivalent wattage of LED lamps of 70W. This option would yield an energy savings of around 40-50%. The expected annual savings are around 55188 kWh per annum which amounts to 3.31 Lakhs. An investment of around Rs.3.6 Lakhs will be needed to incorporate this opportunity which will be paid back in a year.

Encon Rationale:

Energy Savings by replacing all sodium vapour street lights with LED street Lights in HLL-09		
Item Reference	**Units**	**Value**
Existing No of 250 watt Sodium vapour lamps street lighting	No's	60
Power consumption of existing street light including ballast	Watts	280
Suggested replace with LED Lamps	No's	60
Power Consumption of LED	W	70
Power Savings by replacing with LED street lights	W	210
Average operating hours/day	hours	12
No. of days of operation / year	days	365
Avg. cost of Electricity	Rs/kwh	6
Annual Electricity Savings	kwh	55188
Annual cost Savings	Rs. Lakhs	3.31
Cost of LED/Lamp	Rs	6000
Investment	Rs. Lakhs	3.6
Simple Payback period	years	1.087

Table 296: Energy Savings by replacing all sodium vapour street lights with LED street Lights in HLL-09

13.0 ANNEXURES

Annexure: BEE Standards for Effect of Evaporator and condenser temperature

Effect of Variation in Evaporator Temperature on Compressor Power			
Evaporator Temperature(°C)	**Refrigeration Capacity" (tons)**	**Specific Power Consumption(kW/TR)**	**Increase in kW/TR(%)**
5	67.58	0.81	-
0	56.07	0.94	16
-5	45.98	1.08	33
-10	37.2	1.25	54
-20	23.12	1.67	106

Table 297: Effect of Variation in Evaporator Temperature on Compressor Power

Effect of Variation in Condenser Temperature on Compressor Power Consumption			
Condensing Temperature (0C)	**Refrigeration Capacity (tons)**	**Specific Power Consumption (kW**	**Increase in kW/TR(%)**
26.7	31.5	1.17	-
35	21.4	1.27	8.5
40	20	1.41	20.5

Table 298: Effect of Variation in Condenser Temperature on Compressor Power Consumption

Annexure-Power Measurements HLL-03

	V	I	PF	KW	kVAR	kVA	Hz
HLL-03							
Service Block-01							
173 TR-SB-1							
Compressor	412	165	0.89	105	30.6	106	49.9
Secondary Pump #4	416	16.7	0.85	10.2	6.37	12.6	50
Secondary Pump #2	416	21.1	0.87	13.3	7.48	15.1	50.8
CT Fan	409	11	0.37	2.85	7.31	7.87	49.9
Primary Pump #1	425	16.4	0.85	10.8	5.11		49.9
(+5) 400TR							
Compressor	412	152.5	0.97	105.6	53	106.4	50.05
CT Fan	414	14.4	0.575	5.9	16.26	21.2	49.95
Secondary Pump #01	368	21.5	1	14.1		13.5	40
Secondary Pump #02	412	29.5	1	21.0		21.1	50
Primary Pump #02	416	12.2	1	8.8		8.8	49.9
Primary Pump #01	417	14.3	1	10.3		10.3	49.9
(-15) 186TR							
Secondary Pump 02 37kW P-016	423	22.8	1	16.7		16.2	50
Secondary Pump 10 -15/158TR 30kW	418	27.6	1	21.0		20.2	49.9
Compressor B 158TR, -15 132kW	412	95.2	0.76	51.6	45	68.7	49.9
Compressor A 158TR, -15 132kW	408	144	0.87	88.5	50.6	103	49.7
-5 Compressor /RF-002 120TR 160kW	415	178	0.95	121.5	38.5	128	49.7
Nitrogen Plant							
A (Running Hrs: 21864hrs; Loaded Hrs: 18949hrs)	417	190	0.89	117	64	136	49.9
B (Running Hrs: 22476hrs; Loaded Hrs: 19017hrs)	417	166	0.88	105.50	56.7	120	49.9
-15 Compressor / RES-07 186TR 160kW	414	229	0.91	149.42	68.9	164	49.8
Primary Pump 02 20HP -15,186TR (13)	417	13.9	0.82	7.75	5.48	9.49	50.1
Primary Pump 02 20HP -15,186TR (6)	415	20.6	0.87	12.88	7.23	14.8	49.9
Primary Pump 03 -5,10HP, 120TR	415	11.1	0.94	11.48	2.79	7.99	49.9
-5/120TR Secondary Pump #7	416	13.3	0.92	8.8	3.1	9.58	50.1
-5/120TR Secondary Pump #8	417	15.2	0.88	9.7	5.17	11	50
Pumps A-1, B-1, 3HP (B)	417	4.22	0.81	2.5	1.8	3.06	50
Pumps A-1, B-1, 3HP (A)	419	5.18	0.9	3.4	1.78	4.05	50
Service Block-02							
173 TR-SB-2(+5)							
(+5) Primary Pump-02	430	16.7	0.83	10.32	5.42	6.44	49.9
(-20) secondary pump-1	430	16.7	0.83	10.32	7.05	12.5	50

	V	I	PF	KW	kVAR	kVA	Hz
(-40) Primary Pump-1	424	24.4	0.83	14.87	9.95	17.7	49.8
(-20) Primary Pump-2	411	11	0.69	5.40	5.48	7.9	50.8
(+5) Compressor-2(160KW)	421	188	0.91	124.74	58.1	138	50
(-15) Compressor 186TR(160KW)-A	424	160	0.85	99.87	62.2	111.7	49.9
(-15) Compressor 186TR(160KW)-B	425	168	0.86	106.35	68	134	49.9
Air Comp-01	427	50.5	0.79	29.50	6.58	11	49.5
Air Comp-02	419	49.6	0.93	33.47	13.6	36.2	50
(-40) Comp (50TR)	416	80	0.88	50.72	2.86	5.96	49.8
	422	32.9	0.86	20.68	14.2	29.1	49.9
N2 Comp-1	399	130	0.86	77.26	47.7	93.7	49.8
(-20) Comp-1	425	147	0.87	94.13	51	102	50
	413	180	0.89	114.59	59.9	131	50
(+5) Secondary Pump-01	419	14.3	0.96	9.96	2.73	10.4	49.9
(+5) Secondary Pump-03	419	7.89	0.83	4.75	3.73	7.83	50.1
(-20) Evaporative Condenser	419	8.19	0.78	4.63	3.59	5.96	50
Fan	418	12.8	0.63	5.83	7.16	5.81	
(+5) Evaporative Condenser	420	12.3	0.98	8.76	1.64	8.95	50
Fan	419	3.66	0.97	2.57	6.83	2.66	50
(-15) Evaporative Condenser	410	4.63	0.83	2.72	3.98	7.07	50
Fan	425	18.21	0.35	4.69	12.6	13.4	50
(+5) Secondary Pump	427	46	0.35	11.90	32	34.1	50
RFS-07	421	226	0.88	145.01	77.4	165	50
Primary Pump-04	422	20.6	0.87	13.09	7.51	15.1	49.9
Service Block-04							
(+5) Comp-2A 395TR	420	176	0.99	126.75	18.8	128	49.9
(-15) Comp 450TR	421	280	0.79	161.29	126	203	49.9
(-15) Secondary Pump-01	416	28.5	1	20.53		20.5	50
(-15) Primary Pump-02	416	35.8	0.83	21.41	14.3	25.7	49.8
(+5) Secondary Pump-05	411	31.1	0.84	18.60	12.2	22.5	49.9
(+5) Secondary Pump-01	424	39.4	1	28.93		29.5	49.9
(+5) Primary Pump-01	419	37.4	0.88	23.88	15.4	30	49.8
(+5) Secondary Pump-04	421	47.9	1	34.93		35.3	49.9
(+5) Secondary Pump-01	422	24.8	1	18.13		18.1	49.9
(+5) Secondary Pump-02	424	14.8	0.99	10.76		11.3	50
(-20) Secondary Pump-05	424	12.7	0.99	9.23		9.35	50
(-15) Secondary Pump-03	430	9.59	0.77	5.50	4.64	7.05	49.8
(-20) Secondary Pump-01	427	41.3	1	30.54		28.6	50.1
(+5) -2 Evaporator A Fan	413	13.3	0.55	5.23	8.24	9.64	50.1
(+5) -2 Evaporator A Pump-01	423	4.41	0.85	2.75	1.71	3.23	50
(+5) -2 Evaporator A Pump-02	423	4.16	0.87	2.65	1.49	2.5	49.3
(+5) -2 Evaporator B Fan	424	13.9	0.54	5.51	8.62	10.2	49.9
(+5) -2 Evaporator B Pump-01	423	4.39	0.86	2.77	9.62	10.2	49.9
(+5) -2 Evaporator B Pump-02	423	4.49	0.86	2.83	9.62	3.06	49.9

Table 299:Power Measurements of HLL-03

Annexure-Power Measurements HLL-09

	V	I	PF	KW	kVAR	kVA	Hz
Service Block-01							
004 (-15) Comp 1A	408	186	0.87	114.4	65.4	132	49.9
004 (-15) Comp 1B	414	164	0.88	103.5	56.4	118	49.8
005 (-15) Comp 1B	414	206	0.88	129.98	69.3	147	49.9
(-40) 3B	430	192	0.89	127.26	61.7	137	50
(+5) Comp A(395TR)	421	239.5	0.91	158.91			
(+5) Comp B(395TR)	424	231	0.91	154.37			
(+5) Primary Pump -4	420	27	1	19.64	0	197	50
(+5) Secondary Pump-01	418	17.4	1	12.59	0	12.6	50
(+5) Secondary Pump-03	421	44.2	1	32.22	0	32.2	50
(+5) Secondary Pump-02	417	32.8	0.53	12.55	17.5	23.7	49.9
(-15) Primary Pump 01	419	15.2	0.88	9.70	5.19	11	49.7
(-15) Primary Pump 02	420	15	0.88	9.60	5.21	10.9	50
(-15) Secondary Pump 01	420	29.7	1	21.60	0	21.6	50.3
(-15) Secondary Pump 02	421	25	1	18.22	0	18.1	50
(-40) Secondary Pump	420	15.1	0.52	5.71	9.42	11	49.9
(-40) Primary Pump	419	6.6	0.87	4.16	2.39	4.79	50
N2 Air Compressor	417	225	0.85	138.12	88.7	161	49.9
Breathing Air Compressor	412	27.4	0.87	17.01	12.5	29.5	49.9
L BlockRT-01	419	28.6	0.86	17.85			
K Block Rt-02	415	9.42	0.83	5.62			
E Block RT-01	418	14.5	0.85	8.92			
E Block RT-02	420	16.3	0.87	10.32			
Q Block Rt-02	420	6.72	0.94	4.60			
SRS/Rt Pump-03	418	6.44	0.68	3.17			
SRS/Rt Pump-05	417	15.2	0.91	9.99			
SRS/Rt Pump-06	416	9.53	0.82	5.63			
SRS/Rt Pump-01	412	18.7	0.89	11.88			
SRS/Rt Pump-02	415	19.4	0.88	12.27			
(-15) - 04 Comp 1B	406	480	0.92	310.52	134	337	49.9
(+5) -02 Comp (2A & 2B)	408	349	0.97	239.22	57.8	247	49.9
(+5) -02 Comp 2B	409	212	0.92	138.16	58.9	150	49.9
(+5) -02 Comp 2A	408	213	0.92	138.47	48.8	150	49.9
Air Comp-01(instrument Air)	409	77.2	0.96	52.50	16.3	56.3	49.9
Air Comp-02(Plant Air)	409	40.9	0.88	25.49	13.9	29	49.9
Evaporator Cond-02(+5)	405	35.5	0.68	16.93	18.2	24.8	49.9
Air Comp-01(N2 Comp)	400	170	0.85	100.10	61.8	119	49.8
(-40) -1B(High Stage)	412	160	0.89	101.61	51.3	115	49.9
(-40) - 1B(Booster)	413	137	0.9	88.19	42	98.3	49.9
(-40) Primary Pump-01	412	34.9	0.9	22.41	11.7	24.8	49.9
(+5) Secondary Pump-03	411	27.1	0.9	17.36	8.56	19.2	49.8

(+5) Secondary Pump-01	407	60	0.89	37.64	19.5	42.5	49.8
(-15) Secondary Pump-01	407	44.4	1	31.29	0	31.2	49.9
(+5) Secondary Pump-04	411	52.8	0.89	33.45	17.4	32.8	49.9
(-40) Secondary Pump-02	401	51.6	0.89	31.89	16.2	35.6	49.9
	V	**I**	**PF**	**KW**	**kVAR**	**kVA**	**Hz**
(-15) Primary Pump-02	415	59.2	0.9	38.29	18.7	41.9	49.9
(+5) Secondary Pump-01	409	53.5	0.86	32.59	19.2	38	49.9
(+5) Primary Pump-01	412	50.1	0.83	29.67	20.2	35.6	50
Service Block-02							
(-15) 450TR 1A	417	383	0.81	224.06	162	277	49.9
(-15) 450TR 1B	410	379	0.88	236.84	130	272	50
(+5) Chiller-01	413	350	0.97	242.85	30.8	253	50.1
Air Compressor	418	129	0.88	82.19	44.8	93.2	50
(+5) Secondary Pump-03	418	25	0.95	17.19	5.82	18	49.9
(+5) Secondary Pump-02	417	13.5	0.99	9.65	1.37	9.74	49.9
(-15) Primary Pump-01	416	15.3	0.82	9.04	6.36	11.1	49.9
(-15) Primary Pump-02	415	14.2	0.87	8.88	4.95	10.2	49.9
(-15) Secondary Pump-01	415	26.1	0.99	18.57	2.28	18.8	49.9
(+5) Secondary Pump-01	423	34.1	0.85	21.24	13.3	25	50
(-15) Secondary Pump-02	421	50.2	0.48	17.57	18.3	21.1	50
(+5) Primary Pump-02	416	10.9	0.45	3.53	7.02	7.84	50
(-15) Secondary Pump-05	410	40	0.89	25.28	13.1	28.5	50
(-15) Secondary Pump-04	408	54.7	0.89	34.40	17.3	38.5	49.9
(+5) Secondary Pump-05	406	27.9	0.99	19.42	2.9	19.8	49.9
Service Block-03							
(-15)-04,1B	406	480	0.92	310.53	134	337	49.9
(+5) 02 2A & B	408	349	0.97	239.22	57.8	247	49.9
(+5) 02 2A	409	212	0.92	138.16	58.9	150	49.9
(+5) 02 2B	408	213	0.92	138.47	48.8	150	49.9
Air Compressor-01	409	77.2	0.96	52.50	16.3	56.3	49.9
Air Compressor-02	409	40.9	0.88	25.49	13.9	29.1	49.9
Evaporator Condenser	405	35.5	0.68	16.93	18.2	24.8	49.8
Air Comp-01(Nitrogen Plant)	400	170	0.85	100.11	61.8	119	49.8

(-40) Chiller-1B	412	160	0.89	101.61	51.3	115	49.9
(-40) Chiller- Booster1B	413	137	0.9	88.19	42	98.3	49.9
(-40) PP-01	412	34.9	0.9	22.41	11.7	24.8	49.9
	V	**I**	**PF**	**KW**	**kVAR**	**kVA**	**Hz**
(+5) SP-03(H7)	411	27.1	0.9	17.36	8.56	19.2	49.8
(+5) SP-01(H7)	407	60	0.89	37.64	119.5	42.5	49.8
(-15) SP-02	404	44.4	1	31.06	0	31.2	49.8
(+5) SP-04	411	52.8	0.89	33.45	17.4	37.8	49.8
(-40) sp-02	401	51.6	0.89	31.89	16.4	35.6	49.9
(-15) pp-02	415	59.2	0.9	38.29	18.7	41.9	49.9
(+5) sp-01 h10	409	53.5	0.86	32.59	19.2	38	49.9
(+5) PP-01	412	50.1	0.83	29.67	20.2	35.6	49.9
Service Block-04							
(-40) Comp Hi Stage	408	324	0.96	219.7983	684	229	49.9
(-40) Comp Booster-2	417	118	0.89	75.85006	38.5	85	50
(-15) Comp 2B	406	295	1	207.4416		209	50
(-15) Comp 2A	406	317	0.98	218.4536	44.2	225	50
(-15) Comp 1A	408	439	0.99	307.1198	45.7	309	49.9
(-15) primary pump 2	417	41.5	0.85	25.47716	15.7	29.6	49.9
(-15) primary pump 1	411	48.2	0.91	31.22325	14	34.2	49.9
(-40) primary pump 1	410	34.9	0.9	22.30487	0	125	49.9
(-15) Secondary pump 1	410	51	0.83	30.05938	18	35.8	49.9
(-15) Secondary pump 2	413	47.1	0.32	10.78124	31.8	33.6	49.9
(-40) Secondary pump 2	412	39.3	0.93	26.08078	10.5	28	49.9
Service Block - 05							
(-15) Chiller	420	175	0.91	115.84	52.7	128	50
CT Fan	420	15.3	0.68	7.57	8.13	11.1	50
Circulating Pump	419	4.81	0.94	3.28	1.13	3.4	50
Primary pump-02	405	25.1	0.89	15.67	8.25	18.2	50
(+5) Secondary Pump-01	421	30.1	0.76	16.68	14.3	22.1	50
VAM-01(Cooling Water Pump)	421	62.5	0.85	38.74	23.9	45.4	50
VAM-02(Cooling Water Pump)	422	61.4	0.87	39.04	22.4	44.9	50
VAM-01(Chilled Water Pump)	415	29.9	0.89	19.13	9.93	21.6	50
VAM-02(Chilled Water Pump)	419	27.2	0.89	17.57	8.88	19.8	50

VAM-02(Cooling tower fan)	420	13.9	0.56	5.66	7.84	9.51	50
VAM-01(Cooling tower fan)	420	18.6	0.78	10.55	8.57	13.6	50
(+5) Secondary Pump-03	421	56.1	0.89	36.41	19	40.5	50
(+5) Secondary Pump-02	421	45.8	0.89	29.72	15.3	33.4	50
VAM(+5) Secondary Pump-01 SRS-1	420	34.2	0.86	21.40	12.6	24.8	50
VAM(+5) Secondary Pump-02 SRS-1	421	34	0.83	20.58	13.9	24.9	50.1
Air Compressor	419	21.9	0.91	14.46	6.75	16.1	50
Service Block-06							
(-40) Comp Hi Stage	408	324	0.96	219.80	684	229	49.9
(-40) Comp Booster-2	417	118	0.89	75.85	38.5	85	50
(-15) Comp 2B	406	295	1	207.44		209	50
(-15) Comp 2A	406	317	0.98	218.45	44.2	225	50
(-15) Comp 1A	408	439	0.99	307.12	45.7	309	49.9
(-15) primary pump 2	417	41.5	0.85	25.48	15.7	29.6	49.9
(-15) primary pump 1	411	48.2	0.91	31.22	14	34.2	49.9
(-40) primary pump 1	410	34.9	0.9	22.30	0	125	49.9
(-15) Secondary pump 1	410	51	0.83	30.06	18	35.8	49.9
(-15) Secondary pump 2	413	47.1	0.32	10.78	31.8	33.6	49.9
(-40) Secondary pump 2	412	39.3	0.93	26.08	10.5	28	49.9

Table 300:Power Measurements of HLL-09

Annexure Power Measurements Honour Lab

	V	I	PF	KW	kVAR	kVA	Hz
Pharma-2H6/AHU(S)-05	415	5.41	0.98	3.81	0.78	3.93	50
Pharma-3 A Block(AHU(S)-08/PHA-3	415	4.61	0.99	3.28	0.388	3.44	50
Pharma-4 A Block/AHU(S)	416	4.32	1	3.11	0	3.11	50
Pharma-5 A Block(AHU(S)-05/PHA-5	414	4.01	0.56	1.61	2.32	2.84	50
Pharma-6 A Block(AHU(S)/PHA-6	414	7.92	0.87	4.94	2.77	5.68	50
Pharma 8	413	5.24	0.97	3.63	0.8	3.75	50
Crystallizer-V AHU(S)-13	416	1.45	0.99	1.03	0.1	1.03	50
Crystallizer-I AHU(S)-01	411	8.73	0.92	5.71	2.92	6.23	49.9
Crystallizer-II AHU(S)-04	414	7.05	0.74	3.74	3.42	5.05	50
Crystallizer-IV	413	6.94	0.85	4.21	2.54	4.79	50
Crystallizer-VII	413	3.98	0.85	2.41	1.49	2.85	50
Crystallizer-VI	412	4.41	0.89	2.80	1.46	3.13	50
CT-Pump-02	413	12.4	0.98	8.69	1.86	8.89	50
CT Fan	415	18.6	0.8	10.69	7.92	13.3	50
Wet Section 1/AHU(S)-3	415	8.77	0.84	5.29	3.43	6.29	50
Wet Section 12/AHU(S)-6	412	8.13	0.81	4.69	1.33	2.62	50
Wet Section(3)/AHU(S)-12	415	7.7	0.8	4.42	3.26	5.46	50
AHU(S) 20 Corridor G-F(South)	405	4.06	0.69	1.96	2.07	2.9	50.1
AHU(S) 20 Corridor G-F(East)	403	4.59	0.55	1.76	2.67	3.23	50.1
Wet Section-IV/AHU(S)-19	410	9.4	0.59	3.93	5.67	6.91	50
Wet Section-V/AHU(S)-15	411	8.21	0.28	1.63	5.29	5.81	49.9
Wet Section-VI/AHU(S)-17	409	3.46	0.83	2.03	1.43	2.43	50
Wet Section-VII/AHU(S)-9	407	3.89	0.84	2.30	1.5	2.73	50
Corridor Ist	412	7.84	0.77	4.30	3.53	5.55	50

	V	I	PF	KW	kVAR	kVA	Hz
AHU(21)-South							
Corridor Ist AHU(21)-East	411	6.19	0.7	3.08	3.13	4.35	50
Air/Comp-002	415	17.6	0.66	8.34	9.53	12.6	50
Air/Comp-003	411	123	0.75	65.60	54.9	87.2	50.1
Br.Air/Commp-001	415	15.2	0.55	6.00	9.08	10.9	50.2
H9/SSR-005	410	4.68	0.31	1.03	3.22	3.37	50.1
H9/GLR-004	419	3.25	0.28	0.66	2.25	2.36	50
H9/GLR-003	416	3.26	0.31	0.72	2.22	2.34	49.9
H9/SSR-006	417	3	1	2.16	2.07	2.08	49.9

Table 301:Power Measurements of Honour Lab

Annexure-Power Measurements Captive Power Plant

	V	I	PF	KW	kVAR	kVA	Hz
Main Incomer	425.9	125.3	0.907	83.83			
BFP-2	415	364	0.92	240.71	103	268	49.9
FD Fan	423	337	0.98	241.96	44.8	248	49.9
Total ESP	424	28.7	0.84	17.70	11.4	21.2	49.9
Complete Lighting	424	5.22	0.64	2.45	2.92	3.85	50
Water Treatment Plant	423	85.1	0.84	52.37	33.7	62.4	50
Boiler Complete auxiliaries	423	196	0.82	117.75	82.4	144	50.1
Turbine Complete auxiliaries	423	14	0.54	5.54	8.68	10.3	50.1
AFBC	423	210	0.88	135.39	72.6	151	50
PA Fan	413	101	0.67	48.41	55.4	74.1	50.1
ID Fan	423	140	0.99	101.54	13.1	83.3	49.9
Instrument Air Compressor	422	12.2	0.84	7.49	4.88	9	49.9
Unloading Power Service Air Compressor	424	40.7	0.62	18.53	22.5	28.5	49.9
Loading Power Service Air Compressor	421	78.5	0.88	50.37	27.9	57.8	49.9
CT Fan	424	13	0.98	9.36	1.03	9.55	49.9

Table 302:Power Measurements of Captive Power Plant

Annexure-Power Measurements ETP

	V	I	PF	KW
MEE-II	410.7	208	0.99	145.98
RT pump-01	414.8	47.6	0.89	30.44
RT pump-02	410.14	45.6	0.87	28.18
MEE-I(CT Pump-01)	409.4	34.5	0.83	20.30
MEE-I(CT Pump-02)	409.2	34.5	0.82	20.05
MEE-I(CT Pump-03)	408.6	32.5	0.9	20.70
ATFD	414.4	27.5	0.4	7.90
STP	415	19.9	0.73	10.44
Air Blower-02	408.4	32.5	0.88	20.23
Aerator-02	413	23.7	0.72	12.21
Aerator-03	410.9	31.1	0.79	17.49
Aerator-04	412.9	27.6	0.75	14.80
Aerator-06	413.3	24.9	0.66	11.76
Aerator-08	411.7	25.9	0.76	14.04
Aerator-09	412.2	29.1	0.76	15.79
Aerator-10	412.1	23.8	0.73	12.40
Aerator-11	412.6	25.7	0.74	13.59
Aerator-12	412.2	29.2	0.9	18.76
Aerator-13	393.7	26.7	0.67	12.20
Aerator-14	412.9	25.8	0.67	12.36
Aerator-16	411.4	27.2	0.76	14.73

Table 303:Power Measurements of ETP

Annexure-Power Measurements HDL-09

	V	I	Pf	KW
A Block MCC-01	419.7	86.53	0.77	48.43
B Block MCC-02	422.2	70.54	0.69	35.59
(-15) Chiller-2B	421.8	145.5	0.82	87.16
B Block MCC-01	421.6	92.64	0.91	61.56
D Block MCC-01	416.2	178.4	0.96	123.46
QC Block MCC-0	418.1	215.8	0.98	153.15
(-15) Chiller-1B	417.2	183.7	0.87	115.48
A Block MCC-02	416.9	206.2	0.94	139.96
Utility MCC-01	415	50.89	0.97	35.48
Utility MCC-02	413.6	436.7	0.97	303.45
Ware House MCC-01	416.6	33.38	0.74	17.82
Pharma ComplexMCC-01 & 02	415.8	187.3	0.97	130.84
IDS MCC-01	414.7	39.17	0.63	17.72
(-15) Comp-1A	423.2	227.9	0.9	150.34
(-15) Comp-2A	422.1	168.3	0.88	108.28
(-15) Comp-1B	420.4	211	0.91	139.81
(-15) Secondary pump-09	405.5	19.8	0.98	13.63
(-15) Primary Pump	411.4	12.8	0.99	9.03
Air Compressor-02	410.1	90.68	0.87	56.04
Air Compressor-01	409.8	96.55	0.82	56.19
Purified Water Plant	411.5	45.89	0.798	26.10
PA/AHU-03	420	9.7	0.93	6.56
PA/AHU-06	420.9	10.8	0.72	5.67
PA/AHU-08	421.5	10.4	0.84	6.38
PA/AHU-09	420.3	8.6	0.78	4.88
PA/AHU-12	418.2	8.9	0.76	4.90
PA/AHU-13	419.8	7.4	0.82	4.41

Table 304:Power Measurements of HDL-09

Lab Reports

Form 5.10 A-TRP v04

LUCID Laboratories Pvt. Ltd.
Testing to the Core

B-1/A, T.I.E., Phase-II,
Balanagar, Hyderabad-500 037
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Fax: +91-40 2372 0406
E-mail: info@lucidlabsindia.com
Web: www.lucidlabsindia.com

TEST REPORT

Issued to:
HETERO CORPORATE,
#7-2-A2, Industrial Estates,
Sanath Nagar,
Hyd-500018.

Report No.: LLPL/17-18/000230
Issue Date: 15th April, 2017.
Customer Ref.: Letter
Ref .Date: 08th April, 2017.

Sample Particulars: Econominer-11/3/17, 3.00PM.

Qty.: 1 No(200g), Packing: packed in polythene cover.
Test Reqd: Loss on Ignition, Unburnt carbon & Gross calorific value.
Dt. of receipt of sample : 08th April, 2017.
Dt. of starting of analysis : 08th April, 2017.
Dt. of completion of analysis : 14th April, 2017.

TEST RESULTS

S.No	Test parameters	UOM	Results
1	Loss on Ignition	%by mass	40.19
2	Unburnt carbon	%by mass	36.86
3	Gross calorific value	K.Cal/Kg	2840

Test Method: IS: 1350.
Note-1: The above results are as on received basis.
2:The report and results relate only to the samples/items tested.

Page 1 of 1

S.Satyanarayana
Authorized Signatory

Note: This report is subject to the terms and conditions mentioned overleaf

141195

Form 5.10 A-TRP v04

LUCID Laboratories Pvt. Ltd.
Testing to the Core

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TEST REPORT

Issued to:
HETERO CORPORATE,
#7-2-A2, Industrial Estates,
Sanath Nagar,
Hyd-500018.

Report No.: LLPL/17-18/000231
Issue Date: 15th April, 2017.
Customer Ref.: Letter
Ref.Date: 08th April, 2017.

Sample Particulars: APH-11/3/17, 3.00PM.

Qty.: 1 No(200g), Packing: packed in polythene cover.
Test Reqd: Loss on Ignition, Unburnt carbon & Gross calorific value.
Dt. of receipt of sample : 08th April, 2017.
Dt. of starting of analysis : 08th April, 2017.
Dt. of completion of analysis : 14th April, 2017.

TEST RESULTS

S.No	Test parameters	UOM	Results
1	Loss on Ignition	%by mass	46.33
2	Unburnt carbon	%by mass	41.00
3	Gross calorific value	K.Cal/Kg	3290

Test Method: IS: 1350.
Note-1: The above results are as on received basis.
2: The report and results relate only to the samples/items tested.

Page 1 of 1

S.Satyanarayana
Authorized Signatory

Note: This report is subject to the terms and conditions mentioned overleaf

141196

Form 5.10 A-TRP v04

LUCID Laboratories Pvt. Ltd.
Testing to the Core

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TEST REPORT

Issued to:
HETERO CORPORATE,
≠7-2-A2, Industrial Estates,
Sanath Nagar,
Hyd-500018.

Report No.: LLPL/17-18/000228
Issue Date: 15th April, 2017.
Customer Ref.: Letter
Ref .Date: 08th April, 2017.

Sample Particulars: Coal Sample-5.

Qty.: 1 No(500g), Packing: packed in polythene cover.
Test Reqd: Proximate analysis, Gross calorific value & Ultimate analysis.
Dt. of receipt of sample : 08th April, 2017.
Dt. of starting of analysis : 08th April, 2017.
Dt. of completion of analysis : 14th April, 2017.

TEST RESULTS

S.No	Test parameters	UOM	Results
I	**Proximate Analysis**		
1	Moisture	%by mass	30.66
2	Ash	%by mass	7.48
3	Volatile matter	%by mass	36.04
4	Fixed carbon	%by mass	25.82
5	Gross calorific value	K.Cal/Kg	3720
II	**Ultimate Analysis**		
1	Moisture	%by mass	30.66
2	Mineral Matter	%by mass	8.02
3	Carbon as C	%by mass	47.36
4	Hydrogen as H	%by mass	3.39
5	Nitrogen as N	%by mass	0.70
6	Sulphur as S	%by mass	0.55
7	Oxygen as O	%by mass	9.32

Test Method: IS: 1350.
Note-1: The above results are as on received basis.
2: The report and results relate only to the samples/items tested.

Page 1 of 1

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Authorized Signatory

141763

Note: This report is subject to the terms and conditions mentioned overleaf

Form 5.10 A-TRP v04

LUCID Laboratories Pvt. Ltd.
Testing to the Core

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TEST REPORT

Issued to:
HETERO CORPORATE,
≠7-2-A2, Industrial Estates,
Sanath Nagar,
Hyd-500018.

Report No.: LLPL/17-18/000227
Issue Date: 15th April, 2017.
Customer Ref.: Letter
Ref .Date: 08th April, 2017.

Sample Particulars: Coal Sample-3.

Qty.: 1 No(500g), Packing: packed in polythene cover.
Test Reqd: Proximate analysis, Gross calorific value & Ultimate analysis.
Dt. of receipt of sample : 08th April, 2017.
Dt. of starting of analysis : 08th April, 2017.
Dt. of completion of analysis : 14th April, 2017.

TEST RESULTS

S.No	Test parameters	UOM	Results
I	**Proximate Analysis**		
1	Moisture	%by mass	30.52
2	Ash	%by mass	8.50
3	Volatile matter	%by mass	33.23
4	Fixed carbon	%by mass	27.75
5	Gross calorific value	K.Cal/Kg	3910
II	**Ultimate Analysis**		
1	Moisture	%by mass	30.52
2	Mineral Matter	%by mass	9.35
3	Carbon as C	%by mass	46.33
4	Hydrogen as H	%by mass	3.52
5	Nitrogen as N	%by mass	0.41
6	Sulphur as S	%by mass	1.01
7	Oxygen as O	%by mass	8.86

Test Method: IS: 1350.
Note-1: The above results are as on received basis.
2: The report and results relate only to the samples/items tested.

Page 1 of 1

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Note: This report is subject to the terms and conditions mentioned overleaf

141762

LUCID Laboratories Pvt. Ltd.
Testing to the Core

Form 5.10 A-TRP v04

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E-mail: info@lucidlabsindia.com
Web: www.lucidlabsindia.com

TEST REPORT

Issued to:
HETERO CORPORATE,
≠7-2-A2, Industrial Estates,
Sanath Nagar,
Hyd-500018.

Report No.: LLPL/17-18/000226
Issue Date: 15th April, 2017.
Customer Ref.: Letter
Ref .Date: 08th April, 2017.

Sample Particulars: Coal Sample-1.

Qty.: 1 No(500g), Packing: packed in polythene cover.
Test Reqd: Proximate analysis, Gross calorific value & Ultimate analysis.
Dt. of receipt of sample : 08th April, 2017.
Dt. of starting of analysis : 08th April, 2017.
Dt. of completion of analysis : 14th April, 2017.

TEST RESULTS

S.No	Test parameters	UOM	Results
I	**Proximate Analysis**		
1	Moisture	%by mass	33.05
2	Ash	%by mass	6.90
3	Volatile matter	%by mass	33.57
4	Fixed carbon	%by mass	26.48
5	Gross calorific value	K.Cal/Kg	3860
II	**Ultimate Analysis**		
1	Moisture	%by mass	33.05
2	Mineral Matter	%by mass	7.59
3	Carbon as C	%by mass	45.47
4	Hydrogen as H	%by mass	3.29
5	Nitrogen as N	%by mass	0.42
6	Sulphur as S	%by mass	0.48
7	Oxygen as O	%by mass	9.70

Test Method: IS: 1350.
Note-1: The above results are as on received basis.
2: The report and results relate only to the samples/items tested.

Page 1 of 1

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141761

Annexure Lighting Inventory details of HLL-03

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Wattage	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty (Nos)	Total connected load (kW)
1	A	FTL ZONE-I	2x36w	TLD	2	80	61	4.9
2	A	FTL ZONE-I	2x18w	TLD	2	44	14	0.6
3	A	WELL GLASS	2x23w	CFL	2	46	23	1.1
4	A	STREET LIGHT FITTING	250w	HPSV	1	270	10	2.7
5	B	FTL ZONE-I	2x36w	TLD	2	80	60	4.8
6	B	FTL ZONE-I	2x18w	TLD	2	44	20	0.9
7	B	WELL GLASS	2x23w	CFL	2	46	16	0.7
8	B	STREET LIGHT FITTING	250w	HPSV	1	270	6	1.6
9	C	FTL ZONE-I	2x36w	TLD	2	80	35	2.8
10	C	FTL ZONE-I	2x18w	TLD	2	44	33	1.5
11	C	WELL GLASS	2x23w	CFL	2	46	5	0.2
12	C	STREET LIGHT FITTING	250w	HPSV	1	270	10	2.7
13	D	FTL ZONE-I	2x36w	TLD	2	80	1	0.1
14	D	WELL GLASS	2x23w	CFL	2	46	72	3.3
15	D	STREET LIGHT FITTING	250w	HPSV	1	270	7	1.9
16	E	FTL ZONE-I	2x36w	TLD	2	80	45	3.6

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Wattage	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty (Nos)	Total connected load (kW)
17	E	FTL ZONE-I	2x18w	TLD	2	44	40	1.8
18	E	WELL GLASS	2x23w	CFL	2	46	15	0.7
19	E	STREET LIGHT FITTING	250w	HPSV	1	270	8	2.2
20	G	FTL ZONE-I	2x36w	TLD	2	80	41	3.3
21	G	FTL ZONE-I	2x18w	TLD	2	44	37	1.6
22	G	STREET LIGHT FITTING	250w	HPSV	1	270	6	1.6
23	H	WELL GLASS	2x23w	CFL	2	46	141	6.5
24	H	FTL ZONE-I	2x36w	TLD	2	80	12	1.0
25	H	STREET LIGHT FITTING	250w	HPSV	1	270	6	1.6
26	I	WELL GLASS	2x23w	CFL	2	46	150	6.9
27	I	STREET LIGHT FITTING	250w	HPSV	1	270	10	2.7
28	J	WELL GLASS	2x23w	CFL	2	46	50	2.3
29	J	FTL ZONE-I	2x36w	TLD	2	80	14	1.1
30	J	FTL ZONE-I	2x18w	TLD	2	44	5	0.2
31	K	WELL GLASS	2x23w	CFL	2	46	8	0.4
32	K	FTL ZONE-I	2x36w	TLD	2	80	48	3.8
33	K	FTL ZONE-I	2x18w	TLD	2	44	26	1.1

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Wattage	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty (Nos)	Total connected load (kW)
34	K	STREET LIGHT FITTING	250w	HPSV	1	270	7	1.9
35	L	WELL GLASS	2x23w	CFL	2	46	147	6.8
36	L	STREET LIGHT FITTING	250w	HPSV	1	270	9	2.4
37	M	FTL ZONE-I	2x36w	TLD	2	80	47	3.8
38	M	FTL ZONE-I	2x18w	TLD	2	44	33	1.5
39	M	WELL GLASS	2x23w	CFL	2	46	13	0.6
40	M	FTL ZONE-II	2x36w	TLD	2	80	14	1.1
41	M	FTL ZONE-II	2x18w	TLD	2	44	13	0.6
42	M	STREET LIGHT FITTING	250w	HPSV	1	270	9	2.4
43	N	WELL GLASS	2x23w	CFL	2	46	182	8.4
44	N	STREET LIGHT FITTING	250w	HPSV	1	270	12	3.2
45	Q	FTL ZONE-I	2x36w	TLD	2	80	40	3.2
46	Q	FTL ZONE-I	2x18w	TLD	2	44	27	1.2
47	Q	FTL ZONE-I	2x18w	TLD	2	44	10	0.4
48	Q	WELL GLASS	2x23w	CFL	2	46	21	1.0
49	Q	STREET LIGHT FITTING	250w	HPSV	1	270	9	2.4
50	PA	FTL ZONE-II	2x36w	TLD	2	80	25	2.0

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Wattage	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty (Nos)	Total connected load (kW)
51	PA	FTL ZONE-II	2x36w	TLD	2	80	87	7.0
52	PA	FTL ZONE-II	2x18w	TLD	2	44	38	1.7
53	PB	FTL ZONE-II	2x36w	TLD	2	80	23	1.8
54	PB	FTL ZONE-II	2x36w	TLD	2	80	90	7.2
55	PB	FTL ZONE-II	2x18w	TLD	2	44	77	3.4
56	PB	STREET LIGHT FITTING	250w	HPSV	1	270	5	1.4
57	QCD-I	2x2	2x36w	CFL	2	82	95	7.8
58	QCD-I	1x1	2x18w	CFL	2	56	15	0.8
59	QCD-I	STREET LIGHT FITTING	250W	HPSV	1	270	4	1.1
60	QCD-II	FTL ZONE-II	2x36w	TLD	2	80	26	2.1
61	QCD-II	FTL ZONE-II	2x18w	TLD	2	44	28	1.2
62	QCD-II	well glass	2x23w	CFL	2	46	2	0.1
63	QCD-II	1X1	2x18w	CFL	2	56	2	0.1
64	QCD-II	STREET LIGHT FITTING	250w	HPSV	1	270	3	0.8
65	DCB-I	FTL ZONE-I	2x36w	TLD	2	80	42	3.4
66	DCB-I	FTL ZONE-I	2x23w	TLD	2	44	20	0.9
67	DCB-I	STREET LIGHT FITTING	250w	HPSV	1	270	10	2.7

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Wattage	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty (Nos)	Total connected load (kW)
68	DCB-I	FLP FLOOD LIGHT	400w	HPMV	1	420	6	2.5
69	UTB	STREET LIGHT FITTING	250w	HPSV	1	270	21	5.7
70	IDS	STREET LIGHT FITTING	250w	HPSV	1	270	3	0.8
71	ADMIN	2x2	2x36w	CFL	2	82	50	4.1
72	ADMIN	1x1	2x18w	CFL	2	56	58	3.2
73	HR	STREET LIGHT FITTING	250w	HPSV	1	270	8	2.2
74	Ware house	FTL ZONE-I	2x36w	TLD	2	80	85	6.8
75	Ware house	FTL ZONE-I	2x18w	TLD	2	44	26	1.1
76	Ware house	STREET LIGHT FITTING	250w	HPSV	1	270	10	2.7
77	Ware house	FLP FLOOD LIGHT	400w	HPMV	1	420	4	1.7
78	UTB-1	IND.LUMINAIRE	36w	TLD	2	80	30	2.4
79	UTB-1	IND.LUMINAIRE	36w	TLD	1	44	15	0.7
80	UTB-2	IND.LUMINAIRE	36w	TLD	2	80	38	3.0
81	UTB-2	IND.LUMINAIRE	36w	TLD	1	44	12	0.5
82	UTB-4	2x2 SM	36w	CFL	2	82	12	1.0
83	UTB 1&2	STREET LIGHT FITTING	250w	HPSV/MH	1	270	26	7.0

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Wattage	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty (Nos)	Total connected load (kW)
84	Fabrication	STREET LIGHT FITTING	250w	HPSV	1	270	35	9.5
85	Hostel	Box type	28w	TL5	1	33	200	6.6
86	Hostel	STREET LIGHT FITTING	250w	HPSV	1	270	16	4.3

Table 305:Lighting Inventory of HLL-03

Annexure Lighting Inventory Details HLL-09

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
1	HLL-IX POWER HOUSE	TUBE LIGHT SET 2X36	TL8	2	80.3	12	1.0
2	HLL-IX RO PLANT	2X2 FITTING	PL-L	3	126.0	4	0.5
3	A-BLOCK	WELL GLASS FITTING	CFL	1	45.0	152	6.8
4	A-BLOCK	TUBE LIGHT SET 1X36	TL8	1	44.3	8	0.4
5	B-BLOCK	WELL GLASS FITTING	CFL	1	45.0	143	6.4
6	B-BLOCK	TUBE LIGHT SET 2X36	TL8	2	84.0	8	0.7
7	SERVICE BLOCK	STREET LIGHTS	SON	1	278.4	3	0.8
8	SERVICE BLOCK	TUBE LIGHT SET 1X36	TL8	1	44.3	20	0.9
9	SOLVENT YARD	WELL GLASS FITTING	CFL	1	45.0	18	0.8
10	WARE HOUSE	WELL GLASS FITTING	CFL	1	45.0	16	0.7
11	WARE HOUSE	2X36W FLP FITTING	PL-L	2	84.0	58	4.9
12	WARE HOUSE	2X2 FITTING	PL-L	3	126.0	22	2.8

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
13	DRUM YARD	WELL GLASS FITTING	CFL	1	45.0	16	0.7
14	PHARMA-1	WELL GLASS FITTING	CFL	1	45.0	20	0.9
15	PHARMA-1	2X36W FLP FITTING	PL-L	2	84.0	145	12.2
16	PHARMA-1	TUBE LIGHT SET 2X36	TL8	2	84.0	4	0.3
17	PHARMA-II	WELL GLASS FITTING	CFL	1	45.0	12	0.5
18	WAREHOUSE-II	WELL GLASS FITTING	CFL	1	45.0	4	0.18
19	CANTEEN	WELL GLASS FITTING	CFL	1	45.0	10	0.45
20	CANTEEN	2X2 FITTING	PL-L	2	84.0	50	4.20
21	CANTEEN	2X2 FITTING	PL-L	3	126.0	8	1.01
22	CANTEEN	1X1 FITTING	PL-L	2	42.0	8	0.34
23	CANTEEN	TUBE LIGHT SET 2X36	TL8	2	84.0	9	0.76
24	CANTEEN	STREET LIGHTS	SON	1	278.4	2	0.56
25	QA & QC BUILDING	WELL GLASS FITTING	CFL	1	45.0	16	0.72
26	QA & QC BUILDING	1X1 FITTING	PL-L	2	42.0	22	0.92

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
27	QA & QC BUILDING	2X2 FITTING	PL-L	16	84.0	16	1.34

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
1	HLL-IXA Power House	TUBE LIGHT SET 2X36	TL8	2	80.3	11	0.9
2	Service Bock--II	TUBE LIGHT SET 2X36	TL8	2	80.3	12	1.0
3	Service Bock-II	WELL GLASS FITTING	CFL	1	45.0	3	0.1
4	SERVICE BLOCK-II	STREET LIGHTS	SV	1	278.4	2	0.6
5	Service Bock-IV	WELL GLASS FITTING	CFL	1	45.0	13	0.6
6	9A Street Light	STREET LIGHTS	SV	1	278.4	16	4.5
7	Engineering Office	TUBE LIGHT SET 2X36	TL8	2	80.3	4	0.3
8	H4 Block	WELL GLASS FITTING	CFL	1	45.0	41	1.8
9	H4 Block	WELL GLASS FITTING	CFL	1	23.0	14	0.3
10	H4 Block	TUBE LIGHT SET 2X36	TL8	2	80.3	10	0.8
11	H2 Block	WELL GLASS FITTING	CFL	1	45.0	33	1.5

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
12	H2 Block	WELL GLASS FITTING	CFL	1	23.0	5	0.1
13	H2 Block	TUBE LIGHT SET 2X36	TL8	2	80.3	4	0.3
14	D block	WELL GLASS FITTING	CFL	1	45.0	53	2.4
15	D block	WELL GLASS FITTING	CFL	2	23.0	9	0.2
16	D block	TUBE LIGHT SET 2X36	TL8	2	80.3	4	0.3
17	H3 Block	WELL GLASS FITTING	CFL	1	45.0	53	2.4
18	H3 Block	WELL GLASS FITTING	CFL	2	23.0	11	0.3
19	H3 Block	TUBE LIGHT SET 2X36	TL8	2	80.3	4	0.3
20	H7 Block	WELL GLASS FITTING	CFL	1	23.0	24	0.6
21	H7 Block	WELL GLASS FITTING	CFL	1	45.0	9	0.4
22	H 7 Block MCC Room	**TUBE LIGHT SET 1X36**	TL8	2	44.3	**14**	0.6
23	Pharma -3	TUBE LIGHT SET 2X36	TL8	2	80.3	3	0.2
24	9A DM Plant	**TUBE LIGHT SET 1X36**	TL8	2	44.3	**13**	0.6
25	9A DM Plant	TUBE LIGHT SET 2X36	TL8	2	80.3	13	1.0

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
1	HLL-IXB POWER HOUSE	TUBE LIGHT SET 2X36	TL8	2	80.3	4	0.3
2	H10-BLOCK	WELL GLASS FITTING	CFL	1	45.0	12	0.5
3	H10-BLOCK	WELL GLASS FITTING	CFL	1	23.0	9	0.2
4	H10 SOLVENTYARD MCC	TUBE LIGHT SET 2X36	TL8	2	80.3	1	0.1
5	H10 SOLVENTYARD MCC	2X36W FITTING	CFL	2	84.0	2	0.2
6	H10 MCC	TUBE LIGHT SET 2X36	TL8	2	80.3	5	0.4
7	H10 MCC	2X36W FITTING	CFL	2	84.0	2	0.2
8	SERVICE BLOCK	2X36W FITTING	CFL	2	84.0	4	0.3
9	SERVICE BLOCK	STREET LIGHTS	SON	1	278.4	2	0.6
10	FABRICATION SHED	WELL GLASS FITTING	CFL	1	45.0	14	0.6
11	FABRICATION SHED	TUBE LIGHT SET 2X36	TL8	2	80.3	1	0.1
12	FABRICATION SHED	STREET LIGHTS	SON	1	278.4	4	1.1

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
13	Bridge Line	STREET LIGHTS	SON	1	278.4	4	1.1
S.No	**Area / Block**	**Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc**	**Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)**	**No. of lamps per light fitting**	**System wattage (including choke)**	**Qty(Nos)**	**Total connected load (kW)**
1	HLL-IX POWER HOUSE	TUBE LIGHT SET 2X36	TL8	2	80.3	10	0.8
2	HLL-IX POWER HOUSE	TUBE LIGHT SET 1X36	TL8	1	44.3	5	0.2
3	HLL-IX POWER HOUSE	STREET LIGHTS	SV	1	278.4	1	0.3
4	SERVICE BLOCK	TUBE LIGHT SET 2X36	TL8	2	80.3	9	0.7
5	SERVICE BLOCK	STREET LIGHTS	SV	1	278.4	5	1.4
6	SRS I	WELL GLASS FITTING	CFL	1	23.0	85	2.0
7	SRS I	WELL GLASS FITTING	CFL	1	45.0	20	0.9
8	SRS I	TUBE LIGHT SET 1X36	TL8	1	44.3	1	0.04
9	SRS I	STREET LIGHTS	MV	1	442.0	2	0.9
10	SRS I	STREET LIGHTS	SV	1	278.4	1	0.3
11	SRS I SOLVENT YARD	STREET LIGHTS	MV	1	442.0	3	1.3

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
12	SRS I SOLVENT YARD	STREET LIGHTS	SV	1	278.4	2	0.6
13	SRS I SOLVENT YARD	WELL GLASS FITTING	CFL	1	45.0	1	0.05
14	SRS II SOLVENT YARD	STREET LIGHTS	SV	1	278.4	6	1.67
15	SRS II SOLVENT YARD	STREET LIGHTS	MV	1	442.0	1	0.44
16	SRS II	WELL GLASS FITTING	CFL	1	45.0	1	0.05
17	SRS II MCC ROOM	TUBE LIGHT SET 2X36	TL8	2	80.3	3	0.24
18	H12 MCC ROOM	2X18W FLP FITTING	ZONE I	2	41.0	3	0.12
19	WARE HOUSE - 04	WELL GLASS FITTING	CFL	1	23.0	19	0.44
20	WARE HOUSE - 04	WELL GLASS FITTING	CFL	1	45.0	26	1.17
21	CANTEEN	STREET LIGHTS	MV	1	278.4	4	1.11
22	CANTEEN	TUBE LIGHT SET 2X36	TL8	2	80.3	10	0.80
23	CANTEEN	2X18W FLP FITTING	ZONE II	2	41.0	6	0.25
24	CANTEEN	WELL GLASS FITTING	CFL	2	46.0	1	0.05
25	SRS QC	2X36W FLP FITTING	ZONE II	2	80.3	5	0.40

S.No	Area / Block	Existing Luminaire Type like 2X2 / 1X1 /Down Light / Tube etc	Lamp Type (TLD/TL5/CFL/SON/Mercury/Metal Halide)	No. of lamps per light fitting	System wattage (including choke)	Qty(Nos)	Total connected load (kW)
26	SRS QC	2X18W FLP FITTING	ZONE II	2	41.0	10	0.41

Table 306:Lighting Inventory of HLL-09

Annexure: IEEE Standards for Harmonic Distortion for Current and Voltage limits

Currentdistortionlimitsforgeneraldistributionsystemsend-userlimits (120Vthrough69,000V)

Maximum Harmonic Current Distortion in Percent of IL						
Individual Harmonic Order (Odd Harmonics)						
Isc/k	<11	ll:'.Sh<17	17::;h<23	23::;h<35	35::;h	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

- Even harmonics are limited to 25% of the odd harmonic limits above.
- Current distortions that result in a direct current offset, e.g. half wave converters are not allowed.
- All power generation equipment is limited to these values of current distortion, RegardlessofactualIsc/IL.Where,Isc=Maximumshortcircuitcurrentatpointofcommoncoupling(PCC).AndIL=Maximumdemandloadcurrent fundamental frequency component) at PCC. TDD=Total demand distortion (RSS), harmonic current distortion in% of maximum demand load current(15or30mindemand).

Voltage harmonics

Total Harmonic Distribution for Different Voltage Levels in %		
Bus Voltage at PCC	Individual Voltage	Total Voltage Distortion
	Distortion (%)	THD (%)
69 kV and below	3	5
69.001 kV Thru 161 kV	1.5	2.5
161 kV and above	1	1.5

Annexure Conductivity & Pressure parameters of Desalination plant

PLANT 4

S.No	Pressure kg/cm^2	
	After Cartridge -1	After Cartidrige-2
1	3.6	3.25

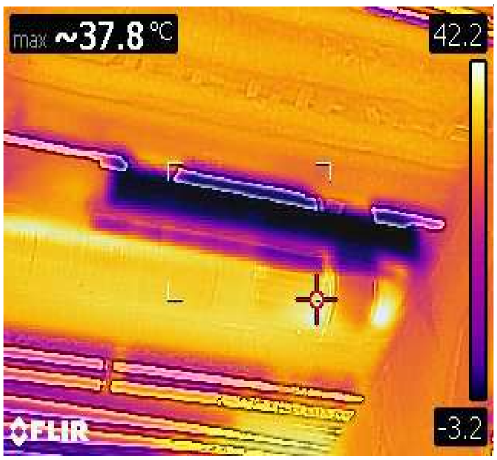
S.No.	Pressure				Conductivity				
	Inlet Pressure HPP O/L	Outlet 1_RO IN	Inlet 2_RO Reject	Out_2 Reject	HPP O/l	Ro Reject	Ro Inlet	Turbo Charger Reject	Permeate water
	Kg/cm^2	Kg/cm^2	Kg/cm^2	Kg/cm^2	S (Ω^{-1})	S (Ω^{-1})	S (Ω^{-1})	S (Ω^{-1})	S (Ω^{-1})
1	54	75	53	1	80	74100	52400	75500	540

PLANT 3

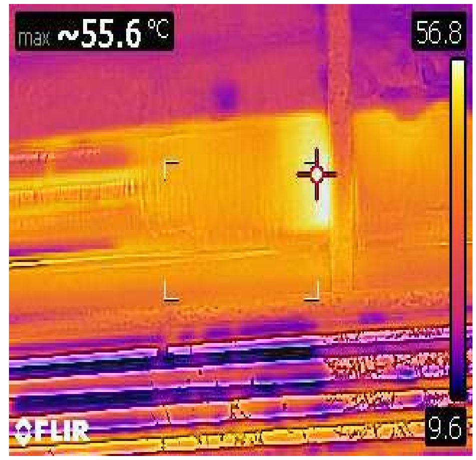
S.No.	Pressure				Conductivity				
	Inlet Pressure HPP O/L	Outlet 1-RO IN	Inlet 2-RO Reject	Out_2 Reject	HPP O/l	Ro Reject	Ro Inlet	Turbo Charger Reject	Permeate water
	Kg/cm^2	Kg/cm^2	Kg/cm^2	Kg/cm^2	S (Ω^{-1})	S (Ω^{-1})	S (Ω^{-1})	S (Ω^{-1})	S (Ω^{-1})
1	40	65	63	-	-	78500	52200	77506	812

S.No	Pressure kg/cm^2	
	After Cartridge -1	After Cartidrige-2
1	3.8-3.2	3.2-2.5

Thermography Images for HLL-03

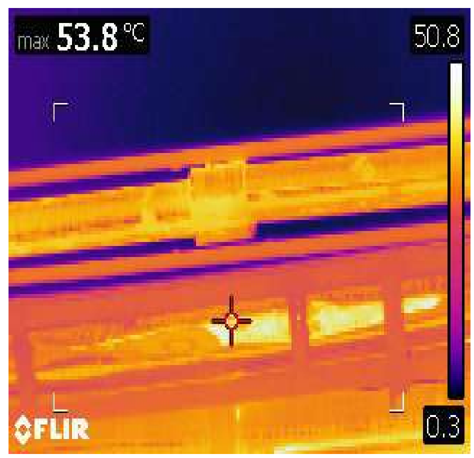


Steam line opposite to DG sets (K-Block)



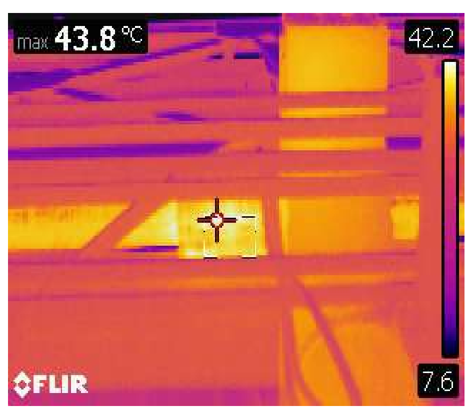
Main line opp. To Transformer

Steam line surface temperature in Q block PRS



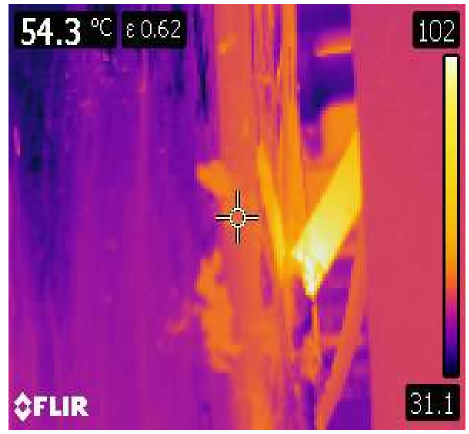
Steam line between Prod Block A & B

Pharma Block-PRV Isolation Valve Not insulated



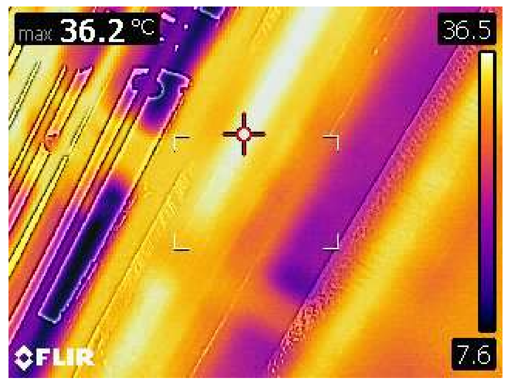
Main steam line near D2 building

Steam line Opp. Service block 1 6" main line

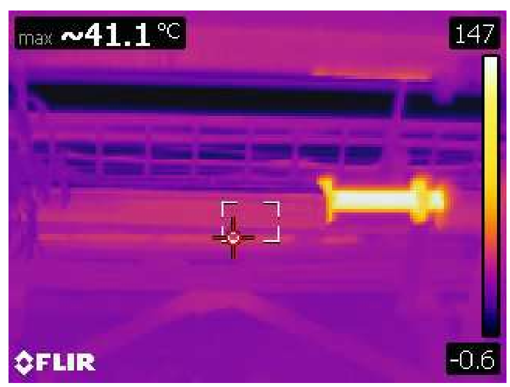


Steam line in SRS PRS

G-Block Skin Temp of uninsulated Valve at Main Line (6 inch)

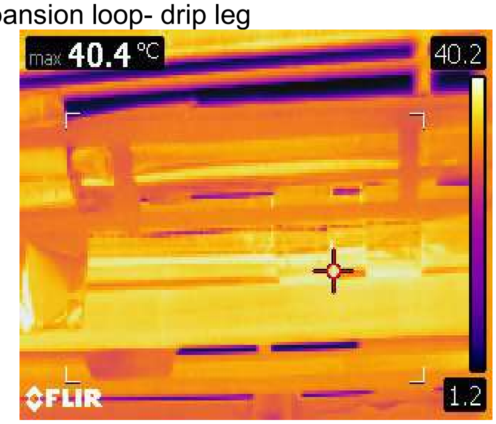


Between 20 tanks SB-2

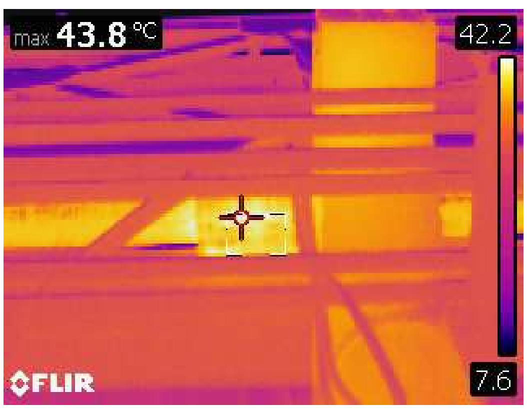


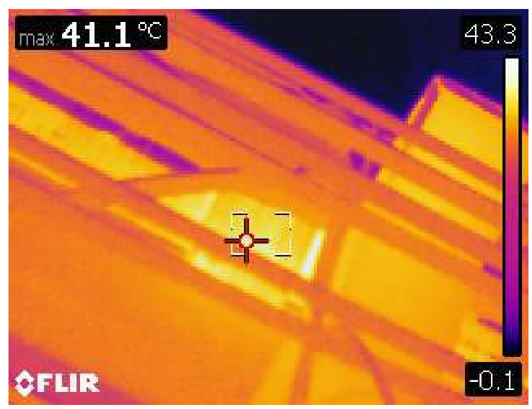
Pharma line after PRV

Opp. PB-B, expansion loop- drip leg

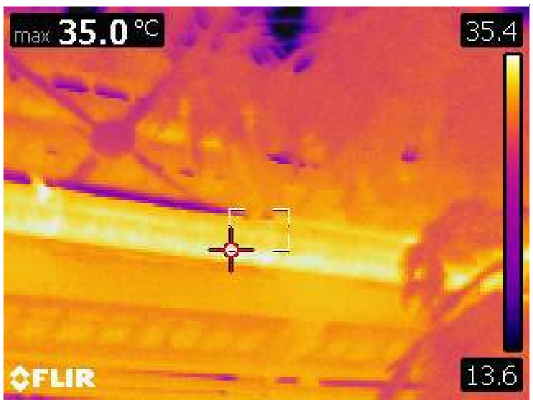


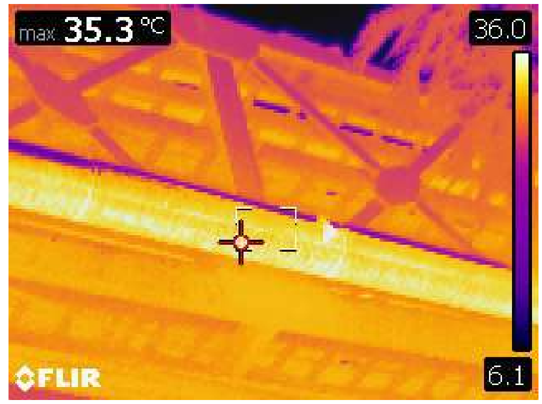
Line Opposite Production Block-A



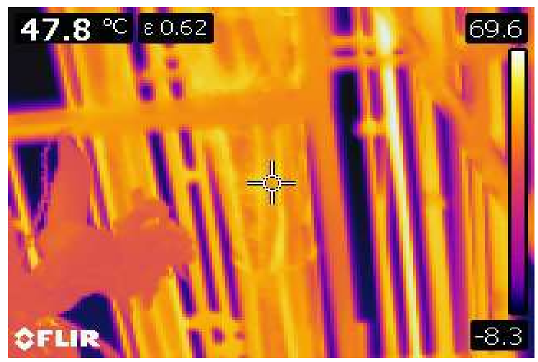


Surface temperature Main line areas



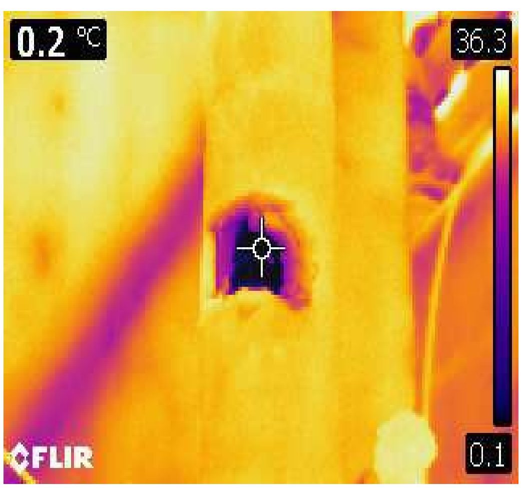


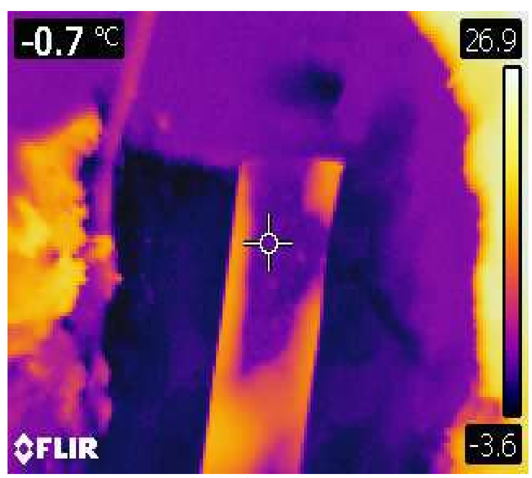
Opposite service block 1 6" main line



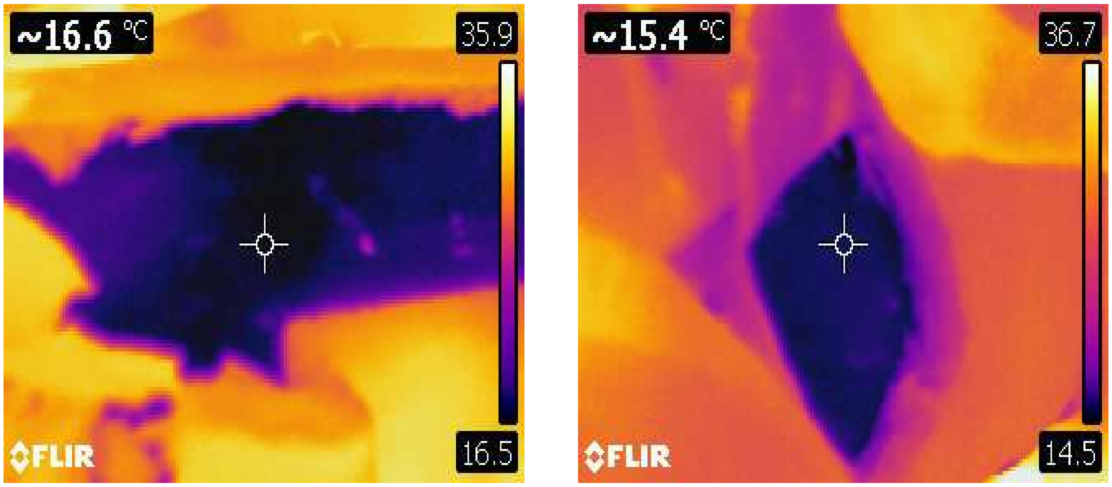
Pipelines near SRS PRS Station

Cold Line Insulation





The above two images refers to -15 chiller line at generation (1st form left) and utilization



a) Return line temperature at prod block (utilization) and b) return line at generation

Boiler Performance Evaluation on 27th April 2017

Item	Value	Units
Date	27.04.2017	
Boiler data		
Mean Sea level	45	m
Barometric pressure	10110	mmWC
Ambient air temperature	35.6	ºC
Avg Steam Flow	43.2	TPH
Steam Pressure operated at	65.433	kg/cm2(g)
Temperature	497.185	ºC
Enthalpy of Steam	814.489	kCal/kg
Flue gas outlet temperature after APH	145	ºC
Gross Calorific Value of fuel (as fired basis)	3462.00	kCal/kg
Avg coal feed rate	0	TPH
Carbon monoxide (Economizer O/L)	88	ppm
Temp. (Economizer Out)	226	ºC
Oxygen (APH O/L)	5.0	%
Carbon monoxide (APH O/L)	67	ppm
Temp. (APH Out)	145	ºC
Oxygen (ID O/L)	6.5	%
Carbon monoxide (ID O/L)	61	ppm
Temp. (ID Out)	135	ºC
Atmospheric Air:		
DBT	35.6	ºC
WBT	27.16	ºC
Abs. Humidity	0.0198	kg of moisture/kgof air
Dew point	24.6	ºC
Fuel firing rate	0.00	TPH
Feed Water:		
Temp. (Before Economiser)	129.78	ºC
Temp. (After Economiser)	214.52	ºC

Fuel analysis			
Carbon Content	C	36.44	%
Hydrogen Content	H	2.07	%
Nitrogen Content	N	1.53	%
Oxygen Content	O	12.93	%
Sulphur Content	S	0.43	%
Ash Content	A	8.15	%
Moisture Content	M	38.45	%
GCV of Coal		3462.00	kCal/kg
Ash Analysis:			
Unburnts in Bottom Ash		0	%
Unburnts in Flyash		9.99	%
GCV		3065.00	
Distribution of Ash:			
Bottom Ash	% of total ash	0.00	%
Fly ash	% of total ash	100.00	%
Total Ash Distribution Quantity			
Bottom ash		0.0000	kg/kgcoal
Fly ash (100% of the total ash)		0.0815	kg/kgcoal
Oxygen (Economizer O/L)		2.84	%

Efficiency By Indirect Method:

Theoretical Air Requirement For complete combustion — $Air_{(theo.)}$ $\frac{((11.6 \times C) + (34.8 \times (H_2 - O_2/8)) + 4.35 \times S))}{100}$

4.40 kg / kg of Coal

Excess Air Supplied (EA) — EA $\frac{O_2\% \times 100}{21 - O_2\%}$

Where O_2 % is oxygen % at Economizer outlet

31.25 %

Actual Mass of Air Supplied (AAS) — AAS (1 + EA/100) X Theoretical Air

5.78 kg / kg of Coal

Mass of Dry Flue Gas — $M_{dry\ Flue\ Gas}$ AAS + (1-Total ash)

6.70 kg / kg of Coal

% Heat Loss in Dry Flue Gas — L1 = $\frac{m \times C_p \times (T_f - T_a) \times 100}{GCV\ of\ Fuel}$

Where T_f is flue gas exit temp

T_a is ambient temp

= 5.08 %

% Heat Loss due to H_2 in Fuel	L2	=	$\frac{9 \times H_2 \times (584 + Cp (T_f - T_a)) \times 100}{\text{GCV of Fuel}}$
		=	3.41 %

% Heat Loss due to Moisture in fuel	L3	=	$\frac{M \times (584 + Cp (Tf - Ta)) \times 100}{\text{GCV of Fuel}}$
		=	7.03 %

% Heat Loss due to Moisture in Air	L4	=	$\frac{AAS \times Humidity \times Cp \times (Tf - Ta)) \times 100}{\text{GCV of Fuel}}$
		=	0.16 %

%Unaccounted and Heat Loss due Radiation and Convection from boiler surfaces	L5	=	[10+(Ts-Ta)/20]*(Ts-Ta)*A*100/GCV of Fuel
Ts=Boiler surface temp [Deg c] Ta= Ambient Temp [Deg C] Hs=Heat Loss [kCal/hr] A = Surface Area [m2}		=	2.00 %

% Heat Loss due to Unburnts in Bottom Ash	a	=	$\frac{\text{Total Ash Collected in Blr bed/ kg of Fuel Burnt X \% Unburnt X GCV X 100}}{\text{GCV of Fuel}}$
		=	0.00 %
% Heat Loss due to Unburnts in fly ash	b	=	$\frac{\text{Total Fly Ash Collected/ kg of Fuel Burnt X \% Unburnt in Fly ash X GCV X 100}}{\text{GCV of Fuel}}$
		=	7.22 %
% Heat Loss due to Unburnts in Total Ash	L6	=	a+b
		=	7.22 %

% Heat loss due to sensible heat of Ash		=	$\frac{m*Cp*(Tash-Tamb)*100}{GCV\ coal}$	
Bottom Ash	a	=	0.00	%
Fly ash	b	=	0.05	%
% Total sensible heat loss due to Ash residue	L7	=	a+b	
		=	0.0546	%

% Heat Loss due to Unburnts (CO) in Flue Gas	L8	=	$\frac{CO(in\ ppm)*28*5654}{10^6*GCV\ coal}$	
		=	0.40	%

Heat Loss due to Venting		0.65	
	=	**74.64**	**%**

Coal Consumption	=	11.45
Evaporation ratio	=	3.77

Efficiency By Indirect Method:			
Theoretical Air Requirement for Complete combustion of 1 kg Fuel		4.40	kg Air' / kg of Coal
Excess Air Supplied (EA)		31.25	%
Actual Mass of Air Supplied (AAS)		5.78	kg / kg of Coal
Mass of Dry Flue Gas		6.70	kg / kg of Coal
% Heat Loss in Dry Flue Gas	L1	5.08	%
% Heat Loss due to H2 in Fuel	L2	3.41	%
% Heat Loss due to Moisture in fuel	L3	7.03	%
% Heat Loss due to Moisture in Air	L4	0.16	%
% Heat Loss due to Unburnts in Bottom Ash'	L5	0.00	%
% Heat Loss due to Unburnts in fly ash	L6	7.22	%
% Total sensible heat loss due to Ash residue	L7	0.05	%
% Heat Loss due to Unburnts (CO) in Flue Gas	L8	0.40	%
% Radiation ,Surface and Unaccounted Loss	L9	2.00	%
Net Boiler Efficiency		74.64	%

Detailed AHU Calculation for HLL-09

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	-	-	**H2/AHU-003**	**H2/AHU-002**	**H4/AHU-003**	**H4/AHU-002**
Usage area			**Crystallizer-III**	**Crystallizer-III**	**Crystallizer-III**	**Crystallizer-III**
Rated Capacity	CFM		19500	19500	19500	19500
Relative Humidity inlet air	%	Measured value	75.0	75.0	72	76
Temperature of inlet air (T_i)	ºC	Measured value	36.0	36.0	35	27.5
Dew point of inlet air (T_{dwi})	ºC	Measured value	31.8	29.6	29.1	22.8
Relative Humidity outlet air	%	Measured value	87.0	85.0	83	85
Temperature of outlet air (T_o)	ºC	Measured value	32.0	31.0	31	24
Dew point of outlet air (T_{dwo})	ºC	Measured value	29.5	28.1	27.13	21.3
Power Input to AC	kW	Measured value	10.00	12.00	7.00	6.50
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	26.24	24.77	24.31	17.44
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	23.92	22.34	22.00	15.50
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.14	1.14	1.14	1.17
Air Flow	**m/s**		**1.4**	**1.5**	**1.09**	**1.0**
Volume flow rate at outlet(V_o)	m^3/hr	v * A	10080.00	10800.00	7848.00	7320.00
Volume flow rate at outlet(V_o)	CFM	-	5929.41	6352.94	4616.47	4305.88
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	11488.26	12308.85	8973.47	8578.65
Refrigeration effect (Q)	TR	$m*(H_i-H_o)/3024$	8.80	9.88	6.85	5.51
SEC	kW/TR	Calculated	1.14	1.21	1.02	1.18
COP	TR_{kW}/kW	Calculated	3.09	2.90	3.44	2.98
EER	$W_{o/p}/W_{i/p}$	Calculated	3.09	2.90	3.44	2.98

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**H7/AHU-001**	**H7/AHU-002**	**AHU-001**	**AHU-006**
Usage area					Pharma Area-III	Pharma Area-I
Rated Capacity	CFM		16000	16000	19000	9000
Relative Humidity inlet air	%	Measured value	72.0	75	72	75
Temperature of inlet air (T_i)	ºC	Measured value	33.0	30	27	25
Dew point of inlet air (T_{dwi})	ºC	Measured value	27.2	25	21.5	19.39
Relative Humidity outlet air	%	Measured value	81.0	83	87	82
Temperature of outlet air (T_o)	ºC	Measured value	29.0	27	24	22
Dew point of outlet air (T_{dwo})	ºC	Measured value	25.4	23.8	21.7	18.8
Power Input to AC	kW	Measured value	15.5	9.2	14.0	6.8
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	22.1	19.5	16.4	14.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	19.5	17.9	15.7	13.5
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.15	1.16	1.17	1.18
Air Flow	**m/s**		1.15	1.10	4.20	1.90
Volume flow rate at outlet(V_o)	m^3/hr	v * A	8280.00	7920.00	30240.00	13680.00
Volume flow rate at outlet(V_o)	CFM	-	4870.59	4658.82	17788.24	8047.06
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	9529.3	9205.2	35498.7	16166.7
Refrigeration effect (Q)	TR	$m*(H_i-H_o)/3024$	8.0	5.0	8.1	5.8
SEC	kW/TR	Calculated	1.9	1.8	1.7	1.2
COP	TR_{kW}/kW	Calculated	1.8	1.9	2.0	3.0
EER	$W_{o/p}/W_{i/p}$	Calculated	1.8	1.9	2.0	3.0

Parameter Reference	Units	Formula	Values	Values	Values
Equipment reference	-	-	**AHU-004**	**AHU-002**	**AHU-001**
Usage area			Pharma Area-II	Production Block-A	Production Block-B
Rated Capacity	CFM		8000	12000	11000
Relative Humidity inlet air	%	Measured value	68	70	68
Temperature of inlet air (T_i)	ºC	Measured value	27	33	32
Dew point of inlet air (T_{dwi})	ºC	Measured value	20.6	26.7	25.3
Relative Humidity outlet air	%	Measured value	78	81	78
Temperature of outlet air (T_o)	ºC	Measured value	24	29	29.2
Dew point of outlet air (T_{dwo})	ºC	Measured value	19.9	25.4	24.9
Power Input to AC	kW	Measured value	8.7	12.6	13.3
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	15.8	21.7	20.5
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	14.7	19.6	19.3
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.17	1.15	1.15
Air Flow	**m/s**		1.75	1.90	2.90
Volume flow rate at outlet(V_o)	m^3/hr	v * A	12600.00	13680.00	20880.00
Volume flow rate at outlet(V_o)	CFM	-	7411.76	8047.06	12282.35
Mass flow rate at outlet (m_o)	kg/hr	$V * \rho$	14791.1	15744.1	24109.2
Refrigeration effect (Q)	TR	$m*(H_i-H_o)/3024$	5.4	10.9	9.7
SEC	kW/TR	Calculated	1.6	1.2	1.4
COP	TR_{kW}/kW	Calculated	2.2	3.1	2.6
EER	$W_{o/p}/W_{i/p}$	Calculated	2.2	3.1	2.6

Detailed AHU Calculation for HDL-09

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**PA/AHU-03**	**PA/AHU-06**	**PA/AHU-08**	**PA/AHU-09**
Usage area			Section-2	Section-5	Section-7	Section-8
Rated Capacity	CFM		6000	6000	6000	6000
Relative Humidity inlet air	%	Measured value	69.8	Difficult to measure the outlet conditions as the block is having powder and issue of opening the outlet door for measurement	70	76
Temperature of inlet air (T_i)	ºC	Measured value	30.0		30.4	27.5
Dew point of inlet air (T_{dwi})	ºC	Measured value	23.4		24.3	22.8
Relative Humidity outlet air	%	Measured value	76.0		77	85
Temperature of outlet air (T_o)	ºC	Measured value	28.0		27	24
Dew point of outlet air (T_{dwo})	ºC	Measured value	23.3		22.6	21.3
Power Input to AC	kW	Measured value	4.50		6.20	6.50
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	18.34		19.08	17.44
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	17.82		17.06	15.50
Density of Inlet air (ρ_o)	kg/m^3	1.29 * (273)/(273+T_o)	1.16		1.16	1.17
Air Flow	**m/s**		**1.5**		**0.97**	**1.0**
Volume flow rate at outlet(V_o)	m^3/hr	v * A	9809.96		6389.63	6687.19
Volume flow rate at outlet(V_o)	CFM		5770.57		3758.61	3933.64
Mass flow rate at outlet (m_o)	kg/hr	V * ρ	11401.89		7416.73	7837.03
Refrigeration effect (Q)	TR	m*(H_i-H_o)/3024	1.98		4.94	5.03
SEC	kW/TR	Calculated	2.28		1.25	1.29
COP	TR_{kW}/kW	Calculated	1.54		2.80	2.72
EER	$W_{o/p}/W_{i/p}$	Calculated	1.54		2.80	2.72

Parameter Reference	Units	Formula	Values	Values
Equipment reference	**-**	**-**	**PA/AHU-012**	**PA/AHU-013**
Usage area			Section-11	Section-12
Rated Capacity	CFM		6000	6000
Relative Humidity inlet air	%	Measured value	75.7	66
Temperature of inlet air (T_i)	ºC	Measured value	25.6	25.8
Dew point of inlet air (T_{dwi})	ºC	Measured value	21.0	19
Relative Humidity outlet air	%	Measured value	83.8	81.8
Temperature of outlet air (T_o)	ºC	Measured value	23.5	22.2
Dew point of outlet air (T_{dwo})	ºC	Measured value	20.6	18.9
Power Input to AC	kW	Measured value	5.0	4.5
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	15.7	14.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	14.9	13.7
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.18	1.18
Air Flow	**m/s**		1.30	1.10
Volume flow rate at outlet(V_o)	m^3/hr	v * A	8550.83	7235.32
Volume flow rate at outlet(V_o)	CFM		5029.90	4256.07
Mass flow rate at outlet (m_o)	kg/hr	$V * \rho$	10084.9	8527.6
Refrigeration effect (Q)	TR	$m*(H_i-H_o)/3024$	2.5	2.5
SEC	kW/TR	Calculated	2.0	1.8
COP	TR_{kW}/kW	Calculated	1.8	2.0
EER	$W_{o/p}/W_{i/p}$	Calculated	1.8	2.0

Detailed AHU Calculation for Honour Lab

Parameter Reference	Units	Formula	Values	Values	Values
Equipment reference	**-**	**-**	**AHU-13**	**AHU-23**	**AHU-08**
Usage area			Crystallizer-V	Pharma-VII	Pharma-III
Rated Capacity	CFM		4500	5500	5500
Relative Humidity inlet air	%	Measured value	Not working	75.9	73.2
Temperature of inlet air (T_i)	ºC	Measured value		28.5	27.1
Dew point of inlet air (T_{dwi})	ºC	Measured value		23.8	21.9
Relative Humidity outlet air	%	Measured value		85.3	82.6
Temperature of outlet air (T_o)	ºC	Measured value		25	23.9
Dew point of outlet air (T_{dwo})	ºC	Measured value		22.3	20.7
Power Input to AC	kW	Measured value		4.8	6.3
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart		18.3	16.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart		16.4	15.1
Density of Inlet air (ρ_o)	kg/m^3	1.29 * (273)/(273+T_o)		1.18	1.17
Air Flow	**m/s**			2.30	1.93
Volume flow rate at outlet(V_o)	m^3/hr	v * A		7617.60	8706.54
Volume flow rate at outlet(V_o)	CFM	-		4480.94	5121.49
Mass flow rate at outlet (m_o)	kg/hr	V * ρ		9002.3	10217.2
Refrigeration effect (Q)	TR	m*(H_i-H_o)/3024		5.6	5.0
SEC	kW/TR	Calculated		0.9	1.3
COP	TR_{kW}/kW	Calculated		4.1	2.8
EER	$W_{o/p}/W_{i/p}$	Calculated		4.1	2.8

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**AHU-24**	**AHU-11**	**AHU-22**	**AHU-14**
Usage area			Pharma-VIII	Pharma-IV	PharmaVI	Pharma-V
Rated Capacity	CFM		5500	5500	5500	5500
Relative Humidity inlet air	%	Measured value	74.0	N/W	76.4	70
Temperature of inlet air (T_i)	ºC	Measured value	27.0		26.4	25.9
Dew point of inlet air (T_{dwi})	ºC	Measured value	22.0		21.9	20
Relative Humidity outlet air	%	Measured value	81.5		82.6	85
Temperature of outlet air (T_o)	ºC	Measured value	23.8		23.9	22
Dew point of outlet air (T_{dwo})	ºC	Measured value	20.3		20.7	19.38
Power Input to AC	kW	Measured value	5.00		4.85	5.10
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart	16.66		16.46	15.19
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart	14.92		15.13	13.87
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$	1.17		1.18	1.18
Air Flow	**m/s**		**2.6**		2.81	2.90
Volume flow rate at outlet(V_o)	m^3/hr	v * A	8970.21		9524.30	9823.00
Volume flow rate at outlet(V_o)	CFM	-	5276.59		5602.53	5778.23
Mass flow rate at outlet (m_o)	kg/hr	$V * \rho$	10530.13		11202.99	11573.65
Refrigeration effect (Q)	TR	$m*(H_i-H_o)/3024$	6.06		4.92	5.06
SEC	kW/TR	Calculated	0.83		0.99	1.01
COP	TR_{kW}/kW	Calculated	4.26		3.57	3.49
EER	$W_{o/p}/W_{i/p}$	Calculated	4.26		3.57	3.49

Parameter Reference	Units	Formula	Values	Values	Values	Values
Equipment reference	**-**	**-**	**AHU-16**	**AHU-10**	**AHU-004**	**AHU-18**
Usage area			Crystallizer-VI	Crystallizer-III	Crystallizer-II	Crystallizer-IV
Rated Capacity	CFM		3000	4000	4000	5000
Relative Humidity inlet air	%	Measured value	Not Working	75.8	Not working	75
Temperature of inlet air (T_i)	ºC	Measured value		29.1		29
Dew point of inlet air (T_{dwi})	ºC	Measured value		28.8		24.1
Relative Humidity outlet air	%	Measured value		81.5		78.8
Temperature of outlet air (T_o)	ºC	Measured value		26.8		27.6
Dew point of outlet air (T_{dwo})	ºC	Measured value		23.3		23.6
Power Input to AC	kW	Measured value		2.7		2.7
Enthalpy of inlet air (H_i)	kCal/kg	From Psychometric chart		18.3		18.6
Enthalpy of outlet air (H_o)	kCal/kg	From Psychometric chart		17.5		17.8
Density of Inlet air (ρ_o)	kg/m^3	$1.29 * (273)/(273+T_o)$		1.17		1.17
Air Flow	**m/s**			2.23		2.30
Volume flow rate at outlet(V_o)	m^3/hr	v * A		6502.68		8280.00
Volume flow rate at outlet(V_o)	CFM	-		3825.11		4870.59
Mass flow rate at outlet (m_o)	kg/hr	V * ρ		7580.4		9655.5
Refrigeration effect (Q)	TR	$m*(H_i-H_o)/3024$		2.1		2.4
SEC	kW/TR	Calculated		1.3		1.1
COP	TR_{kW}/kW	Calculated		2.7		3.1
EER	$W_{o/p}/W_{i/p}$	Calculated		2.7		3.1

Chiller waste Heat Recovery Installations

List of Vendors or suppliers of Chiller waste Heat Recovery System

1.0 Thermax,
2.0 Alfa laval,
3.0 GEA,
4.0 Johnson controls,
5.0 Carrier,
6.0 Promethean Energy,
7.0 Kraft Powers

PHE Technical Specification

Type: Gasketed plate-and-frame heat exchanger for a wide range of applications/HVAC/ Complete Counter flow type

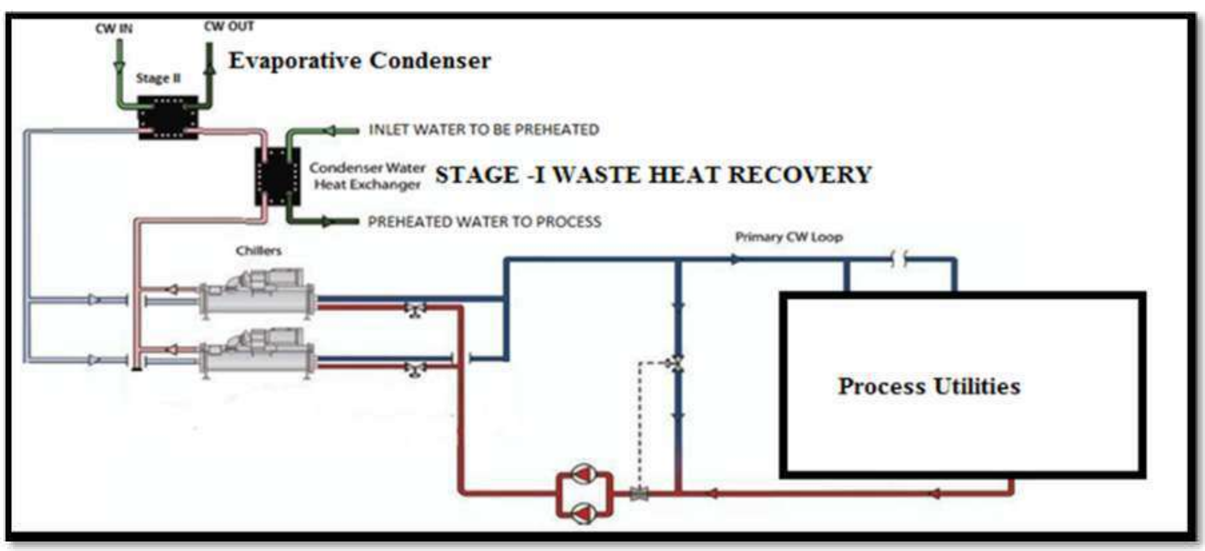
Material :Mild Steel or carbon steel frame/Alloy or stainless steel Heat transfer Plates, Double or single pass

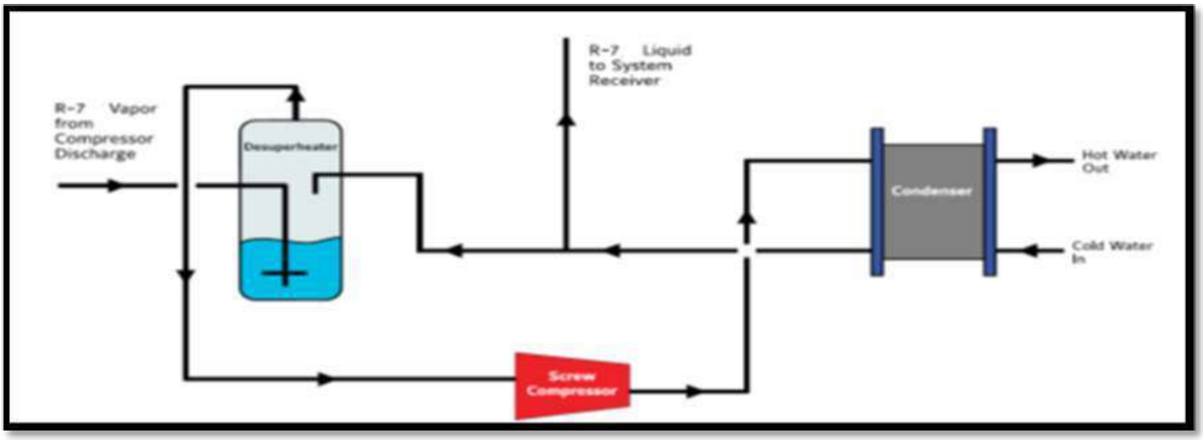
Area- For a Chiller unit of Rated capacity 120 TR, Heat exchanger area required will be approximately 7 m^2. However exact Heat exchanger can be calculated based on the actual site requirements.

Note: Heat exchanger area will be proportionate to the size of the Chiller TR.

Piping Size- 2.5 inches water pipe line connecting to the PHE and discharge going to the process.

The PHE is to be installed between the Compressor outlet and inlet of evaporative condenser. The Evaporative condenser acts as stage I system.




R-7 Liquid to System Receiver
R-7 Vapor from Compressor Discharge
Desuperheater
Hot Water Out
Condenser
Cold Water In
Screw Compressor

1. Project Background

Plant has two ammonia refrigerant chillers (Screw) of ----TR each to cater Process loads of the plant. Evaporative type cooling tower is used to condense the ammonia. Chilled water is used to distribute the heating load from the process to chiller unit.

The following parameters were observed at the condenser

Parameter	Temperature		Qty (m3/hr)
	In	Out	
Ammonia	90	40	-

2. Project Objectives

Basic objective of the project is

1. To recover heat of compression of the chiller to preheat the return condensate.
2. To reduce cooling tower load

By recovering heat of compression of chiller to pre heat boiler makeup water, sizable amount of fuel can be saved. Since heat of compressor is absorbed by boiler makeup water, cooling load on the cooling tower will be reduced substantially. Thus giving duel benefits.

3. Project Scope

Air conditioning / refrigeration systems are designed to remove heat from interior spaces or products and reject it to the ambient (outside) air. Heat rejection may occur directly to the air, as in the case of most conventional air source units, or to water circulating from a cooling tower. The circulating water eventually rejects the heat to the ambient air in the cooling tower. While this heat is of a "low grade variety," it still represents wasted energy. From an energy conservation standpoint, it would be desirable to reclaim this heat in a usable form. The best and most obvious form of heat recovery is for heating water.

The total heat available is the heat removed from the space/process plus the heat of compression. There are four areas in refrigerant systems where heat can be recovered

1. The condenser
2. Superheat in the discharge gas
3. Compressor jacket or oil coolers &
4. Totally enclosed water-cooled motors.

TYPICAL REFRIGERATION CYCLE

The principle of heat recovery in a refrigeration cycle is shown in figure. It will be seen that the discharge gas coming from the compressor is in a superheated state and some heat can be recovered from this gas by desuperheating it before it enters the condenser. The discharge temperatures in most refrigeration systems are quite high (in the range of 70°C to 100°C). The superheat can be used to heat the water to about 60°C. The amount of heat recovered would be of the order 15% of the total heat rejected into the condenser or 20% of the heat rejected at evaporator alone. This heat can be recovered for preheating the process hot water. This process water can be preheated using a PHE in Stage I and remaining heat can be removed using cooling water in Stage II.

Hence it is proposed to recover the heat of compression of chiller to preheat the Process hot water using PHE

CHILLER VENDOR LIST

1. CARRIER,
2. BLUESTAR
3. VOLTAS
4. HITACHI
5. DAIKIN
6. TRANE
7. JOHNSONCONTROLS

ENERGY EFFICIENT PUMP VENDORS LIST

1. GRUNDFOS
2. KSB
3. KIRLOSKAR
4. NEPTUNO
5. SINTECH PUMPS
6. CROMPTON

BLOWERS- LIST OF VENDORS

1. KAYBLOWERS
2. GREATECH
3. PPIPUMPS
4. GRUBERHERMANOS
5. ILLINOISBLOWER

VEERA WASTE MANAGEMENT SYSTEM E-Waste Recyclers

Form-6
[See rule 19]

51 ANNEXURE-XXI

E-WASTE MANIFEST

1.	Sender's name and mailing address (including Phone No.:	Hetero Labs Limited Unit-9
2.	Sender's authorisation No, If applicable. :	7994/APPCB/ZO-VSP/CFO/WZA/2017
3.	Manifest Document No.	03/APPCB/VSP/E-Waste/HO/2017
4.	Transporter's name and address (including Phone No.)	Veera Waste Management Systems
5.	Type of vehicle	(Truck or Tanker or Special Vehicle) Mini Van
6.	Transporter/s registration No.	AP31TF4176
7.	Vehicle registration No.	AP31TF4176
8.	Receiver's name & address :	VEERA WASTE MANAGEMENT SYSTEM (VSP)
9.	Receiver's authorisation No, if applicable.	03/APPCB/VSP/E-WASE/HO/2017-
10.	Description of E-Waste (Item, Weight / Numbers):	Attached as Annexure-1
11.	Name and stamp of sender* (Manufacturer or producer or Bulk Consumer or Collection Centre or Refurbisher or dismantler): Signature : Month Day Year	30-06-2022
12.	Transporter acknowledgment of receipt of E-Wastes	
	Name and stamp: Signature : Month 06 Day 30 Year 2022	30-06-2022
13.	Receiver* (Collection Centre or Refurbisher or Dismantler or Recycler) certification of receipt of E-waster	
	Name and stamp: Signature : R. ESWAR Month 06 Day 30 Year 2022	30-06-2022

VEERA WASTE MANAGEMENT SYSTEMS

* As applicable

Note:-

Copy number with color code (1)	Purpose (2)
Copy 1 (Yellow)	To be retained by the sender after taking signature on it from the transporter and other three copies will be carried by transporter.
Copy 2 (Pink)	To be retained by the receiver after signature of the transporter.
Copy 3 (Orange)	To be retained by the transporter after taking signature of the receiver.
Copy 4 (Green)	To be returned by the receiver with his/her signature to the sender

WASTE MANAGEMENT SYSTEM
E-Waste Recyclers

Form-6
[See rule 19]

52

E-WASTE MANIFEST

1.	Sender's name and mailing address (including Phone No.:	Hetero Drugs Limited Unit-9
2.	Sender's authorisation No, If applicable. :	7994/APPCB/ZO-VSP/CFO/W&A/2017
3.	Manifest Document No.	03/APPCB/VSP/E-waste/HO/2017-
4.	Transporter's name and address (including Phone No.)	Veera Waste Management Systems
5.	Type of vehicle	(Truck or Tanker or Special Vehicle) Mini Van
6.	Transporter/s registration No.	AP 31 TF 4176
7.	Vehicle registration No.	AP 31 TF 4176
8.	Receiver's name & address :	VEERA WASTE MANAGEMENT SYSTEM (VSP)
9.	Receiver's authorisation No, if applicable.	03/APPCB/VSP/E-WASE/HO/2017-
10.	Description of E-Waste (Item, Weight / Numbers):	Attached as Annexure-1
11.	Name and stamp of sender* (Manufacturer or producer or Bulk Consumer or Collection Centre or Refurbisher or dismantler): Signature : [signature] Month 06 Day 30 Year 2022	30-06-2022
12.	Transporter acknowledgment of receipt of E-Wastes	
	Name and stamp: Signature : [signature] Month 06 Day 30 Year 2022	30-06-2022
13.	Receiver* (Collection Centre or Refurbisher or Dismantler or Recycler) certification of receipt of E-waster	
	Name and stamp: Signature : [signature] Month 06 Day 30 Year 2022 13.25	30-06-2022

VEERA WASTE MANAGEMENT SYSTEMS

* As applicable

Note:-

Copy number with color code (1)	Purpose (2)
Copy 1 (Yellow)	To be retained by the sender after taking signature on it from the transporter and other three copies will be carried by transporter.
Copy 2 (Pink)	To be retained by the receiver after signature of the transporter.
Copy 3 (Orange)	To be retained by the transporter after taking signature of the receiver.
Copy 4 (Green)	To be returned by the receiver with his/her signature to the sender

ANNEXURE-XXII

THE NEW INDIA ASSURANCE CO. LTD.
(Government of India Undertaking)

POLICY SCHEDULE FOR PUBLIC LIABILITY (Act Only) INSURANCE

UIN NUMBER - IRDAN190P0076100001

Insured's Name	:	HETERO INFRASTRUCTURE SEZ LIMITED			
Insured's Details			Issuing Office Details		
Customer ID	:	PO92918286	Office Code	:	HYDERABAD LCBO 960000 (960000)
Address	:	SY NO 125 138 150, N NARASAPURAM, NAKKAPALLY MANDAL, N NARASAPURAM, VISAKHAPATNAM, ANDHRA PRADESH, NAKKAPALLI ,ANDHRA PRADESH, 531081	Address	:	LARGE CORPORATE AND BROKERS OFFICE, 7C,7TH FLOOR, SURYA TOWERS, S.P.ROAD, SECUNDERABAD ,500003
Phone No	:		Phone No	:	4027810302
E-mail/Fax	:	krishna.d@heterodrugs.com, /	E-mail/Fax	:	nia.960000@newindia.co.in /
PAN No	:		S.Tax Regn. No	:	AAACN4165CST178
GSTIN/UIN	:	37AABCH6897E3Z6 / NA	GSTIN	:	36AAACN4165C3ZQ
	:		SAC	:	997139 (Other non-life insurance services excl RI)

Policy Details					
Policy Number	:	96000036233300000024	Business Source Code		
Period of Insurance	:	From: 11/11/2023 12:00:01 AM To: 10/11/2024 11:59:59 PM	Dev.Off. level/Broker/Corp. Agent/Web Aggregator/CPSC User	:	DIRECT - (DI00000188)
Date of Proposal	:	11-Nov-23	Agent/Bancassurance/Specified Person	:	
Prev. Policy no.	:	96000036223300000021	Phone No	:	NA / NA
Client Type	:	Non-Corporate	E-mail/Fax	:	/ /

Premium(₹)	ERF Premium(₹)	GST(₹)	Total (₹)	Total (₹ in words)	Receipt No. & Date
11132	11132	0	22,264	RUPEES TWENTY-TWO THOUSAND TWO HUNDRED SIXTY-FOUR ONLY	96000081230000005181 - 17/11/23

Details of risk covered under current year policy:

								Deductibles	
Retroactive Date	Paid Up Capital	No Of Locations Involved	AOA	AOA:AOY	AOY	Annual Turnover - Previous Year	Annual Turnover - Proposed Year	No of workmen	No of Other Employee
11/11/2021	<= 15 Crore	1	50000000	1:3	150000000	1000000000	1100000000	90	24

Retroactive Dates

									Deductibles	
Retroactive Date Details	Date	Paid Up Capital	No Of Locations Involved	AOA	AOA:AOY	AOY	Annual Turnover - Previous Year	Annual Turnover - Proposed Year	No of workmen	No of Other Employee
RETROACTIVE DATE 1	11/11/2021	<=15Crore	1	50000000	1.3	150000000	1000000000	1100000000	90	24

RETRO-DATE IS SUBJECT TO LESSER OF LIMITS - NARROWER OF COVER.

Extensions under the Policy

Name of the Extension	Sub Limit of the Extension	Deductibles of the Extension

Signature Not Verified
Digitally signed by JAGATJAYEE PANIGRAHI
Date: 2023.11.23 10:54:34 IST

Special Conditions	Paid up capital:₹1cr. Estimated Annual Turnover:₹110 crs. Condition precedent to liability- Nil claims as on date of inception ofpolicy.AS PER PUBLIC LIABILITY ACT POLICY Absolute exclusion for losses directly or indirectly arising out of contributed to by or resulting from Coronavirus (Covid 19 and /or nCov 2019) or any mutations or variations thereof
Special Exclusions	NA
Special Excess/Deductible	0

Retroactive Dates	**Date**
Retroactive date	11/11/2021

The Policy shall be subject to PUBLIC LIABILITY (Act Only) INSURANCE Policy clauses attached herewith.

Clauses	Description

Premium and GST Details

	Rate of Tax	Amount in INR
Premium		₹ 22,264
SGST	0	0
CGST	0	0
IGST	0	0

In witness whereof the undersigned being duly authorised by the Insurers and on behalf of the Insurers has (have) hereunder set his (their) hand(s) on this 23rd day of November,2023.

For and on behalf of
The New India Assurance Company Limited

Date of Issue: 23/11/2023

Duly Constituted Attorney(s)

Stamp Duty under the Policy is ₹1

Mudrank____________Dt.__________consolidated Stamp Fees Paid by Pay Order Number______________vide receipt number__________dt._________.

IRDA Registration Number: 190
NIA PAN NUMBER: AAACN4165C

ANNEXURE XXIII

HETERO INFRASTRUCTURE SEZ LTD.
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Annexure-XXIV

Letter No:HIS/EHS/APPCB/2023-24/17

30TH September 2023

The Environmental Engineer
Regional Office
Andhra Pradesh Pollution Control Board
Visakhapatnam

Dear Sir

Sub : **Submission of Environmental Statement in Form-V of M/s Hetero Infrastructure SEZ Ltd, for the Financial Year 2022-2023 – Regarding**

Ref : **APPCB/VSP/218/CFO/HO/2010 Dated :15/02/2023**

With reference to above, we are here with submitting the environmental statement in Form-V for the financial year 2022-2023 for your information and perusal.

Kindly acknowledge the receipt of the same.

Thanking You Sir,

Yours Faithfully

For Hetero Infrastructure SEZ Ltd.

S. Kullayi Reddy
Associate Vice President - EHS

Enclosures: As above

3.10.23

Corporate
[illegible] Hyderabad [illegible] Telangana, India
T [illegible], Fax: [illegible]

[illegible]

PROFILE

M/s. HETERO INFRASTRUCTURE SEZ Ltd. obtained EC & consent for establishment for setting up of 17 manufacturing facilities for producing Bulk Drug Intermediates & APIs and also got Consent for operation for the same SEZ. Out of 17 permitted units, Hetero constructed following 03 units in Hetero Infrastructure SEZ Ltd,

- Hetero Drugs Ltd. Unit-IX (Plot No:1)
- Hetero Labs Ltd, Unit- X (Plot No: 2 & 3)
- Honour Lab Ltd. Unit-III (Plot No:4)

All above mentioned units are producing Bulk Drugs & API and all these products are being manufactured on Regular basis. Manufacturing of the products is being undertaken as per the consent conditions.
Hetero Infrastructure is providing services like Water, Steam, Effluent Treatment Plant, Sewage Treatment plant, Vermi Compost plant, Scrap Yard, Hazardous waste management etc to all the above mentioned units.

Apart from above mentioned units, the other unit Hetero Labs Ltd, Unit-III is making use of these facilities of Hetero Infrastructure SEZ Ltd as per the CFE & CFO.

Salient features of
M/s. Hetero Infrastructure SEZ Limited

Total Site Area	340 Acres
Built up Area	100 Acres
Area of Green Belt Developed	100 Acres
Area available for Green Belt Development	50 Acres
Year of Establishment	2010
Year of Commissioning	2011
Capital Cost	170 Crores
Type of plant	Facilitator for Bulk Drug Manufacturing units
Water Consumption as on date	242 KLD
Investment on Pollution Control	
▪ Capital Investment	100 Crore
▪ Recurring O & M	300 Lakhs/annum
Employment	300

MINISTRY OF ENVIRONMENT AND FORESTS NOTIFICATION
New Delhi, the 22nd April 1993
[PART II, SECTION 3, SUB-SECTION (i)]

"FORM - V"
ENVIRONMENTAL STATEMENT FOR
THE FINANCIAL YEAR ENDING THE 31ST MARCH 2023

PART – A

Name and address of the owner/ Occupier of the industry, operation Or process	:	**Dr. C. Mohan Reddy, Director** 7-2-A2, Hetero Corporate, Industrial Estate Sanathnagar Hyderabad -500018
Registered Office Address		**M/s. Hetero Infrastructure SEZ Ltd,** 7-2-A2, Hetero Corporate Industrial Estate Sanathnagar Hyderabad -500018 Tel: 040- 23704923/24/25
Works address	:	**M/s. Hetero Infrastructure SEZ Ltd,** N.Narasapuram (V), Nakkapally (Md), Visakhapatnam Dist - 531081.
Industry Category	:	Red.
Production Capacity	:	NA (Only Services)
Month and Year of Establishment	:	2013.
Date of Last Environmental Statement Submitted	:	September 2022

PART-B
Water and Raw Material Consumption

Water Consumption (m³/day)

S.No	Water Consumption	Quantity (KL/day) Including power plant	Quantity (KL/day) Including power plant
1.	Process & Washing		-
2.	Cooling tower Make up	-	-
3.	Boiler Feed	242	243
4	Domestic	-	-
5.	Raw water RO make up	-	
Total		242	243

PART-C

Pollution discharged to environment/unit of output
(Parameter as specified in the consent issued)

	Quality of Pollutants discharged (mass/day)	Concentrations of Pollutants discharges (Mass/volume)	Percentage of variation from prescribed standards with reasons.
1. Ambient Air Quality	Analysis Report Enclosed		Within the limits
2. Stack Emissions			
3. Noise levels			
4. Effluent			

PART-D

HAZARDOUS WASTES

(As specified under "Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008")

Hazardous Wastes	Total Quantity (Kg.)	
	During the previous financial Year (2021-22)	During the current financial Year (2022-23)
Forced Evaporation Salts	1075.84	2050T
ETP Sludge	47.48	54.85T
Incinerator Ash	0	9.92T

PART-E

Solid Wastes

Solid waste	Total Quantity	
	During the previous financial year (2021-22)	During the current financial year (2022-23)
Boiler ash	9416 Tons	9079 Tons

PART-F

Characteristics in terms of Composition and quantum of hazardous as well as solid wastes and the disposal practices adopted by them

Fly Ash from Boiler : To Brick Manufacturers
Spent Carbon from Process : To TSDF, Parawada / Cement Industries
Forced Evaporation Salts : To TSDF, Parawada
Organic Residue : To TSDF, Parawada and Cement Industries

PART-G

Impact of the pollution abatement measures taken on Conservation of natural resources and on the cost of production.

The Industry has adopted following measures for the conservation of natural resources:

- Sea water Desalination Plant for meeting the water requirement of the industry.
- Sewage Treatment Plant for reuse of Domestic wastewater for gardening purposes.
- Usage of vermicomposting for green belt and grounding purpose as a replacement for chemical fertilizers.
- Green belt Development for abatement of pollution

The industry adopted all possible pollution control measures (Common Facility located at M/s Hetero Infrastructure SEZ Ltd) which includes Equipment's for Conservation of energy, Effluent Treatment Plants (Stripper, MEE, ATFD Bio-tower & Dual stage aerobic Treatment plant based on ASP), Sewage Treatment plants, Equipments for controlling fugitive emissions (Scrubbers, Condensers) for the abatement of pollution. To avoid any chances of ground water/ Soil contamination, the industry has constructed all above Ground tanks for ETP, STP etc.

Further the industry has installed [illegible] nos of Continuous Ambient Air Quality Monitoring (CAAQM) stations for monitoring the quality of the air, Online effluent monitoring system (OEMS) for various parameters to check the quality of treated effluents being disposed into Sea, Portable & online VOC meters for measuring organic vapours concentration in and around factory area.

PART-H

Additional measures/investment proposal for environmental protection including abatement of pollution, prevention of pollution.

The industry has already invested around Rs. [illegible] Crores towards installation of pollution control devices in Hetero Infrastructure SEZ Ltd and developed green belt in and around the factory Premises in an area of more than 40% of the total area of the Industry. Green belt consists of various plants like Sonuga, Neem, Almond, Silver oak, Pinnaform, casuarina, Eucalyptus and Conocarpus etc.
All installed Pollution control equipments are periodically evaluated and necessary modifications/replacements are being made for improvement in their performances from time to time as and when required irrespective of Budget allocations

The Industry proposed to invest additional amount of Rs 100 crore towards installation of new 1.2 MLD Effluent Treatment plant and associated facilities.

PART-I

Any other particulars for improving the quality of the environment

- Increasing the greenbelt area by planting more plants, lawns, bushes etc.
- Industry is maintaining good housekeeping, mitigating fugitive emissions, reducing spills of raw material by taking all possible measures.
- Recovering of solvents from the effluents in stripper thereby reducing the organic vapours entry into the atmosphere and effective biological treatment.
- Rainwater harvesting by collecting complete run off in an open pond for recharging of ground water as well as for reuse
- Captive power generation of 6.1 MW in connection to the existing 45 TPH Boiler
-

CONCLUSION

Hetero Infrastructure SEZ limited is taking all possible measures for the abatement of pollution and certain steps are in consideration for workplace improvement and cost reduction. The following are the pollution abatement measures taken by the industry:

Taking all steps required to assure low emission levels, without any prejudice to the quantum of production.

1. Utilization of domestic wastewater discharges for development of greenery after treating in Sewage Treatment Plants.
2. Giving due importance to the greenery and ultimately taken care in abating the pollution.
3. Rainwater harvesting by way of collecting rainwater in a pond created by the industry
4. Online instruments for monitoring the pollution levels in and around factory premises
5. Operating Effluent Treatment Plant (Common) for bringing the pollution levels well within the norms of the Board
6. Regular monitoring of air, water, effluent and Ground water by third party once in a month to keep watch on the pollution levels.