

is exothermic, the outlet temperature rises. This gas is then cooled down in another Waste Heat Boiler by producing HP Steam. Finally the gas is cooled in BFW Pre-heater before entering Low Temperature CO Shift Converter (LTS). In LTS Converter, CO is further converted to CO₂ by reaction over a Copper based Catalyst. This reaction is also exothermic, which is given below:



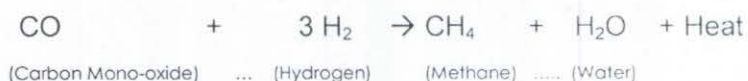
34. Gas is then further cooled in two BFW Pre-heaters. Then it enters the Re-boiler of CO₂ removal system after the removal of process condensate in a separator. This process condensate is sent to Process Condensate treatment section.

2.2.1.6 CO₂ Removal Section (GV Process)

35. GV is the Process Licensor of CO₂ Removal Process and in this process Carbon Dioxide is removed by absorption in Hot Potassium Carbonate solution.
36. The process gas from the Re-boiler is cooled by exchanging heat in a DMW Preheater. Then it enters the CO₂ Absorber where its CO₂ content is brought down to the level of around 500 ppm. The absorber is a packed column having a combination of structured and random packings. The Hot Potash solution is introduced into the Absorber at two places, the lean solution at the top bed and the semi-lean at the middle-bed. The CO₂ rich solution from the Absorber bottom is depressurized through a Hydraulic Turbine with a power recovery system, before it is discharged to the top of the Regenerator, where the CO₂ flashes off. The heat for regeneration is supplied to the regenerator partly from the Re-boiler and partly from flashed steam/live steam. The regenerated solution is then pumped to the CO₂ Absorber by Lean & Semi-lean solution circulation pump. Product CO₂ from the CO₂ regenerators is sent to Urea Plant.

2.2.1.7 Methanation

37. The gas from CO₂ Absorber is pre-heated by heat exchange with the outlet gas from the Methanator in a Gas/Gas exchanger. The small quantities of CO and CO₂ in the gas are converted to methane by reaction with hydrogen over a nickel-based catalyst. This reaction, which is given below is exothermic and the heat is used for heating the feed gas. The gas from Gas/ Gas Exchanger outlet is cooled in a final gas cooler and sent to the suction of Synthesis Gas Compressor:



2.2.1.8 Ammonia Synthesis & Refrigeration

38. The synthesis gas, which has hydrogen & nitrogen in a volumetric ratio of 3:1 and some inerts, is compressed to synthesis loop pressure

by Synthesis Gas Compressor and is introduced into the synthesis loop from where it goes to series of Ammonia Converters (containing iron based catalyst) to get maximum ammonia conversion along with re-circulating gas. Ammonia Converter synthesis reaction is given below:



39. The converter effluent gas is cooled in a Waste Heat Boiler after both ammonia converters for generating HP Steam. This is further cooled in a BFW pre-heater and then its further cooled in BFW Preheater and then in a hot heat exchanger. It is then cooled in water cooler & chillers. The condensed ammonia is separated from the circulating gas in Ammonia Separator. From this Ammonia Separator, separated hot ammonia is sent directly to Urea Plant and cold ammonia can be sent to Atmospheric Ammonia Storage tank.
40. Ammonia Refrigeration system consists of centrifugal Refrigeration compressor along with condenser.

2.2.1.9 Ammonia Absorption and Condensate Recovery

41. Purge gases from the synthesis loop are fed to PGRU for hydrogen recovery. Letdown & Inert gases from the Synthesis loop are fed to an Absorber where ammonia is absorbed in the circulating water. The ammonia free gas is then sent as fuel to Primary Reformer.
42. The Ammonical water is treated in a distillation Column to strip out free ammonia, which is condensed and sent to ammonia accumulator in the refrigeration system. The process condensate and CO₂ absorption section condensate are treated in a process condensate stripper to remove ammonia, CO₂ and methanol etc. The purified condensate is sent to Offsite and Utilities facilities for reuse as boiler feed water after polishing.

2.2.2. Urea – I

43. Urea-I plant is based on Snamprogetti, Italy process and has two streams with common Prilling Tower and Process Condensate Treatment Sections.
44. The Urea production process involves the following steps:
 - Urea Synthesis
 - Urea Purification
 - Urea concentration
 - Urea Prilling
 - Process Condensate Treatment

UREA-I PROCESS FLOW BLOCK DIAGRAM (SNAMPROGETTI PROCESS)

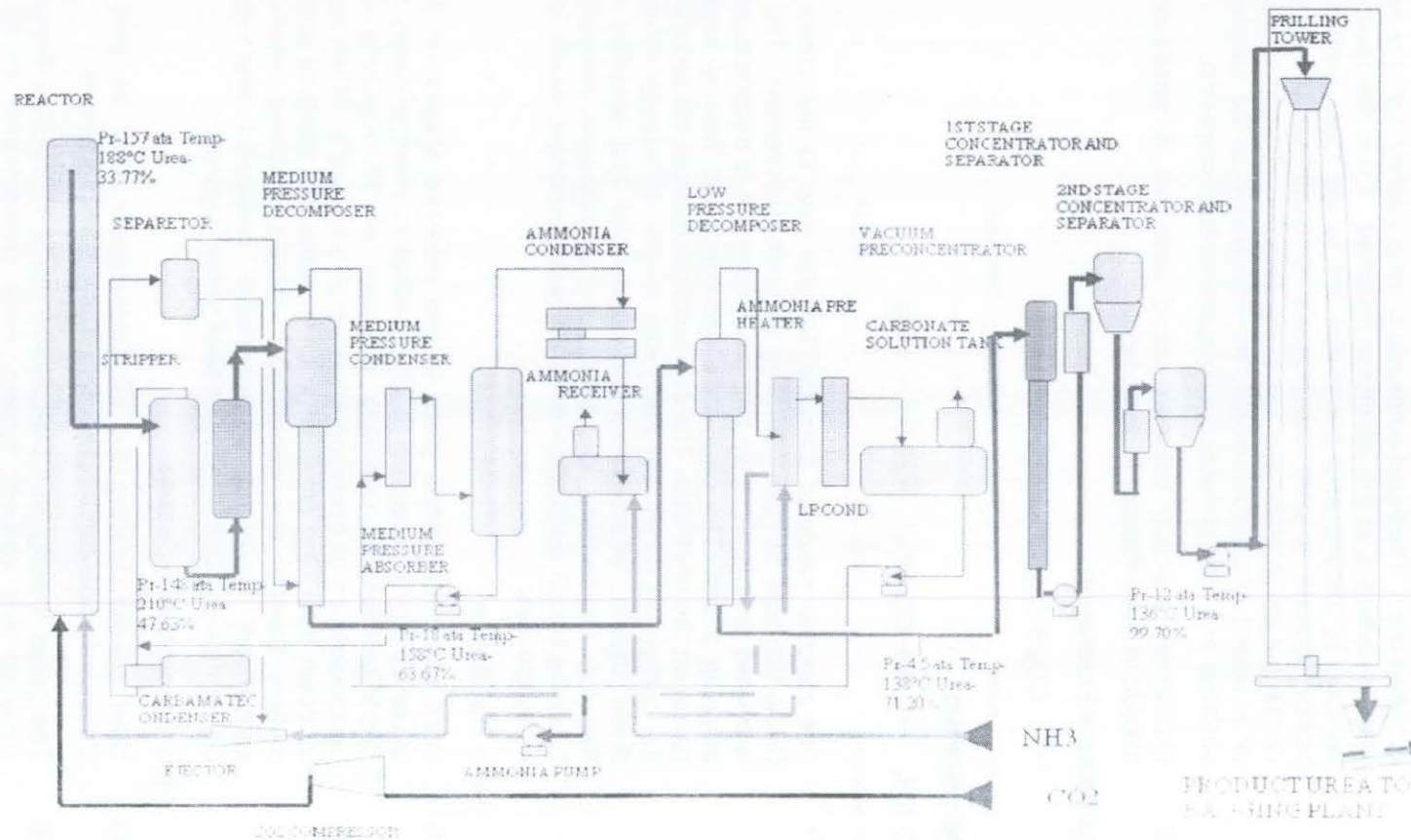
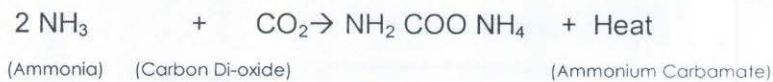


Figure 2.2 : Flow diagram of the Urea - I Plant

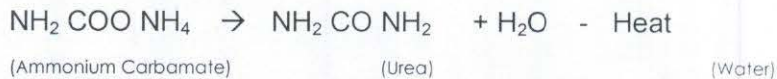
2.2.2.2 Urea Synthesis

45. Synthesis of Urea is carried out at high pressure of 156 Kg/Cm²g and temperature of about 190°C in a carbon steel Reactor with SS 316L modified liner. The liquid ammonia coming directly from the Ammonia Plant is collected in the Ammonia Receiver. From the receiver, it is pumped by means of a pump and fed to the Urea Reactor. The carbon dioxide is also compressed to Synthesis pressure by a centrifugal compressor and fed to the Reactor. The small quantity of air is added into carbon dioxide for Passivation of the stainless steel surfaces and thus protects the equipments from corrosion.
46. Exothermic reaction between Liquid ammonia & gaseous carbon dioxide in Urea Reactor is given below:

a) Carbamate Formation



b) Dehydration



47. The reaction products from the Reactor flow to the steam heated falling film type Stripper operating at Synthesis pressure. The mixture is heated as it flows down and the carbamate is decomposed by the stripping action. The carbamate decomposition heat is supplied by steam on the shell side. The overhead gases from the stripper flow to the carbamate condenser along with recycle carbamate solution from down stream, where these are condensed and recycled back to Reactor. Condensing the gases at high-pressure results in low-pressure steam generation in carbamate condenser, which is utilized in the process.

2.2.2.3 Urea Purification

48. Urea purification takes place in two pressure stages i.e. MP pre-decomposition (proposed to be installed in revamp case) and MP Decomposition at operating pressure of 17 Kg/Cm²g and LP Decomposition at operating pressure of 3 Kg/Cm²g. When solution is let down from high pressure to lower pressure, gaseous ammonia & carbon dioxide are generated. These gaseous mixtures are condensed/ absorbed at respective pressures and recovered Carbamate solution is recycled back to the Reactor.

2.2.2.4 Urea Concentration Section

49. Urea solution leaving the LP Decomposer shall be sent to first Vacuum Concentrator operating at 0.3 Kg/cm²a pressure.
50. The gases leaving from pre-concentrator & 1st Vacuum Separator are removed first vacuum system. Final concentration of 99.7 % is achieved in the second vacuum concentrator operating at 0.03 Kg/cm²a pressure. The gases leaving the top separator are removed by the second vacuum system. Water vapors from the concentration section are condensed in cooling water Surface Condensers and

recovered condensate, which contains urea mist, CO₂ and Ammonia is sent to Process Condensate treatment section.

2.2.2.5 Urea Prilling

51. The molten Urea solution after final concentration in vacuum section is fed to the Prilling bucket by means of a Urea Melt pump. The urea coming out from the rotating prill bucket encounters cold airflow in a natural draft Prilling tower, which causes its solidification. The product urea prills falling to the bottom of the Prilling tower are collected through a rotary scrapper and are sent to Bagging Plant / Silo.

2.2.2.6 Process Condensate Treatment

52. The process condensate containing small amount of CO₂, Ammonia and Urea coming out of vacuum condensers is collected in a buffer tank. The solution from this tank is fed to Process Condensate Stripper to strip ammonia and CO₂. The solution drawn from an intermediate tray of this column is sent to a Hydrolyser. In the Hydrolyser Urea is hydrolyzed to ammonia and carbon dioxide. Hydrolyser vapors are recycled to the stripper for further stripping of ammonia & CO₂. The treated condensate is sent to off sites and Utility facility for reuse as Boiler Feed water after polishing.

2.3. Project Execution – Gadepan- II

53. After stabilization of the Gadepan-I plants, CFCL decided to double its existing plant capacity in 1995 and global tenders were invited for the expansion project. Considering various aspects like minimum energy consumption, proven process and state of the art technology, CFCL opted for Kellogg's Ammonia process for Ammonia production and Toyo Engineering Corporation's Advanced Cost Energy Saving process for Urea production. A turnkey lump-sum contract was signed with M/s TEC Japan for supply of both these plants with Zero Date of 25.12.1996. The site for expansion had been kept allocated right in the beginning of the project itself.

• Plant	:	1520 MTPD (One Stream)
• Urea Plant	:	2620 MTPD (Twin Streams) (8,64,600 MTPA)
• MoEF Clearance	:	24 th of July 1996
• Zero Date	:	25 th of Dec 1996
<u>Mechanical Completion</u>		
• Ammonia	:	25 th of July 1999
• Urea	:	15 th of August 1999
<u>Date of Trial –run production</u>		
• Ammonia	:	November, 1999
• As per Project	:	November, 1999
• Actual	:	September 22, 1999
<u>Date of Commercial production</u>		
• As per project	:	December, 1999
• Actual	:	October 20, 1999

- Time overrun :Project is well within the schedule
- Cost overrun : No Cost overrun

2.3.1. Manufacturing Process of Gadepan-II Plants

2.3.1.1 Ammonia-II

54. Ammonia plant is based on M.W. Kellogg's Technology. Natural Gas/Naphtha or both can be use as a feedstock. Flow Diagram of Ammonia Plant is given in Figure and process features in brief are as below:

- De-sulphurization of Feedstock
- Steam Reforming
- Shift Conversion Section
- CO₂ Removal Section (Benfield Process)
- Ammonia Synthesis & Refrigeration
- Ammonia Absorption and Condensate Recovery

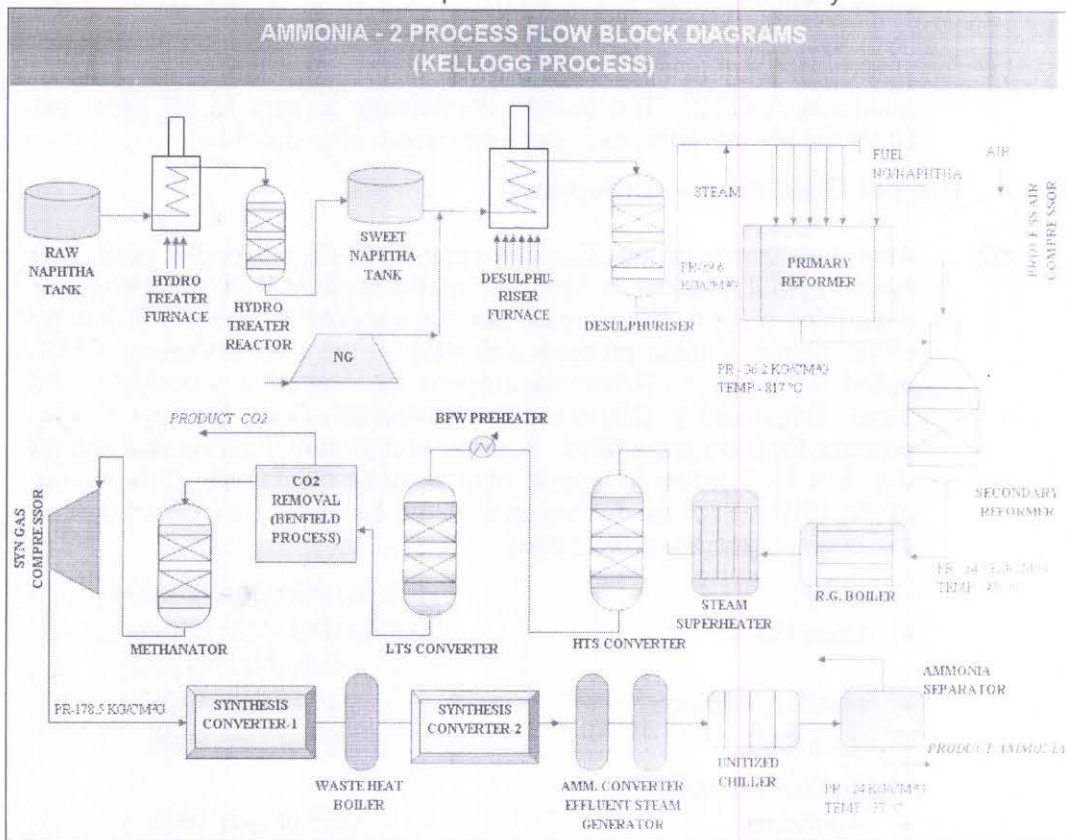
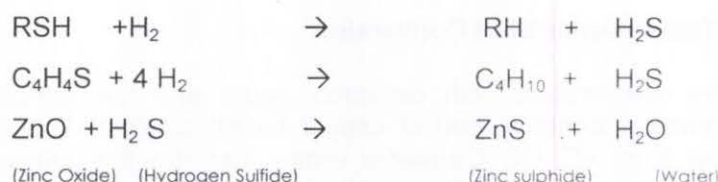


Figure 2.3 : Process Flow Block Diagram of Ammonia - 2 Plant

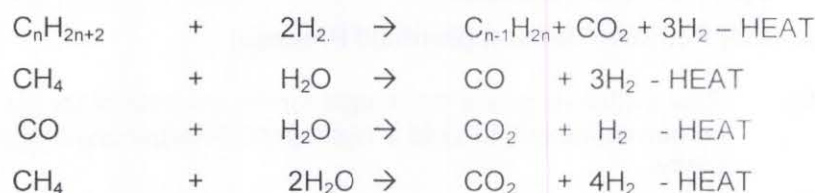
2.3.1.2 Feed Desulphurization

55. In Desulphuriser unit the sulfur compounds in Natural Gas (around 10 ppm as H₂S by volume) are hydrogenated over cobalt–molybdenum catalyst in presence of hydrogen rich gas and hydrogen sulphide form is absorbed by ZnO keeping sulfur content is less than 0.1 ppm as per the following reaction:



2.3.1.3 Reforming of Hydrocarbons in Primary Reformer

56. Natural gas after removal of sulfur is fed into the primary reformer along with process steam. In primary reformer reforming of hydrocarbons take place in the presence of nickel catalyst. Reforming reaction, as given below are endothermic in nature and require constant heat input from the Primary Reformer top fired burners to maintain the Primary Reformer outlet temperature.



57. The methane slip at the outlet of Primary Reformer is around 11%.

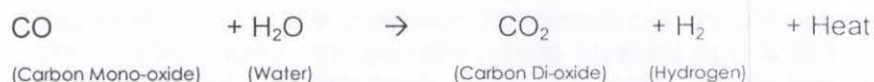
2.3.1.4 Reforming of hydrocarbons in Secondary Reformer :

58. Partly reformed gas from Primary Reformer enters the Secondary Reformer. In Secondary Reformer, Pre-heated process air from turbine driven Process Air Compressor enters into Secondary Reformer at required pressure and mixed with process gas from Primary Reformer resulting in rapid combustion and distribution of the heat over the entire surface of the catalyst bed.
59. The combustion zone temperature remains in the range of around 1250°C. From the combustion zone of the Secondary Reformer the hot gases passes through the bed of Nickel catalyst to complete the reforming reaction. Hot gases leaving the Secondary Reformer at 989°C are cooled in Waste Heat Boiler to 371°C.
60. The final methane slip at the outlet of Secondary Reformer is reduced to 0.31%.

2.3.1.5 Shift Conversion of Carbon Monoxide to Carbon Dioxide : Shift conversion of CO to CO₂ is carried out in two steps:

a. High Temperature Shift Conversion

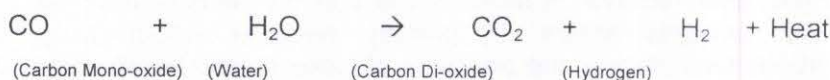
61. High temperature shift converter contains a single bed of iron based catalyst. The gas/steam flow from Secondary Reformer enters in High Temperature Shift Converter at about 371°C temperature where a large percentage of CO content is converted to CO₂ by the following reactions:



62. The CO content from HT CO Converter outlet is about 3.32 %.

b. Low Temperature Shift Conversion

63. Low temperature shift converter guard and low temperature shift converter contains bed of copper based catalyst. The process gas flow from HT CO Converter enters into the low temperature shift converter guard at 217°C and leaves from LT shift converter at 235°C. In LT Shift Converter, further CO converts into CO₂ by following shift reaction is given as below:



64. The CO content at the outlet of CO Shift Converter is around 0.3%.

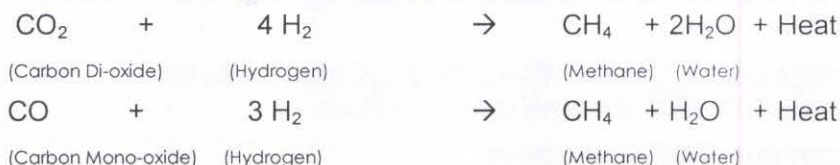
2.3.1.6 Synthesis Gas Purification

a. CO₂ Removal Section (Benfield Process)

65. Raw synthesis gas is processed for the removal of carbon dioxide and carbon monoxide to yield a Hydrogen / Nitrogen synthesis gas of high purity.
66. The Benfield process accomplishes removal of the carbon dioxide & yields a synthesis gas with less than 0.1 vol.% of Carbon dioxide. The Benfield solution is a 30 % aqueous solution containing potassium carbonate, which absorb the carbon dioxide. The solution also contains additives, which improve the CO₂ absorption rate, inhibit corrosion and helps control foaming of the solution. Flashing, under low pressure into a CO₂ Stripping Tower, regenerates the rich solution from bottom of the CO₂ Absorber. The Stripper overhead vapors are cooled and the Carbon Dioxide product is separated from the condensed water and delivered to Urea Plant.

b. Methanation :

67. Synthesis Gas from the CO₂ Absorber outlet flow to the Methanation for removal of residual carbon oxides by reacting the carbon oxides with Hydrogen over a catalyst bed producing methane and water as per the following reactions:



2.3.1.7 Ammonia Synthesis & Refrigeration

a. Ammonia Synthesis

68. Methanator outlet synthesis gas is compressed in a turbine driven centrifugal Synthesis Gas Compressor. Discharge of the compressor is directed through two Ammonia Converters, which are in series and consist of a high-pressure shell containing Iron based catalyst and heat exchanger. After 2nd stage discharge of Synthesis Gas Compressor the synthesis gas passes through the Molecular Sieve Dryers, where any remaining moisture is absorbed to ensure the dry

gas is available for the Ammonia Converter. In the presence of the Iron catalyst a portion of the total hydrogen and Nitrogen will combine to yield Ammonia at a concentration of about 17%. The synthesis reaction is given as below:



69. Ammonia converters are operated at 178.5 Kg/cm²g inlet pressure and 229°C inlet temperature. The converter-1 exist gas is cooled into the waste heat boiler and entered into he converter-2. Converter-2 gas is cooled in the boiler feed water exchanger, giving up heat to high pressure BFW. Further cooling is accomplished by heat exchange with the converter feed gas and then with cooling water. The synthesis gas then flows through the unitized chiller, a **specially designed exchanger consisting of multiple concentric tubes passing through a partitioned four-compartment shell**. At the outlet of unitized chiller the cold stream enters the Ammonia Separator where liquid Ammonia is removed & letting it down to the Ammonia Let-Down Drum. Vapors from the Ammonia Separator pass to the tube of the utilized chiller and to the recycle stage of the Synthesis Gas Compressor. Liquid Ammonia from the letdown drum is sent to the Urea Plant through warm Ammonia Product Pump.

b. Ammonia Refrigeration System

70. A four-stage Refrigeration system provides refrigeration for Ammonia condensation in Synthesis loop & synthesis gas compressor make-up chilling. Refrigeration Compressor discharge flows to Ammonia Condenser & after condensation liquid Ammonia is collected into Refrigerant Receiver. From Refrigerant Receiver, hot Ammonia is pumped to Urea Plant. Cold Ammonia from the coldest chamber of utilized chiller can be pumped to Ammonia Storage Tank in case of tripping of Urea plant.

2.3.1.8 Ammonia Absorption And Condensate Recovery

71. Purge and letdown gases from the Synthesis loop are fed to an Absorber where ammonia is absorbed in the circulating water. The ammonia free gas is then sent to fuel system. The Ammonical water is treated in a Distillation Column to strip out free ammonia, which is condensed and sent to ammonia refrigerant receiver in the refrigeration system.
72. The process condensate from the separators is treated in a process condensate stripper to remove in a high pressure process condensate stripper to remove Ammonia, CO₂ and Methanol. The purified condensate is sent to Offsites & Utilities facilities for reuse as Boiler feed water after polishing.

2.3.2. Urea-II Plant

73. Urea plant is based on TEC Advance Cost & Energy Saving (ACES) process. This process has the advantage of High Conversion, better heat utilization due to which Low Overall Energy consumptions, High Reliability % lower emission of liquid & gaseous pollutants. Flow diagram of the Urea Plant is given in Figure 2.5. Urea Plant consists of

two streams each with common Prilling Tower & Process condensate Treatment Section. Major steps/ features of the process are as below:

**UREA-II PROCESS FLOW BLOCK DIAGRAM
(TEC'S ACES PROCESS)**

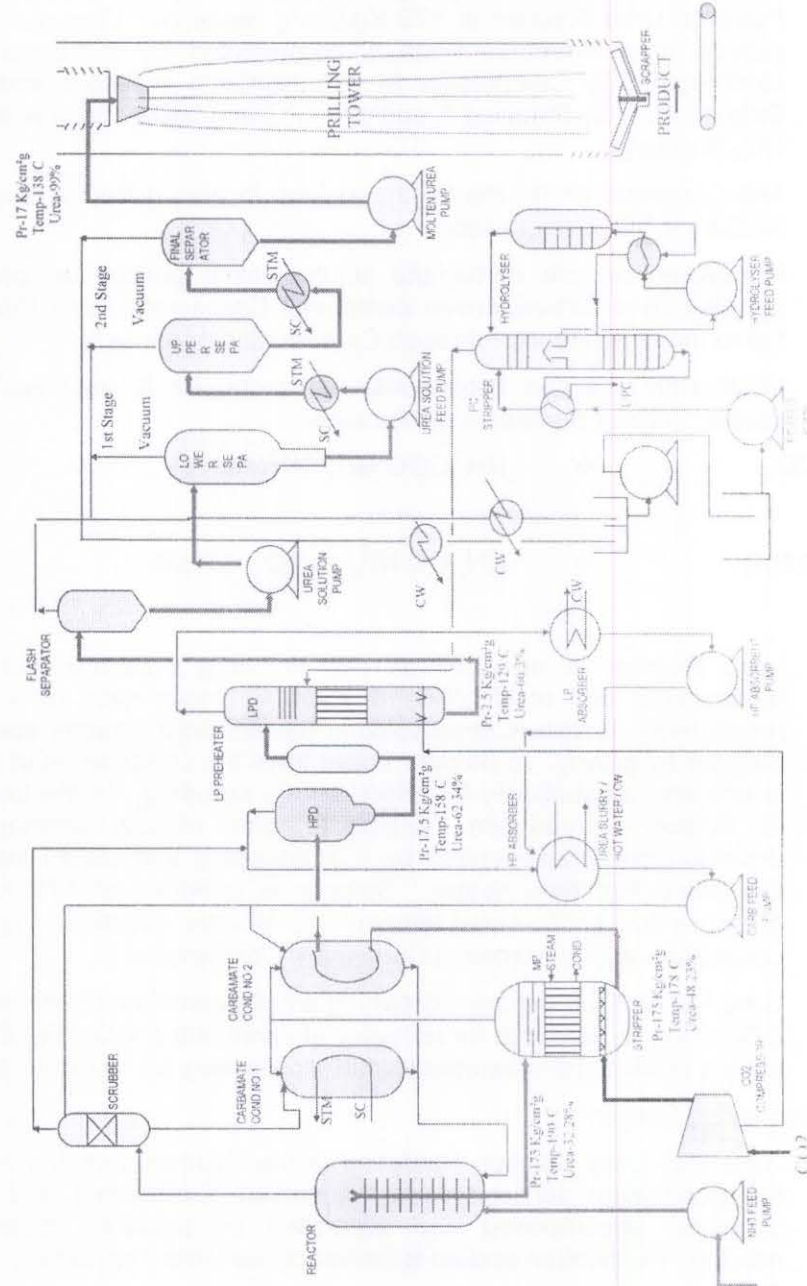


Figure 2.4 : Process flow diagram of Urea – 2 Plant

2.3.2.2 Synthesis Section

74. Liquid Ammonia from Ammonia Plant is collected into Urea Plant Ammonia Receiver and pumped by turbine driven Ammonia Feed Pump to Urea Reactor at 175 Kg/Cm²g pressure. Gaseous Carbon dioxide from Ammonia Plant is compressed by a turbine driven centrifugal CO₂ Compressor to 175 Kg/Cm²g pressure and fed to Stripper for CO₂ Stripping & partly to LP Decomposer for low pressure CO₂ Stripping.
75. Anti-Corrosion air for the synthesis loop is also added at 2nd Stage suction of CO₂ Compressor.
76. Recovered recycle carbamate solution from purification section is pumped by a turbine driven centrifugal Carbamate Feed Pump and fed to the Urea Reactor through Carbamate Condensers.
77. Exothermic reaction between Liquid ammonia & gaseous carbon dioxide in Urea Reactor is given below:



(Ammonium Carbamate)



Urea

78. Urea Reactor is operated at 175 Kg/Cm²g pressure and 190°C temperature and at NH₃/CO₂ & H₂O/CO₂ molar ratio of 4 & 0.65 respectively. Synthesis Urea solution passes from Reactor enters into Stripper by gravity. In Stripper upper trays the composition of solution is adjusted adiabatically for effective CO₂ stripping. In the lower part of stripper Ammonium Carbamate and excess ammonia are decomposed and separated by CO₂ Stripping and steam heating in the falling film type heater. Stripper is operated at 175 Kg/Cm²g pressure and 178°C outlet temperature. Stripper overhead vapors are condensed and absorbed in Carbamate Condensers.
79. Urea Reactor top vapors, containing small quantities of Ammonia and CO₂ is fed to Scrubber for recovery of Ammonia & CO₂, Scrubber top vapors is fed to HP Absorber for further recovery of Ammonia & CO₂.

2.3.2.3 Purification Section

80. Synthesis Urea Solution Produced in the Synthesis section is fed to the purification section where Ammonium Carbamate and excess ammonia decomposed and separated by pressure reduction & heating. Purification section is further divided into two parts.

(a) HP Decomposition

81. Pressure of Synthesis Urea solution is reduced from 172 to 17.5 Kg/Cm²g and is heated to 158°C in No.2 Carbamate Condenser & fed to HP Decomposer. In HP Decomposer the Ammonia & CO₂ vapors in the synthesis Urea solution are separated and are then fed to Absorbers for further recovery and finally recycled to the Synthesis Section.

82. HP Decomposer is operated at 17.5 Kg/cm²g pressure and 158°C temperature.

(b) LP Decomposition

83. Urea solution from HP Decomposer is fed to the LP Decomposer at 2.5 Kg/Cm²g pressure.
84. LP Decomposer is operated at 2.5 Kg/Cm²g pressure and 129°C bottom temperature. CO₂ stripping in LP Decomposer at the lower packed bed accelerates separation of Ammonia. The Ammonia and CO₂ vapors from Urea solution are separated and are fed to LP absorber for recovery and finally recycled to Absorbers. LP Decomposer outlet solution is fed to flash separator, in which flashing under vacuum separates residual Ammonia & CO₂. The urea solution at LP Decomposer outlet contains about 66.3 Wt.% of Urea.

2.3.2.4 Concentration section

85. Urea solution from the purification section is first fed to Lower Vacuum Concentrator, which is operated at the pressure of 150 MMHGA vacuum and a temperature of 77°C for concentration to about 84 Wt.% Urea. Further urea solution is heated to 132°C under 150 MMHGA vacuum by low-pressure steam to attain Urea concentration of 97.5 Wt.% at the outlet of Upper Vacuum Concentrator.
86. In the last stage of this section, concentrated urea solution is fed to Final Concentrator and is heated to 138°C temperature by low-pressure steam. Final concentrator is operated under 25 MMHGA vacuum. After Final Concentrator, Molten Urea Pump, pumps urea (99.8 Wt.%) to Prilling Tower top.
87. Water vapors from the concentration section are condensed in cooling water Surface Condensers and recovered condensate, which contains urea mist, CO₂ and Ammonia is sent to Process Condensate treatment section.

2.3.2.5 Prilling Section

88. 99.8 Wt.% concentrated molten urea solution is sprayed, cooled and solidified to produce prilled Urea in Prilling Tower. Cooling air is sucked through the intake at the Prilling Tower bottom and rises inside the tower. This air is blown out of the Tower by natural draft. Droplets of 99.8 Wt.% molten urea are formed by Prilling Bucket which uses centrifugal force. Urea Prills thus produced are collected through Scraper & are sent to Bagging Plant.

2.3.2.6 Process Condensate Treatment Section

89. The condensate from concentration section is collected in the Process Condensate Tank and then sent to Process Condensate Stripper and Urea Hydrolyzer for treatment.
90. Process Condensate Stripper and Urea Hydrolyzer is operated at the pressure of 3 Kg/cm²g & 23 Kg/cm²g respectively.

91. Recovered Ammonia & CO₂ vapors from Process Condensate treatment section are recycled to LP Decomposer of the purification section for recovery.
92. The treated condensate is discharged to off sites and Utility facility for reuse as Boiler Feed water after polishing.

2.4. Utilities and Off Site Facilities

2.4.1. Gadepan-I

• Auxiliary Boilers	:	2 x 80 TPH
• Gas Turbines	:	17.65 MW (1+1)
• Heat Recovery Steam Generation	:	70 TPH (1+1)
• Water Pre-treatment Plant	:	1200 M ³ /hr
• Ammonia Cooling tower	:	28000 M ³ /hr
• Urea Cooling tower	:	16000 M ³ /hr
• DM Water Plant	:	3 x 90 M ³ /hr
• Urea Silo	:	40000 Tons
• IGG Plant Capacity	:	600 NM ³ / hr
• Main Air Compressor Capacity	:	3500 NM ³ /hr
• Auxiliary Air Compressor Cap.	:	1000 NM ³ /hr
• Raw Naphtha Tanks	:	5000 KL
• Purchased Power from Rajasthan State Electricity Board (existing)	:	2.5 MV (132 KV)

2.4.2. Gadepan-II

93. Additional facilities / expansion were carried out in following utilities and Offsite facilities during execution of Gadepan-II Project:
 - Auxiliary Boilers : 1x160 TPH
 - Ammonia Cooling Tower : 25,500 M³/Hr
 - Urea Cooling Tower : 15,800 M³/Hr
 - Water Pre-treatment Plant : 400 M³/Hr
 - Raw Naphtha tank : 3X16810 KL
 - Sweet Naphtha tank : 5000 KL
 - Water Pre-treatment facilities
 - DM Water Plant
 - Emergency DG Set
 - Instrument Air Dryer and Reservoir
 - Naphtha Storage and Transfer facilities
 - Additional Bagging facilities
 - Additional Lines in the Railway Siding
 - Effluent Treatment facilities
 - Additional Safety and Fire Fighting facilities
 - Ancillary and Communication Equipment
 - Township & Greenbelt

94. The electric power requirements of the expansion project are met from the existing captive power generation facilities. No addition to the existing power generation facilities has been done.
95. **Note:** Since April 2006, CFCL – Phase-II Plant has started receiving regasified –LNG from Petronet resulting into substantial reduction of naphtha usage. From 1st January 2007, entire RLNG requirement has been met through new Vijaipur – Gadepan pipeline. Therefore naphtha facilities are used in extreme exigencies when there is interruption in NG/RLNG supply.

2.5. Existing Infrastructure

2.5.1. Railway Siding

96. The existing railway line is coming from Bhonra railway station on Kota-Bina section into the plant.
97. Four Railway lines were installed originally in the existing siding, two for Urea loading, one for Naphtha unloading and one for engine escape. Two more lines were added. Together with these two additional lines and some changes in layout of existing 4 lines, the number of lines available for Urea loading have increased from two to four, for naphtha unloading from one to two and any free line is available for engine escape. Company operates without any Loco Engine, which is an example in itself.

2.5.2. Raw Water

98. Water requirements for the existing plant are drawn from Kalisindh River, which is 6 KMS away from the site. In order to carry out rain water harvesting CFCL has constructed an anicut (with due approval from statutory authorities) over the river Kalisindh for water harvesting and storage.
99. The existing plants receive water from Kalisindh River through 4 pumps installed on a Jack-well at the River. The impellers of these pumps have been modified to give higher capacity to meet the requirement of the expansion project as well. The main pipeline from the river to the Plant was augmented during GP-II expansion project.

2.5.3. Transportation

100. Natural gas, the main raw material, is available to the project site through pipeline from GAIL terminal at Vijaipur (MP). The finished product “bagged urea” is transported by rail & road.

2.5.4. Ammonia Storage

101. Two double-walled integrally refrigerated atmospheric pressure storage tanks for ammonia are available. Each tank is having storage capacities of 5000 MT.

2.5.5. Urea Storage

102. The urea silo has capacity of 40,000 MT of urea.

2.5.6. Naphtha Storage

103. Naphtha storage capacity of 60,430 KL is available (3 tanks of 16810 KL capacity each & two tanks of 5000 KL capacity each).

2.5.7. Fire Fighting Facilities

104. Fire Fighting Facilities are adequate and designed as per TAC requirements.

2.5.8. Other Facilities

105. The basic infrastructure facilities such as road, drainage, communication etc. have been developed.

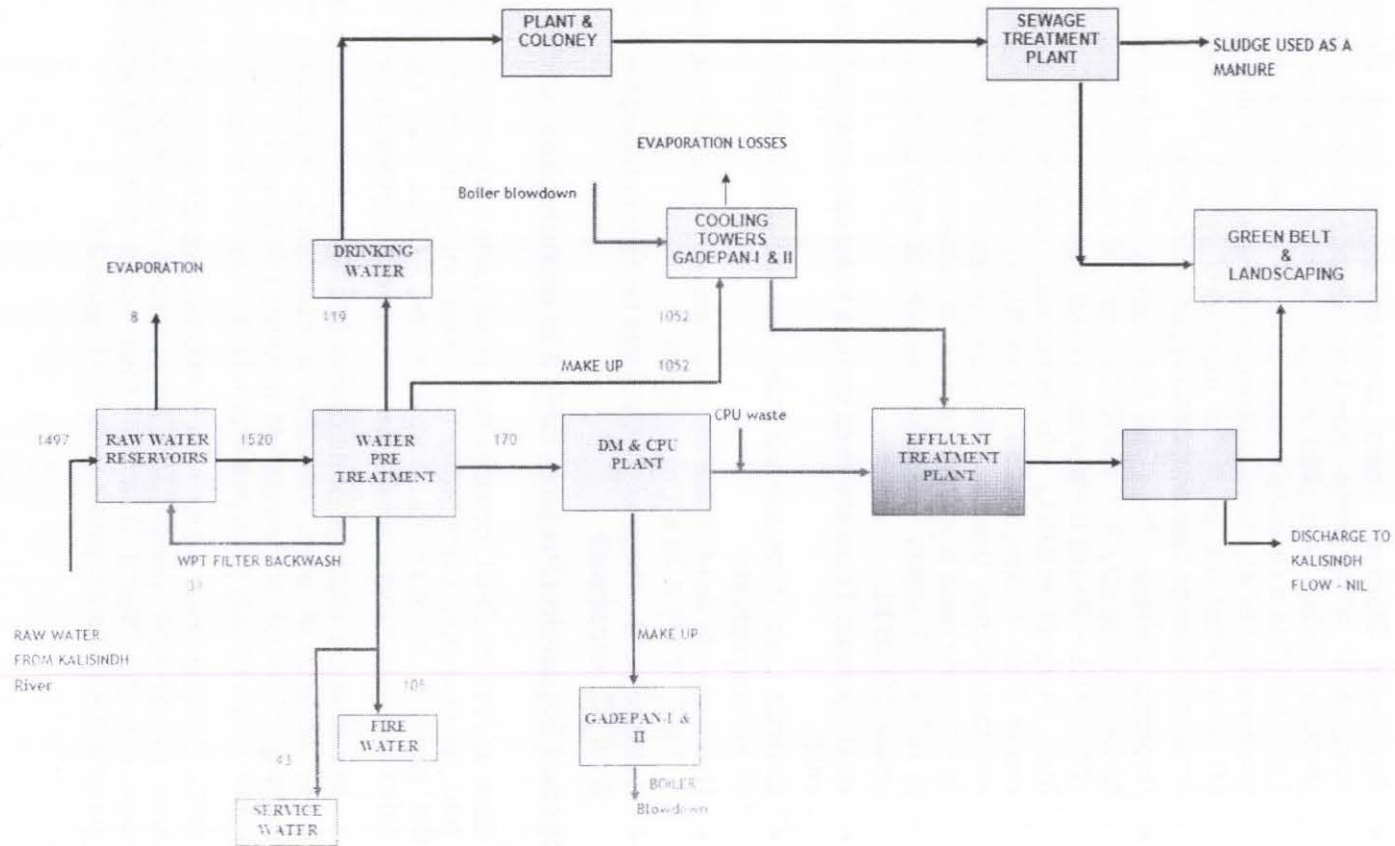
2.5.9. Effluent Disposal

106. Treated effluent from Gadepan-I & II plant is being used for the green belt development around the plant and in the colony. However, the excess effluent in monsoon season due to rain water surface run offs is discharged into the river Kalisindh only during rainy season.

2.5.10. Water Management

107. The total water requirement for Gadepan - I and Gadepan - II is around 1497 m³/hr. The water from the river is received in two reservoirs at site (Cap. 60000 M³each). Raw water is treated in the water pre treatment plant by clariflocculation and sand filtration. The existing water balance is shown in **Figure 2.5**.

POST REVAMP WATER BALANCE FOR GP-I & GP-II PLANTS



NOTE: ALL VALUES ARE IN TON/HR

Figure 2.5 : Existing Water Balance Diagram (Post Revamp for GP-I & II)

2.5.11. Storages of Important Chemicals and Fuels

108. Some of the important chemicals and liquid fuels stored in bulk are as follows:
- **Ammonia Storage:** There are two double-walled integrally refrigerated atmospheric pressure storage tanks for storing ammonia during urea plant outages or other related problems. Each tank has a capacity to store 5000 MT of Ammonia. Normally the inventory of Ammonia (maximum) in the tanks is around 4000 MT only. After the proposed expansion project no change in Ammonia storage capacity is envisaged or proposed.
 - **Naphtha Storage:** There are five floating roof Naphtha storage tanks with capacity 3 X 16810 KL and 2 X 5000 KL. Since April 2006 CFCL – Phase-II Plant has started receiving regasified –LNG from Petronet resulting into substantial reduction of naphtha usage. From 1st January 2007, entire RLNG requirement has been met through new Vijaipur – Gadepan pipeline. Therefore naphtha facilities are used in extreme exigencies when there is interruption in NG/RLNG supply. Naphtha inventory is maintained minimum (around 5000 KL).
 - **HSD Storage:** There are three storage tanks with capacities 20 KL each.
 - **Caustic Lye:** There are two tanks with capacities 33.35 MT and 90 MT respectively.
 - **Hydrochloric Acid:** There are three storage tanks with capacities 118 MT, 75 MT & 70 MT respectively.
 - **Sulfuric Acid :** There are two storage tanks with capacities 90 MT & 30 MT respectively

2.6. Proposed Expansion Project - CFG 3 to manufacture 'Urea'

109. Each section of CFCL complex has been performing very well right from the inception. Considering the consistent good performance of the plant & in order to improve further, CFCL has completed debottlenecking project to increase the capacity of existing plants.
110. In view of acute shortage of nitrogenous fertilizer in the country and heavy imports of urea, company is considering expanding their existing capacities at Gadepan to produce additional 1.2 Million Ton Prilled urea annually through a brown field expansion Project (CFG3).
111. CFCL plant occupies a total area of 400 hectare. Existing constructed area include main plants, area for proposed expansion, Storages/ ware houses, Effluent Treatment Plant, plant office, township and green belt etc. Plant layout is shown in **Figure 2.6**.

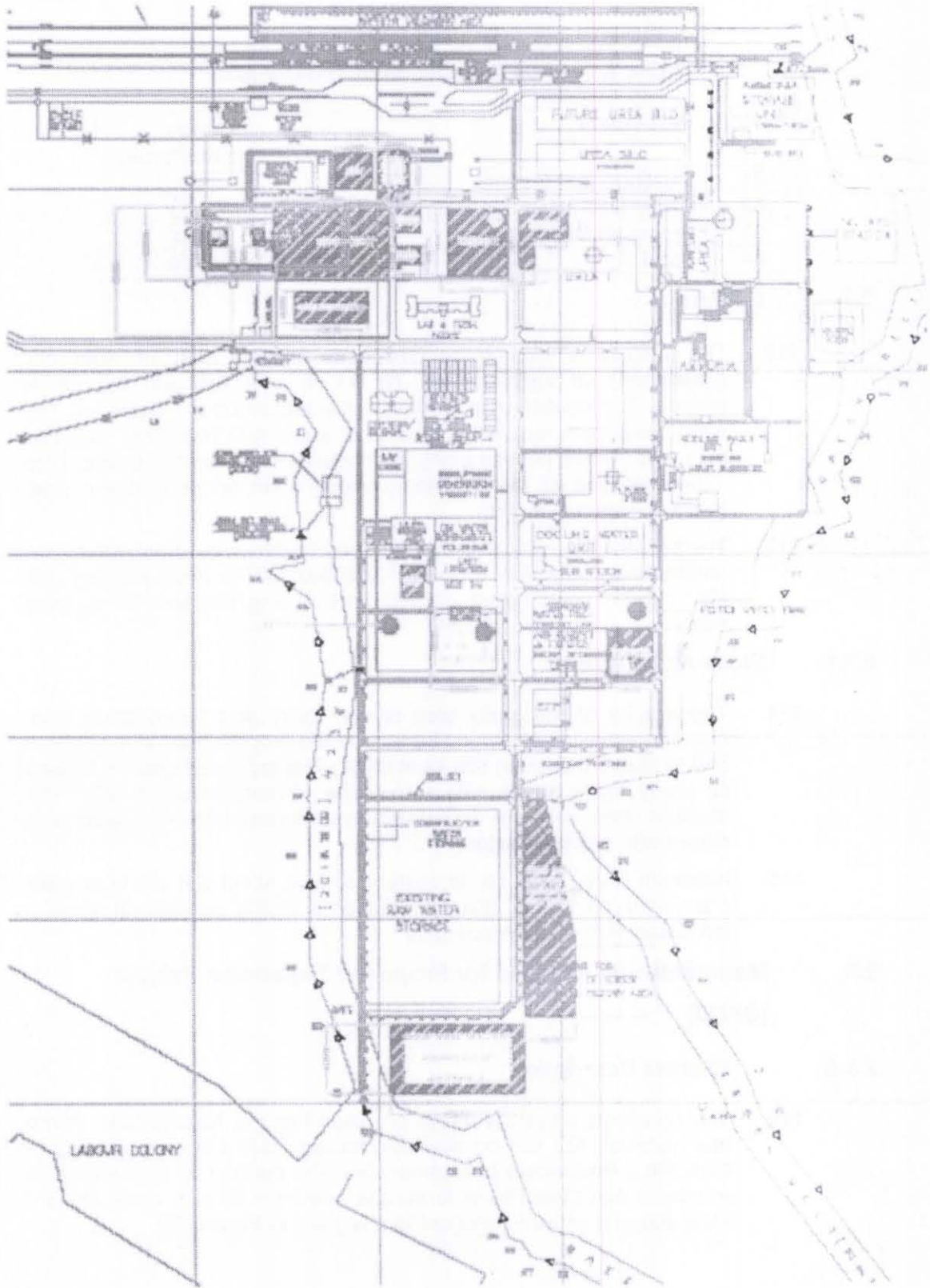


Figure 2.6 : CFG-3 Plot Plan

Table 2.1 : Land Distribution of The Complex

S. No	Particulars	Area (in Hectares)
01	Existing Plant facilities	180.6
02	Green Belt, Land Escaping & Township	213
03	Proposed CFG3 Project	6.4
04	Total	400

2.7. Location

112. The project is located at Gadepan, 35 km East of Kota city (Rajasthan), at approximately 76° 11' E longitude and 25° 08' N latitude. The location map for the plant is presented in **Figure 1.1**. The plant complex is located in an area of about 400 Hectares. National highways NH-76 passes along the complex on its northern side. Bina – Kota section of railway line is about 1 km on its northern side. Nearest Airport is at Kota.
113. The present EIA is for the manufacture of Ammonia – 6,90,000 MTPA (intermediate product), Urea – 12,00,000 MTPA (final product), 18 MW captive power plant, 60.TPH HRSG and RO unit (of suitable size).

2.7.1. Study Area Features

114. Topography of the study area is flat, rocky and nearly plain land. Average elevation of ground surface at the proposed location is about 249 m above the mean sea level (MSL). The proposed plant is located on partly rocky terrain with some area of medium black soils. The medium black soils are dark brown to dark grey brown in colour and clayey with blocky structure.
115. Kalisindh River flows on its eastern side at about 6.0 km from plant site. Right main canal (Chambal canal) is in SW direction at about 3 km distance from plant boundary.

2.8. Manufacturing Process for Proposed Expansion Project (CFG3)

2.8.1. Process Description

116. The proposed project is based on clean fuel i.e. Natural Gas as the raw material. NG will be available through Gail pipe line (source – GAIL/RIL). Preliminary assessment is on for state of art technology for Ammonia and Urea Plants to achieve minimum Energy consumption. Flow diagram of the Ammonia Plant is given in **Figure 2.7**.

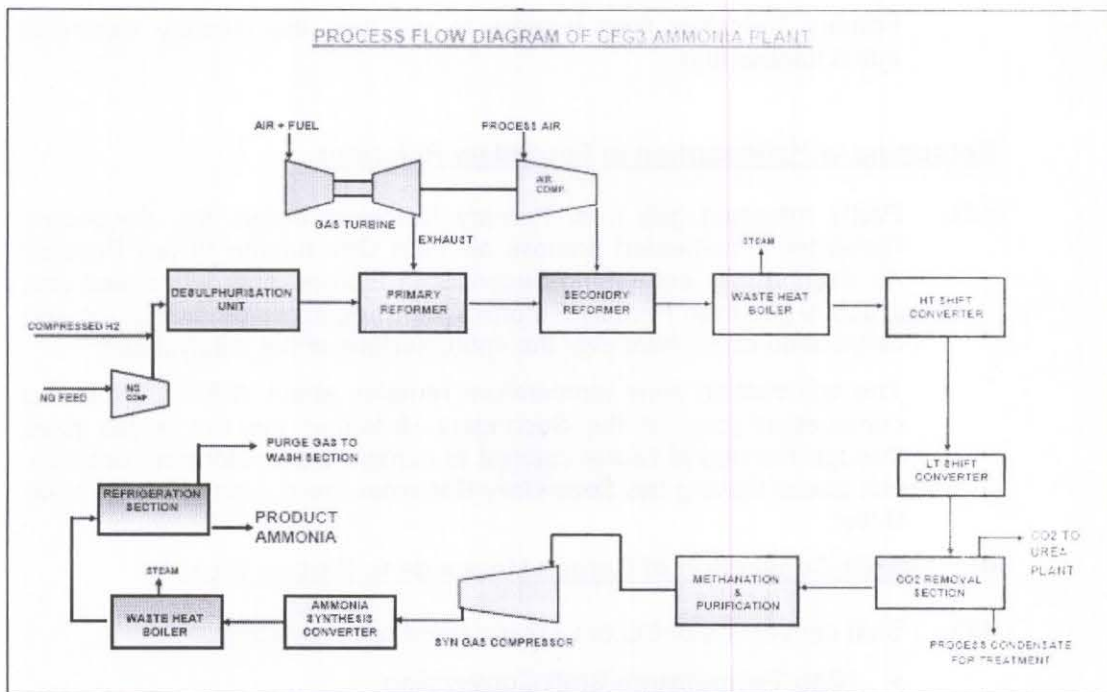


Figure 2.7 : Proposed Flow Diagram of CFG3 Ammonia Plant

117. The process steps are described in the following paragraphs.

2.8.2. Ammonia Manufacturing Process

118. The ammonia production process is based on natural gas feed stock which involves the following steps:

- a) Feed Desulfurization
- b) Reforming of Hydrocarbons
- c) Shift Conversion
- d) Syngas Purification
- e) Ammonia Synthesis & Refrigeration

a) Feed Desulfurisation

119. In this section Natural Gas which contains sulfur compounds is treated for sulfur removal in two step desulfurization process. In first step the heated natural gas is fed to the desulfuriser Reactor with Hydrogen rich stream, where sulfur is converted in to Hydrogen Sulfide & in second step Hydrogen Sulfide is adsorbed in ZnO Reactor.

b) Reforming of hydrocarbons in Primary Reformer

120. NG feed after removal of sulfur is fed into the Primary Reformer along-with Process Steam. In Primary Reformer reforming of Hydrocarbons take place in the presence of Nickel catalyst. Reforming reactions are endothermic in nature and require constant heat input from the

Primary Reformer fired burners to maintain the Primary Reformer outlet temperature.

Reforming of Hydrocarbon In Secondary Reformer

121. Partly reformed gas from Primary Reformer enters the Secondary Reformer. Pre-heated process air from Gas turbine driven Process Air Compressor enters into Secondary Reformer and gets mixed with process gas from Primary Reformer resulting in rapid combustion and distribution of the heat over the entire surface of the catalyst bed.

The combustion zone temperature remains about 1250°C. From the combustion zone of the Secondary Reformer the hot gases pass through the bed of Nickel catalyst to complete the reforming reaction. Hot gases leaving the Secondary Reformer are cooled in Waste Heat Boiler.

c) Shift Conversion of Carbon Monoxide to Carbon Dioxide

122. Shift conversion of CO to CO₂ is carried out in two steps:

- **High Temperature Shift Conversion**

123. High temperature shift converter contains a single bed of iron based catalyst. The gas/steam from Secondary Reformer enters in High Temperature Shift Converter, where a large percentage of CO content is converted to CO₂.

- **Low Temperature Shift Conversion**

124. Low temperature shift converter contains bed of copper based catalyst. The process gas from HT Shift Converter enters into the low temperature shift converter guard; the CO content from LT CO Converter outlet is about 0.3 %.

d) Syngas purification

125. Raw synthesis gas is processed for removal of carbon dioxide and carbon monoxide to yield a Hydrogen / Nitrogen synthesis gas of high purity.

- **CO₂ Removal**

126. The CO₂ Removal section accomplishes removal of carbon dioxide & yields a synthesis gas with less than 0.1 vol% of Carbon dioxide. The CO₂ Removal section containing 30 % aqueous potassium carbonate solution absorbs the carbon dioxide. The solution also contains additives, which improve the CO₂ absorption rate, inhibit corrosion and helps to control foaming of the solution. Flashing, under low pressure into a CO₂ Stripping Tower, regenerates the rich solution from bottom of the CO₂ Absorber. The Stripper overhead vapors are cooled and the Carbon Dioxide product is separated from the condensed water and delivered to Urea Plant.

- **Syngas Purification Methanation**

127. Synthesis Gas from the CO₂ Absorber outlet flow to the Methanator for removal of residual carbon oxides by reacting the oxides of carbon with Hydrogen over a catalyst bed producing methane and water. Methane acts as inert in Ammonia synthesis reaction.

e) **Ammonia Synthesis & Refrigeration**

• **Ammonia Synthesis**

128. Methanator outlet synthesis gas is compressed by a turbine driven centrifugal Synthesis Gas Compressor. Discharge of the compressor is directed to the Ammonia Converter, which consist of a high-pressure shell containing Iron based catalyst and heat exchanger. In the presence of the Iron catalyst a portion of the total hydrogen and Nitrogen combine to yield Ammonia at a concentration of about 17%. The synthesis reaction is given as below:



129. The converter exit gas is cooled in the Waste heat Boiler, further cooling is accomplished by heat exchange with the converter feed gas and then with cooling water. The synthesis gas then flows through the Ammonia chiller. At the outlet of Ammonia chiller the cold stream enters the Ammonia Separator where liquid Ammonia is removed & is let-down to the Ammonia Let-Down Drum. Vapors from the Ammonia Separator pass to the recycle stage of the Synthesis Gas Compressor. Liquid Ammonia from the letdown drum is sent to the Urea Plant.

f) **Ammonia Refrigeration System**

130. Refrigeration system provides refrigeration for Ammonia condensation in Synthesis loop & synthesis gas compressor make-up chilling. Refrigeration Compressor discharge flows to Ammonia Condenser & after condensation liquid Ammonia is collected into Refrigerant Receiver. From Refrigerant Receiver, hot Ammonia is pumped to Urea Plant. Cold Ammonia from the coldest chamber of chiller can be pumped to Ammonia Storage Tank in case of tripping of Urea plant.

g) **Process Condensate Recovery**

131. The process condensate from the separators is treated in a process condensate stripper to remove Ammonia, CO₂ and Methanol. The purified condensate is sent to DM Plant for complete recycle.

h) **Carbon Dioxide Recovery (CDR) Unit**

132. As the NG/RLNG proposed for feed & fuel for CFG 3 is lean gas, its carbon content is low. Thus to match ammonia and urea production, excess syngas will have to be recycled back to reformer as fuel.

In order to match this Ammonia and Urea production imbalance, CFCL has considered to set up a CDR unit which will not only achieve the above target but also help in reducing CO₂ gas emission in atmosphere, a step towards Green House gas emission reduction.

In CDR unit, flue gases from ID fan discharge of Ammonia Plant are passed through an absorption Vessel where CO₂ from flue gases are

absorbed in an Amine Solution. The Solution is then regenerated in a stripper and liberated CO₂ after compression shall be sent to Urea Plant through main CO₂ header. The CDR unit will produce CO₂ for existing Gadepan -1 and Gadepan-2 plants also.

2.8.3. Urea Manufacturing Process:

133. The Urea production process involves the following steps:

- a) Urea Synthesis
- b) Urea Purification
- c) Urea concentration
- d) Urea Prilling
- e) Process Condensate Treatment

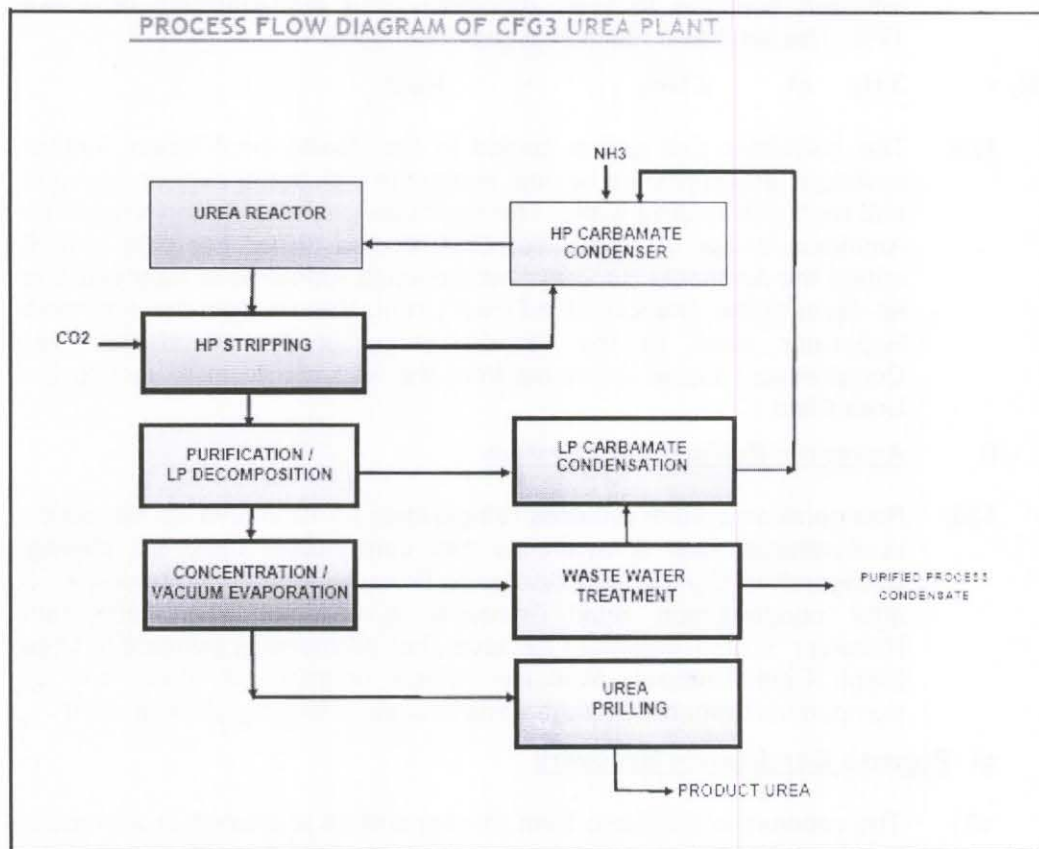
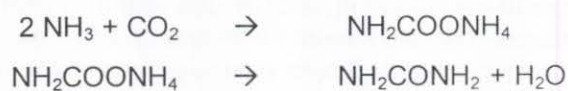


Figure 2.8 : Flow diagram of the Urea Plant

a) Urea Synthesis

134. Urea is produced by reacting liquid ammonia and gaseous carbon dioxide at about 170°C to 185°C and 13.5 to 14.5 MPa according to the following reactions:



135. In the first reaction, carbon dioxide and ammonia are converted into ammonium carbamate. This reaction is fast and exothermic. In the second reaction, which is slow and endothermic, the ammonium carbamate dehydrates to produce urea and water.
136. The liquid ammonia coming directly from the Ammonia Plant is collected in the Ammonia Receiver. From the receiver, it is pumped by means of a pump and fed to high pressure carbamate condenser. The carbon dioxide is also compressed to Synthesis pressure by a centrifugal compressor and fed to the Stripper for CO₂ Stripping. The overhead gases from the stripper flow to the HP carbamate condenser along with recycle carbamate solution from down stream, where these are condensed and recycled back to Reactor. Condensation of gases at high-pressure results in low pressure steam generation in HP carbamate condenser, which is used in the process. Small quantity of air is added to carbon dioxide for Passivation of the stainless steel surfaces which protects the equipments from corrosion.
137. The reaction products from the Reactor flow to the steam heated falling film type Stripper operating at Synthesis pressure. The mixture is heated as it flows down and the carbamate is decomposed by the stripping action. The carbamate decomposition heat is supplied by steam on the shell side.

b) Urea Purification

138. Urea purification takes place in a Low Pressure Decomposition/recirculation section operating at a pressure of 0.4 MPa. In this section essentially all of the small amounts of non-converted ammonia and carbon dioxide are recovered from the effluent leaving the high-pressure stripper. When solution is let down from high pressure to lower pressure, gaseous ammonia & carbon dioxide are generated. Also the heat required for decomposition is supplied by low-pressure steam generated in the high-pressure carbamate condenser. These gaseous mixtures are condensed / absorbed at low pressure carbamate condenser and recovered carbamate solution is recycled back to the high pressure carbamate condenser. Process condensate is also supplied to the low-pressure carbamate condenser together with the carbamate from the reflux condenser in the process condensate treatment system in order to control the water concentration in this carbamate solution.

c) Urea Concentration Section

139. Urea solution leaving the LP decomposer, containing about 72% by weight of urea, is sent to the urea solution storage vessel. The urea solution is pumped from this storage vessel to the first stage evaporator where the urea solution is concentrated to about 95% by weight. The sub-atmospheric pressure in this evaporator is about 34 kPa and the temperature of the solution leaving this evaporator is about 130°C. This urea solution is sent to a second stage evaporator in which the solution is concentrated to a melt. The urea concentration in this melt is 98.5% by weight. The sub-atmospheric pressure in the second stage evaporator is 3 kPa and the temperature of the melt leaving this evaporator is 140°C.