(i) Unit Profile:

Nagarjuna Fertilizers and Chemicals Limited operates large modern integrated Ammonia-Urea complex laid out in two streams each with Ammonia and Urea plants. The manufacturing facilities are located at Kakinada in the East-Coast of India in the state of Andhra Pradesh. Unit-I, which was commissioned in Aug 1992 comprises a 900 MTPD Ammonia plant and matching 1500 MTPD Urea plant and is fully based on Natural Gas both as feed and fuel. The Ammonia plant is based on Haldor Topsoe's steam reformation process and the Urea plant on Snamprogetti's Ammonia self-stripping process.

NFCL is proud to be accredited with ISO 9001, ISO 14001 & OHSAS 18001. Also it was awarded with the coveted "5 star rating" from the British Safety Council during Jan 2005 for the excellent safety standards maintained.

(ii) Energy Consumption:

Include information on total energy consumption (i.e., coal, oil, gas, electricity and money value). Information on energy consumption in terms of percentage of manufacturing cost should also be presented. Also, it should highlight the specific energy consumption for the period 2004-05, 2005-06 & 2006-07. Good Computer Graphic Presentation related to Specific Energy Consumption may also be incorporated.

Please refer Annexure-2a & 2b.

(iii) Energy Conservation commitment, policy and organization set up

Energy conservation policy:

The specific energy consumption reduction by 1% every year for the next five years.

The copy of the Energy Management Policy has been attached. Please refer Annexure - 1
The organization setup is attached as Annexure-3.

(iv) Energy conservation achievements:

(Include one paragraph write up on each major energy conservation project implemented during the year 2006-07 only.

a. Installation of Fluid Coupling for Ammonia-I Induced Draft Fan Motor Drive has resulted in power saving of nearly 200 kw and also resulted in improving the life of the motor.

Energy Savings	: 8.16 Gcal / Day
Equivalent Savings	**: 14.14 Rs. Lakhs / year**
Cost Incurred	: 18 Rs. Lakhs
Payback	**: 1.27 Years**

b. MS extraction header pressure was gradually brought down from 24.5 to 21.5 kscg at a plant load of 35,300 Nm3/hr which has resulted in energy Saving of 0.355 TPH of high pressure (KS) Steam.

Energy Savings	: 2277 Gcal / Yr
Monetary Benefit	**: 11.95 Rs. Lakhs / year**

(v) Energy conservation plans and targets

The main target set is the implementation of the energy audit findings that was conducted between Aug 2004 and Jan 2005. Projects, which don't require investment, have already been implemented and the rest are being done in a phased manner depending upon the quantum of investment required. The projects identified by the team of energy audit have been mentioned in the table under Question number 18. In addition to above new projects will be considered for implementation as per the latest technical innovations, improved reliability and technical up gradations.

(vi) Environment and safety

Environmental protection is an avowed corporate philosophy at Nagarjuna.

Nagarjuna Group's commitment towards Environmental Management is widely appreciated and prestigious awards were conferred:

- 'Environmental Protection Award' in Nitrogenous Fertilizer plants category for the year **2001-02** from Fertilizer Association of India, New Delhi.

- Cleaner Production Award for Good Practices for the year **2003-04** from Andhra Pradesh Pollution Control Board, Hyderabad.

- 'Environmental Protection Award' in Nitrogenous Fertilizer plants category for the year **2004-05** from Fertilizer Association of India, New Delhi.

The Kakinada Plant is built on the principle of zero effluent discharge and is totally Eco-friendly. The complex adopted the strategy of:

- Zero discharge of liquid effluents outside factory premises
- Ambient Air Quality Monitoring and control well within NFCL's standard, which are more stringent than Pollution control board's limit.
- Development of Green Belt.
- To reduce water consumption and effluent generation, a target of 2% reduction every year is being followed. Water consumption in three years (2004-05, 2005-06 & 2006-07) was 6.041, 5.549 & **5.529 m^3 / MT of Urea** product, which is much lower than the Industry Average of **6.100 m^3 / MT of Urea** in 2005-06.

In consonance with this, an integrated Environmental Management Plan (EMP) was envisioned at the conceptualization stage of the project and, as a result, a number of environmental control and monitoring measures have been incorporated in the basic design itself to ensure strict adherence to International standards.

An Environmental Impact Assessment (EIA) was made at the pre-project stage based on which the EMP was developed incorporating all the findings of the EIA. Utmost care was taken to maximize the recycle and reuse of various waste waters generated within the complex.

A number of new technological features implemented in this complex were used for the first time in India. Some of the major pollution control features installed in the process plants are disc oil separators for removal of Oil & Grease, use of low NO_x emission and high efficiency burners in the reformers, de-dusting system for prilling towers in urea plants, dust extraction system in the product handling and bagging plants, non-chromatic cooling water treatment system with chemicals that easily biodegrade, facilities to segregate process, storm/rain water and oily water to enable treatment of pollutants more effectively, impervious lining to all pits and tanks to avoid seepage of any effluent to the ground water system, flare stacks with continuous and dual firing facility etc.

The company has been accredited with ISO 14001 certification (an Environmental Management System) from M/s BVQI, Netherlands effective from May 2004.

The safety and health of all employees is of paramount concern in NFCL. The management is fully committed to maintain the highest standards of safety and health in the work place. The emphasis is on sound safety management systems and practices.

The employee participation is ensured by the Departmental Safety Committees where matters concerning safety are dealt with promptly. The company has won a number of certificates and recognitions from BSC (U.K), NSC (USA) and ROSPA (U.K) for its safety performance. The company has been accredited with OHSAS 18001 certification from M/s BVQI effective since April 1999.

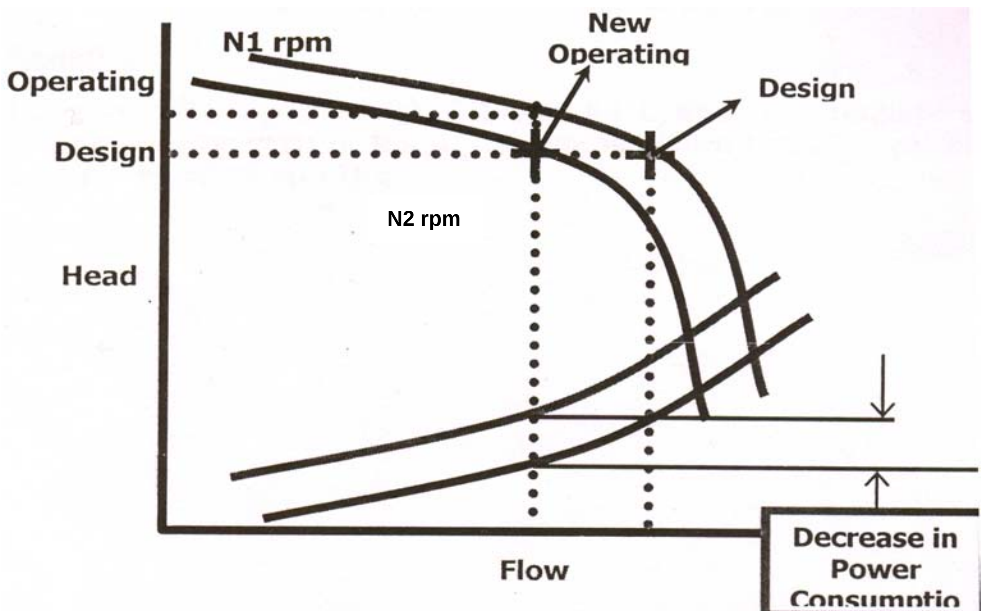
NFCL is actively involved in Implementation of the PSMS (Process Safety Management System) as per OSHA standards. PSMS focuses on application of management controls to operations involving hazardous materials in a way that process hazards are identified, understood and controlled so that process related injuries and incidents can be eliminated. It has totally 13 elements which are being implemented in a phased manner.
The major elements part of PSMS are Process Safety Information, Process Hazard Analysis, Operating procedures, Contractor Control, Safe Work Practices, Training, Pre start-up Safety Review, Mechanical Integrity, Management of Change, Incident Investigation, Emergency Planning and Response, Employee Participation & Compliance Audits and Management Review. Though it is not mandatory as of now for Indian Industries, NFCL is implementing the same out of commitment and involvement towards safety.

Projects for the Year 2006 to 2007:

1. Fluid Coupling Installation for Ammonia-I Primary Reformer ID Fan:

In Ammonia plant, Primary Reformer is one of the major energy intensive equipment. The primary reformer is balanced draft, side fired furnace. During normal operation it was observed that the suction damper of ID (Induced Draft) fan is open by only 20 to 25% even at higher loads. Thus the ID fan was running in an inefficient zone due to over design capacity of fan that is driven by electric motor at constant speed. The fan has two drives namely turbine and motor with in between clutch arrangements. Motor drive is preferred to turbine owing to higher efficiency. The rpm of motor and fan is fixed by the frequency (Hz).

The motor power consumption and fan efficiency were 883 Kw and 51.2 % respectively. Normally for these types of fans, 75% of efficiency can be achieved. Too much throttling of Inlet dampers was causing higher pressure drop and inefficiency of fan. So, by operating the fan at optimum speed, the inlet dampers opening can be increased and the fan operating point can be shifted towards the best efficiency point. This also results in less suction pressure drop. The following performance curve explains the concept. It can be seen that for the same capacity, by reducing the speed, the efficiency is brought in line with the design curve.



Though VFDs (Variable Frequency Drives) are ideal for these types of applications, owing to cost implication, it was decided to install a Variable Speed Fluid Coupling.

It was very tough to install the fluid coupling due to space and foundation constrain. However, the installation including the modification of existing foundation, modification of base plate to place Fluid coupling and motor were carried out with the technical expertise available within NFCL. There was no consultant involved at any stage of the project. The commissioning of the equipment was done jointly by NFCL and the Fluid Coupling supplier.

The original speed of the fan was 1000 rpm and after installation of the fluid coupling the speed of fan was brought down to 790 rpm which resulted in considerable power savings in the motor. The power consumption after installation of Fluid Coupling was 683 KW. Thus resulted in power savings to a tune of 200 KW. The Fluid Coupling unit continues to run successfully since commissioning. The other benefits of the Fluid Coupling project are

1. Motor can be started on no-load condition which avoids overloading of motor during startup.
2. Motor life is improved as load is considerably reduced.
3. Extended Life of motor and fan bearings.

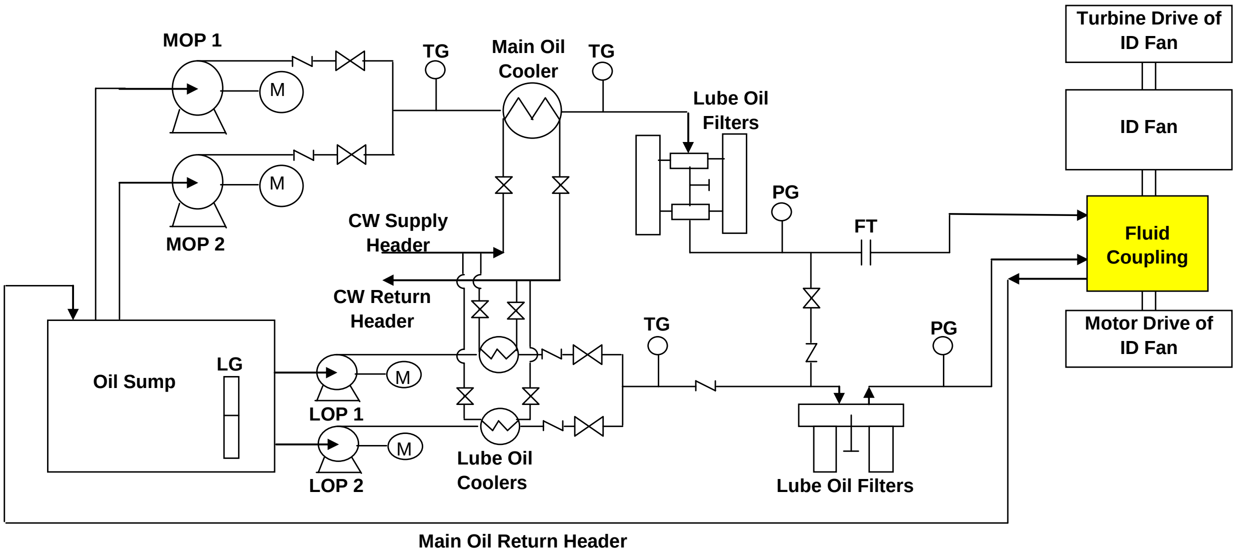
The photographs of the unit are shown below:

Photo showing the oil circuit

Photo Showing the Coupling

The Schematic of the fluid coupling oil circuit has been attached below

FLUID COUPLING OIL CIRCUIT SCHEMATIC



Payback Calculation of the Project:

Total Investment for the Project	:	18 Lakhs
Savings Obtained	:	200 kW
	:	1584 MW/Year
	:	2693 Gcal/Year
	:	14.14 Lakhs/Year
		(Based on NG Energy Cost Rs. 525/Gcal)

2. Lowering of MS Header Pressure in Urea-I

The Urea Plant-1 stripper, made up of Titanium tubes was in service from August 1992 to April 2005. The stripper was reversed in May 1996 to extend its operating life as the Titanium material had eroded in the upper zones. In the year 2000, the stripper tube ends were modified by Zirconium bush insertion into the tube and also fixing of 2RE69 adapters to the tube ends. Ferrules were placed / fixed on the adapters unlike earlier arrangement of directly fixing to the tube ends.
In view of deteriorating performance of stripper, to achieve maximum stripper bottom temperature, the MS header pressure was being maintained higher than PFD value. The MS extraction header pressure was 24.5 kscg and the Titanium Stripper shell side pressure was 23.5 kscg. The maximum stripper bottom temperature that could be achieved was 198 Deg C for CO_2 feed rate of 31,500 Nm3/hr.

The stripper was replaced with new Bi-metallic Stripper during May 2005. However, the operation continued with MS header pressure of 24 kscg for some period. Based on calculation, the desired Stripper bottom temperature of 204 Deg C could be achieved with a Stripper shell side pressure of 19.8 kscg. But the CO_2 compressor drive turbine extraction steam low pressure trip was set at 20 ksc. The OEM was consulted and clearance obtained to bring down the low extraction pressure trip setting to 18 kscg. MS extraction header pressure was gradually brought down to 21.5 kscg at a plant load of 35,300 Nm3/hr. This has resulted in High pressure steam (KS) savings to the tune of 0.355 MT/hr in the CO_2 compressor drive turbine.

The low MS steam header enabled us to have a correspondingly low supply pressure for the MS steam de-superheating condensate. The reduced MS header pressure permitted us to stop the MS desuperheating pump (MP-104) by making use of the HW header pressure operating at 24 kscg. An interconnection between De-superheating Pump (P-104) and Steam Condensate Flushing Pump (P-110) was made earlier to cater to the emergency requirement during both P-104 failures. This was utilized to stop the P-104 pump and thereby open the HW to the MS steam desuperheating station. This change enabled us to stop a 30 kW motor and add further to the savings.

The Detailed Saving Calculation are attached here with

CO_2 compressor drive turbine steam flow changes due to change in MS extraction header Pressure

	Flow	Pressure	Temperature	Enthalpy
	Kg/hr	kscg	Deg C	Kcal/kg
Before the change				
25/05/2005 'A'				
KS	81642	101.6	498.6	803.3
Extraction MS	67107	23.03	333.1	736.8
LS	24921	3.77	152.0	655.6
Exhaust (7% wetness)	39456	-0.89	48.5	577.3

Turbine Power (Thermal efficiency not considered) 11.275 MW

The following calculation is based on:

1. The MS extraction pressure was reduced from 23.03 to 21.415 kscg while the flow was constant at 67107 Kg/hr.
2. The LS injection pressure and flow were maintained constant at 3.77 kscg and 24921 Kg/hr
3. The benefit gained through MS header pressure reduction was converted to KS gain.
4. The total power output from the Turbine is same as before.

After the change				
KS	81270	101.66	498.6	803.3
Ext MS	67107	21.42	329.2	735.5
LS	24921	3.77	152.0	655.6
Exhaust (7% wetness)	39084	-0.89	48.5	577.3

Turbine Power (Thermal efficiency not considered) 11.275 MW

KS savings		
As per Calculation	**372**	**Kg/hr**
As per Simulation	**355**	**Kg/hr**

Total Energy Savings of the Scheme : 2277 Gcal/Yr
Monetary Gain : 11.95 Lakhs/Yr

PROCESS DESCRIPTION

AMMONIA PROCESS

The feed stock natural gas is desulphurised by conversion of stable organic sulphur compounds into Hydrogen Sulphide in presence of Nickel Molybdenum catalyst followed by adsorption of Hydrogen Sulphide on Zinc Oxide bed. The desulphurised natural gas is mixed with super heated steam to give steam to Carbon ratio of 3.3:1, preheated and fed to the catalyst tubes in Primary Reformer. The Primary Reformer is a side-fired furnace with radiant burners. The natural gas, which is predominantly methane, undergoes following reactions producing Hydrogen and Carbon Oxides:

$$CH_4 + H_2O \text{ ------------- } 3\,H_2 + CO - \text{heat}$$

$$CO + H_2O \text{ ------------- } CO_2 + H_2 + \text{heat}$$

The process gas from the tubes is gathered by a collector system and sent to the Secondary Reformer.

The Secondary Reformer is a refractory lined vessel containing Nickel catalyst. Air from atmosphere comes in contact with the process gas from Primary Reformer. Combustion of some part of Hydrogen and Methane occurs consuming the total oxygen in the air and the temperature rises to about 1300 deg. C. This supplies the heat needed for completion of the endothermic reaction in the catalyst bed. Nitrogen needed for ammonia synthesis gets introduced in to the system in the Secondary Reformer through the process air. The gas leaving Secondary Reformer contains residual Methane of 0.6%. The exit gas from Secondary Reformer is cooled to about 380 deg. C in the Waste Heat Boiler where high-pressure steam is generated.

The carbon monoxide formed in the reforming step is converted to CO_2 by water gas shift reaction in two stages, namely, high temperature shift conversion and low temperature shift conversion. The HT shift reaction takes place in presence of iron oxide chromium oxide catalyst and LT shift reaction takes place in presence of copper oxide zinc oxide catalyst. The shift conversion reaction being exothermic, steam is produced by heat recovery.

The reaction-taking place in the shift conversion can be represented as:

$$CO + H_2O \text{ --------- } CO_2 + H_2 + \text{heat}$$

The process gas leaving the CO conversion step contains in addition to Hydrogen and Nitrogen, large quantity of CO_2 and small quantities of CO, Argon and Methane. The CO2 present in the process gas is removed in the CO_2 removal section using Giammarco Vetrocoke process.

Here, CO_2 absorbed in potassium Carbonate solution is regenerated by reducing the pressure and addition of heat in two stage regenerators.

The regenerated solution is pumped back to the absorber. Thus, the system operates in closed circulation. The CO_2 gas stripped from the solution in the regenerators is cooled and sent to Urea plant.

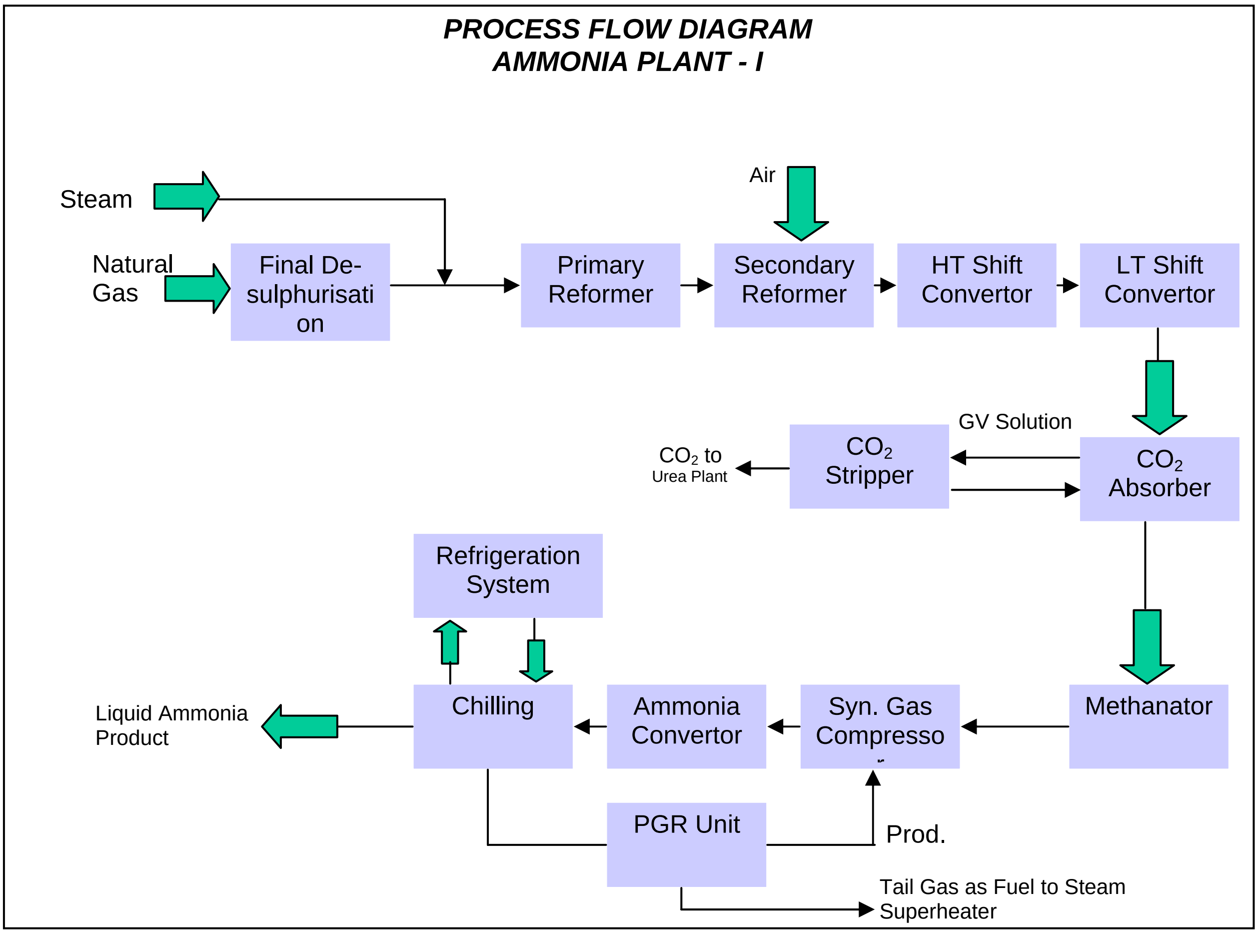
The process gas exit absorber now contains only traces of CO and CO_2. Since carbon oxides act as poison to the ammonia synthesis catalyst, the residual carbon oxides present in the process gas are converted into methane in a methanator reactor containing nickel catalyst. This step is the reverse of reforming reaction and consumes a small amount of hydrogen.

The methanator exit gas after cooling and removal of condensate is the synthesis gas with some inert. This gas is compressed from 24 Kg/Cm^2g to 134 Kg/Cm^2g in a centrifugal syn gas compressor. Also, there is a recirculation stage in the compressor where the recycle of unconverted gas along with the compressed make up gas are further compressed to about 142 Kg/Cm^2g. This gas after pre-heating is admitted to ammonia synthesis converter containing promoted iron catalyst, where Hydrogen and Nitrogen combine to form ammonia with evolution of heat. The ammonia synthesis reaction is:

$$N_2 + 3\,H_2 \text{ ------------- } 2\,NH_3 + \text{heat}$$

The gas from the converter is cooled in a series of heat exchangers including a Waste Heat Boiler. The condensed ammonia is separated and the uncondensed gases are recirculated back to the converter via the recirculator compressor. The product ammonia is cooled to a temperature of -33 deg. C by means of ammonia refrigeration system. The inerts level in the synthesis loop is kept low by taking an inerts purge and sending the same to the purge gas recovery unit where ammonia and Hydrogen are recovered and the remaining off gas is used as fuel. The product ammonia is pumped to the ammonia storage tanks or directly to Urea Plant.

The Process Flow Diagram for Ammonia Plant is shown below:



UREA PLANT

The production of Urea requires ammonia and CO_2 as the inputs, both of which are available from Ammonia plant. The CO_2 from ammonia plant is compressed to about 160 Kg/CM^2 and sent to the Urea Reactor. Liquid Ammonia is pumped using high-pressure reactor feed pump and along with recycle carbamate enters into Urea Reactor. Urea Reactor operates at about 156 Kg/CM^2 and 188 deg. C.

Following reactions take place in the Urea Reactor:

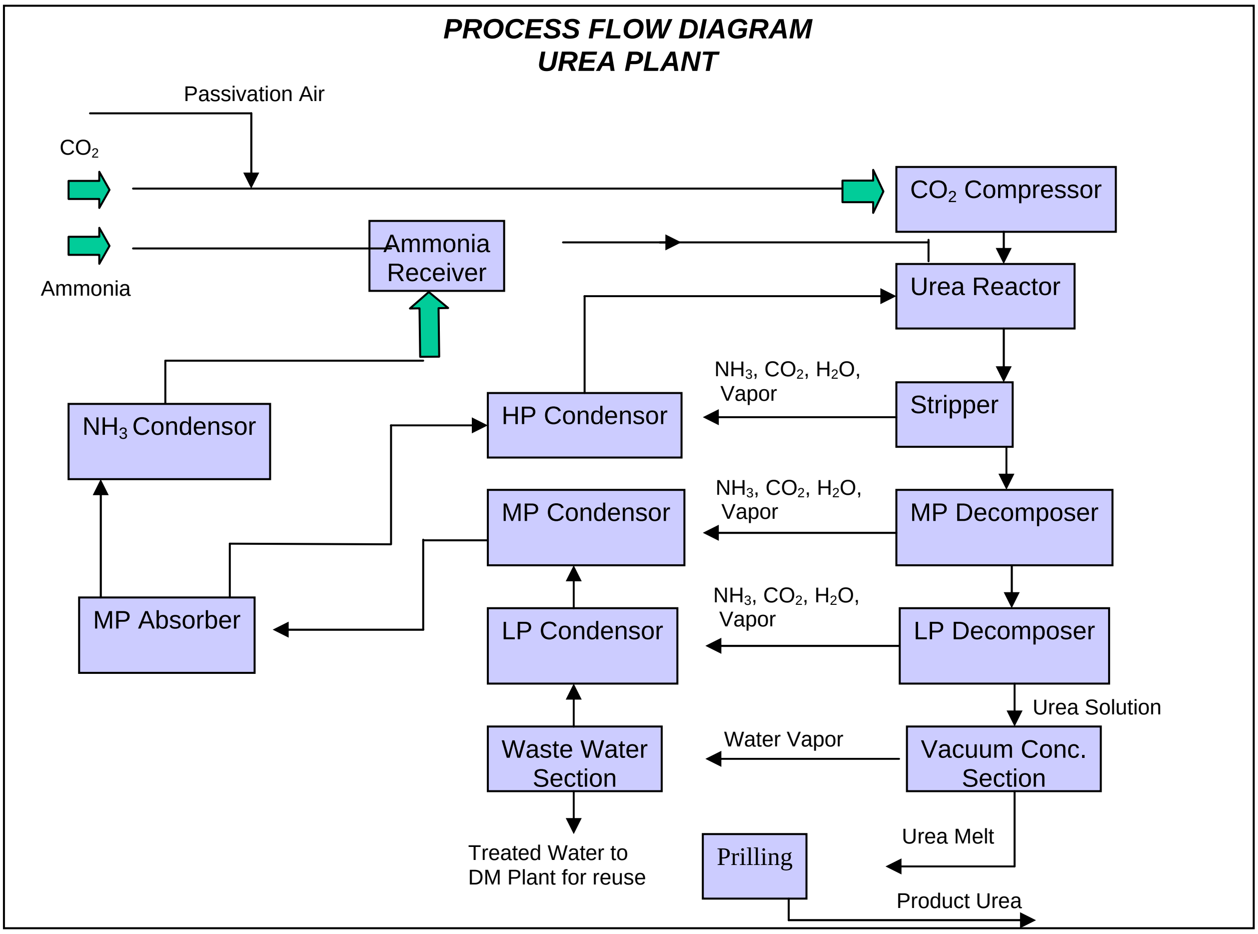
$2\ NH_3 + CO_2$ -------- NH_2COONH_4 (Ammonium Carbamate) + heat

NH_2COONH_4 ----- $CO\ (NH_2)_2 + H_2O$ – heat (Urea)

The product stream from the Urea Reactor contains in addition to Urea, large quantity of unconverted ammonia, CO_2 and water. The ammonium carbamate in the product stream is recovered in three stages viz., high pressure stage, medium pressure stage and low pressure stage by decomposing the carbamate into ammonia and CO_2, separating the gases from the liquid product stream and recondensing the gases back to carbamate solution which is recycled back to the Urea Synthesis Reactor. In this process, the product stream becomes richer and richer in the urea content. In the high-pressure section, separation of Ammonia and CO_2 in the falling film of liquid in the tubes is stripped by ammonia vapour. Medium pressure steam supplies the required heat.

As the Urea Reactor operates with excess ammonia, the excess ammonia is recovered in ammonia condenser. The product stream leaving the low-pressure section contains 70% Urea. This is further concentrated in the vacuum concentrators to get 99.8% Urea melt. This molten Urea is pumped to the top of urea prilling tower and fed into a prilling bucket. The prilling tower of 22-M diameter and 75 M free fall height operates under natural draft. The Urea Prills from the bottom of the prilling tower are transported through mechanized belt conveyor system into urea storage silo or directly to urea bagging plant. The bagged urea is dispatched by rail wagons/road trucks.

Process Flow Diagram for Urea Plant:



Schematic Diagram showing the production process of the entire complex:

OVERALL MATERIAL FLOW DIAGRAM