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INDIAN FARMERS FERTILIZER CO-OPERATIVE LIMITED

KALOL UNIT

TECHNICAL DEPARTMENT

TECHNICAL MANUAL

ON

PURGE GAS RECOVERY PLANT.

FEBRUARY, 1980

LIST OF CONTENTS.

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CHAPTER-1

INTRODUCTION

Inert gases like argon, methane and helium, present in the synthesis loop, tend to reduce the partial pressure of the reactants; nitrogen and hydrogen, thereby reducing the equilibrium conversion in the synthesis gas converter. Moreover the presence of these inerts is wasteful for converter capacity and the effect is cumulative because of closed-loop system. So after the maximum recovery of ammonia from the loop, uncondensed gases are "expurgated" out at a fixed rate through Flash Gas Chiller (126C).

Purge gas from 108-F is used at present as a fuel in the Reformer Furnace, thereby loosing a definite quantity of hydrogen in it. With rising cost of energy, burning of hydrogen cannot be considered an economical proposition. Recovery of hydrogen for reutilisation received an attention of Ammonia plant owners. A number of design-engineering firms came out with various processes for the hydrogen recovery thereby proposing an increase of ammonia production.

IFFCO considered recovery of hydrogen for boosting the ammonia production in latter part of 1977. This was necessary not only to run urea plant at higher loads but also to supply adequate quantities of ammonia to Kandla unit for running NPK plant also at higher loads.

At IFFCO, Kalol unit, normal purge rate is 8000 NM^3/Hr from the synthesis loop. However, it is desired to run the plant at 1000 Te/day capacity . Also considering the capacity limit--ation of syngas compressor detailed material and energy balance calculations were made and a capacity of 10000 NM^3/hr. was finalised. Ammonia content of the purge gas works out to about 4Te/day.

Evaluation of various technologies was made and cryogenic technology was selected . Briefly these technologies are described in Chapter-2.

An order for a purge gas recovery plant was placed on L'Air --Liquide, France in May, 1978. Details of IFFCO's PGR plant are described in Chapter-3 and onwards.

CHAPTER-2

EVALUATION OF PROCESSES FOR LOWERING HYDROGEN LOSS

For the recovery of hydrogen from the purge gas, number of technologies are developed. In one process a converter is used for reacting hydrogen and nitrogen into ammonia with high inerts. In another process, attempts are made to reduce the inerts in the synthesis make-up, thereby minimizing the purge flow. Other processes are based on physical separation and they are aimed at recovering hydrogen with maximum rejection of inerts and recycle to the synthesis loop.

1. PURGE GAS CONVERTER.

The process is based on sound principles of ammonia conver-sion in a catalytic reactor. Pullman Kellogg offer this technology. Purge gas after compression is sent to a quench bed catalytic converter to form ammonia. Gases from the converter are cooled and ammonia is separated by chilling the gases. Exit gases from the chiller are divided into two portions; one is recycled while another (smaller portion) is purged out as a fuel gas.

Although the process has a sound footing, it is yet to be proven commercially. The quench bed reactor requires 9.5M^3 catalyst against 64.2M^3 catalyst packed in base ammonia plant. Thus the space velocities are much lower than those in the existing reactor.

The level at which refrigeration is required is - 23.4°C with the help of ammonia as a refrigerant. Kellogg proposed a package refrigeration unit in case the existing refrigerant compressor in ammonia plant (105-J) is limiting.

2. ENGELHARD'S SELECTOXO PROCESS:-

Methane, an inert in the synthesis loop, finds its source from two places namely (i) slippage of methane from secondary reformer (0.3%) and (ii) slippage of carbon monoxide from the low temperature shift converter. Selectoxo focusses attention on the latter source of methane. The process is not a replacement for water-gas shifting which produces hydrogen, but rather a follow-up to shift conversion. The purpose of this process is to save hydrogen when it is not economical to shift further.

Shifted gases are cooled in a heat-exchanger and condensed water is separated in a knock-out drum. Water-free gases, alongwith air, after being further cooled, are sent to a catalytic bed. The catalyst is highly selective in the sense that it promotes the conversion of CO into CO_2 and restricts the oxidation of hydrogen. Carbon-di-oxide, thus formed, is removed in the subsequent step.

Selectoxo claims that CO content of the feed can be reduced to 0.03% (v/v) from 0.4%(v/v) which would lead to increase in ammonia production by about 35 Te/day. Though the argon content increases from 0.23%(v/v) to 0.24%(v/v) yet the purge is drastically reduced to 40-55% of the original purge. Selectoxo unit will also allow a considerable flexibility in scheduling shift-catalyst change-outs by extended operation at high CO leakages.

A few plants have adopted this technology in last couple of years but certain problems are experienced in operation which are being resolved.

Both the above processes are based on chemical reaction principles; one which converts purge H_2 and N_2 into ammonia partially while another converts CO into CO_2 , thereby reducing the inerts inthe purge.

3. PRESSURE SWING ADSORPTION (PSA) SYSTEM.

There are a few physical separation processes which separate hydrogen or hydrogen/nitrogen mixture for recycling and production of additional ammonia. One such system is PSA system.

The application of this system inthe separation of oxygen from air is extended to the separation of hydrogen from the purge gas of ammonia plant.

It involves an unit comprising of multiple of four beds containing mixture of molecular sieves. When a mixture of gases, containing hydrogen is passed under pressure through the unit, all the componentsof purge gas except hydrogen at high pressure, are absorbed. During regeneration, pressure is released thereby letting-off the gases from the absorbent beds.

The major short-coming of the process is that ammonia from the purge gases cannot be recovered. The process has an edge over the other processes in the sense that recovered hydrogen has high purity and the process can be started and shutdown within a short time by push-button on-off operation. But the system is generally used for smaller size plantswhere economy favours such type of systems and marketing of high purity hydrogen is the main aim.

4. SELECTIVE ABSORPTION PROCESS:

This process, like PSA system, is based on the hydrogen recovery from the purge stream and recycling it to the synloop. The process is based on the principle that all the components of the recycle stream have definte solubilities in liquid ammonia which increase with increasing temperature in the range of -20°C to 100°C. Solubilities ar e in order of $H_2 < N_2 < Ar < CH_4$.

In this process, a side stream from the synthesis converter effluent is fed to a plate type absorption column and liquid ammonia at about 80°C is allowed to fall countercurrently to gas from the top. In the upper half liquid ammonia absorbs some of all the four gases and in lower half much of H_2 and N_2 are stripped out by rising vapours. Generated gases containing mainly H_2 and N_2 leave the absorption column and join the recycle loop

Though the process incorporates several high pressure equipments, yet its benefits are two fold-saving of H_2 and N_2 lost in the purge and behefication of argon content of purge gas. Argon content will become approximately 16.6% (v/v) from 4.9% (v/v) in the purge stream. Due to this reason this process can be generally adopted in conjuction with argon recovery unit which would require additional refrigeration load.

Considerable theoretical work is done on this process but commercial exploitation of the process is still not done by any engineering company.

5. MEMBRANE SEPARATION:

In recent years, membrane separation has come out in which permeable membranes, made of hollow fibres are used. The technique is similar to reverse osmosis technique. Monsanto Co. offers this technology with Du Pont membrances. At first, ammonia is removed by water scrubbing. ~~Gas mixture~~, ~~leaving the~~

ammonia is removed by water scrubbing. Gas mixture, leaving the scrubber is passed through two banks of membrane separators in series. Permeated hydrogen from the first bank is sent to second case of syngas compressor while product hydrogen from the second bank is sent to the first case of the compressor. The system is quite simple in operation. A full commercial scale installation in a 600 short tons (544 Te/day) per day ammonia plant is reported which was commissioned in Sept. 1979. Hydrogen recovery of the order of 86% is calimed to have been achieved. Longer experience on the performance of the unit; in particular stability of membrances is necessary to be ascer--tained.

6. CRYOGENIC RECOVERY OF HYDROGEN:

The unit is an 'add-on' unit to the ammonia plant. Dilution of the recycle hydrogen stream by inerts, going to the syn-gas compressor is minimised in this process. As the name of the process connotes, the system involves very low temperature nearly - 193°C. The process is based on the principle that due to wide differencebetween vapour pressure of H_2 and other components of purge gas, hydrogen gets separated. This can be inferred from the following table of normal boiling points at atmospheric pressure. The cooling is mainly a hieved by Joule-Thomson effect i.e. by throttling of a stream from high pressure to low pressure and supplemented by either external refrigeration unit or an expander.

Gas.		Boiling °C at 1 atm abs.
CH_4	-	- 161.6
Ar	-	- 185.8
NH_3	-	- 33.4
N_2	-	-195.8
H_2	-	-252.7

Purge gas having 60.66% hydrogen and 2.22% of Ammonia is scrubbed with water to form about 4% (Wt) ammonia liquor solution which fulfills the requirement for regeneration of anion bed of water treatment plant and for maintaining pH in effluent tank. If necessary, aqueous ammonia solution can be distilled to produce anhydrous ammonia. Scrubbed gases are dried in an adsorber to remove water and ammonia vapour. Ammonia and moisture free gases are sent to the cryogenic exchanger contained in cold box where the gases are cooled by liquid inert stream.

Gases exit exchanger are partially condensed and hydrogen escapes uncondensed. Liquid stream containing most of the inerts is throttled and is used for heat exchange by re-evaporation and heating. The vapourised stream is known as tail gas and is sent to primary reformer as a fuel.

Infiltration of heat from the surrounding into the cold box is inevitable, So additional cooling equivalent to radiation heat gain is obtained by an additional external refrigeration unit.

The reduction of inert content in the loop has a dual effect; conversion per pass increases due to increased partial pressing of H_2 and N_2 and sensitivity of plant operation due to CH_4 slip from secondary reformer and CO-slip from LTS converter is greatly reduced. In the process of condensation, most of the nitrogen is also condensed due its to close boiling point to that of inerts. So more nitrogen (and O_2) must be introduced to secondary reformer in order to maintain $H_2:N_2$ ratio as 3:1 in the synloop, The increased O_2 means greater combustion in secondary reformer. Consequently primary reforming duty is decreased. The process leads to a reduction of about 1.9×10^5 kcal/tonne of NH_3. The process has a few disadvantages too. Start up period of the unit is quite long. Air compressor will be required to be operated at a higher speed.

Cryogenic add-on units are adopted by a number of ammonia plants in the world. The technology is well established and the experience has confirmed that this technology is safe and reliable in operation.

BIBLIOGRAPHY:

1. Cryogenic Recovery of Hydrogen from Ammonia Plant Purge Gas, a paper presented at the Kellogg/ Client Ammonia Club Meeting, held at Atlantic City, U.S.A. on September 2, 1976.

2. Hollow Fiber Permeateor for separating gases, by R.J. Gardens, R.A. Crane and J.F. Hannan, Chemical Engineering Progress, Vol. 73, No. 11, p. 76 (1977).

3. Hydrogen Recovery Unit ups NH_3 - plant Efficiency by R. Banks, Chemical Engineering Vol. 84, No. 21, p-90 (Oct. 10, 1977).

4. Syngas Purifier cuts Ammonia costs by B.J. Grotz, Hydrocarbon Processing, April, 1967.

5. Ammonia synthesis can be Argon source by S. Lynn and C. Alesandrini.

6. Removal of Argon and Methane from Ammonia Plant synthesis gas by C.G. Alesandrini, A.D. Sherman and S. Lynn, Ind. Ergg. Chem. Process Design and Development; Vol. 12, No. 3, p-217 (1973).

7. Improve Ammonia plant yields with Engel Hard's Selectoxo Process by C.M. Buckthorp, a paper presented at the symposium of Science of Catalysis and its Application in Industry, held at Sindri on 22-24th February, 1979.

8. Production of pure Hydrogen by K.S. Raghuraman, and F. Tiemann, a paper by kinetic Technology bv, the Netherlands.

9. An Energy Savings Program in a 600 short ton per day Ammonia plant by D.L. Maclean, C.E. Prince and Y.C. Chae. A paper presented at the 24th Symposium on Safety in Ammonia plants and Related Facilities held at San Francisco, U.S.A. at November, 1979.

10. Explosion of Ammonia Liquor Tank at ICI, CEP Technical Manual on Ammonia plant Safety & Related Facilities Vol.17.

11. Design Guide on Ammonia Liquor Storage by Imperial chemical Industries Ltd., U.K.

CHAPTER-3

PROCESS DESCRIPTION

1. PURGE GAS FROM AMMONIA PLANT.

Followinn diagrams are included at the end of the manual.

1. Process Flow sheet.
   Drg. No. 07 3173 XX-02-00-0-01 Rev. a
2. Notice for diagram (Abreviations used in P&I diagrams)
   Drg. No. 07 3173 A3-014-2 Rev. a
3. P& I diagram of the plant.
   Drg. No. 07 3173 A0-014-1 Rev. J.
4. P & I diagram of Refrigeration Unit
   Drg. No. 07 3173 A0-671-4 Rev. E
5. P&I Diagram for Ammonia Liquor Tank
   Drg. No. 01 DC 01250 Rev. 0
6. Plot Plan
   Drg. No. 07 3173 A1-015-02 Rev. C.
7. Process Efficiencies.
   Document No. 07 3173 XX 02-10-5-01 Rev. 0
   PGR plant is designed for the following conditions.

1.1 Quantity: 10,000 NM^{3*}/HR

1.2 Composition:-

Gas component	Mole %
H_2	61.99
NH_3	2.22
N_2	20.64
CH_4	11.05
Ar.	4.10
	100.00

Helium content, being only 100 to 150 ppm in purge gas, is assumed to be negligible while making material balance.

*NTP=1 atm absolute and 0°C.

1.3 Range of Input pressure and temperature:

Pressure of the purge gas may vary depending upon the amount of inerts content in the syn-loop, which in turn, is governed by the CO-slip of LTS converter, activity of the synthesis converter catalyst, and operation load of PGR plant. Variation in purge gas temperature may also be observed due to various reasons.

The PGR plant is designed for the feed gas temperature range of $-23^{o}C$ to $-10^{o}C$ and a pressure range of 131 kg./cm^2a to 153 kg/cm^2a.

2. PRESSURE LETDOWN AND PREHEATING OF GASES :-

2.1 Reduction of pressure:- In the plant, brazed aluminium exchanger is used in the cold box which is normally not designed to withstand very high pressure say above 55 kg/cm^2a and therefore the pressure of incoming purge gases is reduced by throttling to a pressure of about 47.6 kg/cm^2a through FV-100 B. Temperature of the gas gets lowered down to $-28^{o}C$ due to Joule-Thomson effect. A provision has been made to divert incoming purge gas to tail gas, through FV-100 A at the time of any abnormality in the plant. This valve is designed for high pressure drop across the incoming purge gas and the tail gas. Temperature of gas after FV-100 B is shown by TI-102A*.

Flow of incoming purge gas is metered and controlled by FIC-100, facilitating the operator to vary the plant load. PI-143 indicates the pressure of incoming gas. HV-141 is provided to isolate the incoming purge gas during any abnormality and is interlocked with FV-100 A.

*TI-102 is a multipoint temperature indicator, located in control room. Alphabets refer to push button.

2.2 Heat-Exchange between Demineralised water and Feed gas

Preheating of purge gases is done in the Gas Exchanger (E_3) with the help of demineralised water to utilise 'cold effect' and economise on refrigeration. In the subsequent absorption operation, gas leaves at nearly the same temperature at which water is sprayed in the absorber. Therefore if cooled water is introduced at the top of Washing Tower (K1), gas leaving K1 will be at low temperature and will therefore carry very low moisture.

In case, the gas is not preheated in E3 and the water is introduced at 34°C in K1, it will leave the washing tower at 34°C and the water vapours, carried by the gas, will be substantially higher than the system, proposed in the PGR Plant. Also there is an additional danger of freezing at the bottom of K1 if gas at -23°C is introduced at the bottom of K1. Refrigeration load of the refrigeration unit X1 will increases and the size of absorbers will also increase many fold.

The demineralised water enters into a water tank B-3A located above the Gas Exchanger(E-3) at 34°C(max.) . Flow to this tank is controlled by level control valve LV-103. The gases enter the tube side of a vertical finned-type pipe heat-exchanger, and water travels down in the annulus by gravity. Water capacity B-3B stores cool water at the bottom of Gas-Exchanger. Flow of water through annulus can be observed through FG-107 and FG-117, located at 180°apart, PSV-106 protects E-3 from overpressure.

Level of B-3B is controlled by LIC-105 by controlling the flow of water from B-3A to E-3 . Low level alarm and low level switch are provided to protect the system. A close watch on TI-102C is needed to ensure that no freezing takes place in B-3B.

3.0 Washing Tower: It is an ammonia recovery unit which is a tray column. Plunger pumps p_1 and p2 take suction from the water capacity B-3B and discharges water to Washing Tower (K-1) top at 51.6 kg/cm^2a(max.) and + 3°C(min). Basket type conical stra--iners are provided in the suction of pumps. Normally one pump is in operation while another is a standby. The pumps will trip due to low level in water-capacity(B-3B) and high level in Washing Tower (K1) . PSV-118 and PSV-119 protect the plunger pumps. Low pressure alarm and pressure switch are provided at the discharge of pumps . Gas at -4°C (indicated by TI-102B) enters the tower (K1) from the bottom and water is sprayed from the top. The PGR plant will automatically trip (FSL-115) at low flow of water to the tower. Flow of water to K1 can be controlled with the help of FI-115. This is done by recycling the balances water through HICV-109 to B-3A. Ammonia having high solubility in water at the operating conditions, gets absorbed in it and collect at the bottom of the tower. Dissolution of ammonia in water, being an exothermic process, raises temperature of ammonia liquor to 30°C (max.). Ammonia liquor at 4% as NH_3 (wt.) flows to an Ammonia liquor tank (172-F) via a level control valve LV-134. The provision of ammonia liquor handling facility is described separately in para 12.0.

Level in the Washing Tower (K1) is controlled by LIC-134. A low level alarm LAL-134 and LSL-134 are provided to ensure that no purge gas finds its way to Ammonia Liquor Tank(172-F). High level (LAH-134) is provided and at extra high level (LAHH-134), pump motor trips.

4. ADSORPTION: The gases, almost free from ammonia are analysed for ammonia by a infrared analyser AP-136 A and recofded by AR-136. If the ammonia content reaches 10 vpm. an alarm (AAH-136) will alert the operator. If the temperature of the gases going to drying vessels R1 and R2 exceeds 20°C, an alarm (TAH-135) will give audio-visible indication. The gases going to the drying vessels have following conditions.

4.1 Conditions:-

Flow: 9778 NM^3/Hr.

Pressure: 47.06 kg/cm^2 a.

Temperature: 5^oC to 20^oC

4.2 Compositions:

Gas	Composition (Mol.%)
NH_3	5 vpm
H_2	63.40
N_2	21.11
A	4.19
CH_4	11.30
	100.00

4.3 The Process of Adsorption: The absorption unit consists of two drying vessels R1 and R2. Alumina balls having volume 0.7M^3 occupies thebottom portion of the vessel and Molecular sieves having 0.873 M^3(of 5 A quality) are placed on the grid in the upper portion of the drying vessels. One drying vessel remains in operation while other remains under regeneration.

Alumina adsorbs a major portion of moisture and relative humidity of the gas gets lowered. Molecular sieves, being superperformers at low relative humidity adsorbs all the remaining moisture. Any traces of carbon-dioxide coming from syn-loop and entrained trades of ammonia from washing tower are also adsorbed by molecular sieves.

Hygrometer AR-154 is provided to analyse samples collected from in between alumina bed and molecular sieve bed in R1 and R2, respectively. For moisture content above 3 vpm an alarm (ASH-154) is provided. The process of adsorption continues for 8 hours in a drying vessel in normal operation. After the lapse of this period, change over of drying vessel is automatic.

However a provision is made to change the service cycle period as desired with the help of a timer but the regeneration period is fixed. Since adsorption is an exothermic process, there will be a small increase in temperature of exit gases. Consequently respective valves will also open or get closed. TI-157 and TI-158 indicates temperature of gases leaving R_1 and R_2, respectively. PI-155 and PI-156 indicates pressure of gases leaving the drying vessels R1 and R2 respectively.

4.3.1 Activated Alumina:-

This is a hard, hydrated aluminium exide which is activated by heating to drive off the moisture. The porous product is available as granules or powers and is used as a desiccant for gases and liquids.

Alumina has a wide spectrum of pore diameter(20Å-100Å) and ratio of cavity volume to surface area is smaller than that of molecular sieve. Although per unit mass dehydration capacity of alumina is lower than silica-gel, the final dew point achievable by alumina is lower than that with silica gel . Adsorption is an exothermic process and heat of adsorption on activated alumina is between 1 and 1.3 times the latent heat of condensation of water.

The water adsorptive capacity (gm of water/100 gm mass) of alumina is proportional to the boiling points of adsorbates. Water having the highest boiling point in the purge gas gets adsorbed fastest and in maximum quantity. The adsorptive capacities of activatedalumina and silica gel do not vary much at low relative humidity. Typical specifications of alumina are given in Table-1.

4.3.2 Molecular Sieves: It is a synthetically produced crystalline adsorbent (Zeotities) which behaves as if it is a finely meshed-screen of molecular proportions, enabling the separation of unlike materials based on their size differences on a molecular scale. Those moleculars which have smaller diameter than the "windows" or pores of the sieve will enter the sieve structure and will be trapped in the cavities and unable to move out of sieve structure. Those molecules whose diameter are larger than the windows of molecular sieve crystal will pass through the bed unadsorbed and out into the exit stream unaffected.

Molecular sieves surpass all other adsorbents such as silica gel and activated alumina, as far as adsorptive capacity is concerned at low relative humidity. At 20% relative humidity, absorptive capacity of molecular sieves is twice that of silica gel and alumina, thereby bringing moisture level to a few parts per billion.

Adsorption capacities of silica gel and alumina are roughly proportional to the boiling points of the adsorbates, while the selective adsorption capacity of molecular sieve depend on the molecular size and polar properties of the adsorbates.

Thus, components having almost the same boiling points can be separated with sieve if adsorbate molecular sizes are different. Due to high polarity of water and ammonia, molecular sieve denudes the gas from water and ammonia. Molecular sieves are thermally stable for high temperature service, say more than 570°C and have the ability to withstand several hundred cycles of adsorption and desorption.

Normal life of molecular sieves is about 5 years when the operating conditions are within design limits. Typical specifi-cations of molecular sieves are given in Table-2.

5. REGENERATION.

5.1 Methods of Regeneration:

When an adsorber is exhausted and can not adsorb moisture or ammonia any more, it is to be reactivated by regeneration for reuse. Desorption of water-vapour from the molecular sieve can be done by following methods:

(a) Thermal swing: It involves adsorption at lower temperature and desorption at elevated temperature. Temperature increase can be brought about by direct or indirect heating.

(b) Pressure swing: It involves adsorption at high pressure and desorption at lower pressure.

(c) Dieplacement cycles: It operates on the principle that the displacement fluid is more strongly adsorbed by adsorption bed anc therefore will desorb the saturated bed of prime adsorbate.

(d) Purge-gas stripping: It involves the stripping of adsorbate with a non-adsorbable purge-gas. Higher operating tempe rature and lower pressure aid stripping. At high temperature, the trapped molecules are expelled out of the cavities and enter into purge-gas stream.

For regeneration of the Drying vessels (R_1/R_2), the last method, i.e. purge gas stripping with operation at higher temperature and lowerpressure, is adopted.

5.2 Tail Gas as a Regenerant Gas.

Tail gas is proposed to be used for regeneration. The operating conditions are detailed below:

5.2.1 Flow: 800 NM^3/Hr.
Pressure: 4.39 kg/cm^2a.
Temp.: 8^oC to 23^oC.

5.2.2 Composition of tail gas:-

Gas	% mole.
N_2	44.01
Ar	9.73
H_2	16.81
CH_4	29.45
	100.00

5.3 Regeneration with Tail Gas.

5.3.1. Preheating of Tail Gas: A part of tail gas, leaving the cold-box is used for regeneration of the adsorbent. The portion of the gas pass through the Regeneration Heater(E-4). A relief valve PSV-180 has been provided on the line going to E.4. PI-150 indicates pressure of the tail gas entering into the heater E-4. The incoming gas is metered by F1-149 which is to be controlled. If necessary,throttle KV-120.12 to get desired flow. If the flow through the heater is low (FSL-149) and the heater is on, low flow alarm will be heard. The regeneration heater has nine heating elements each of 9.5 KW. Total rating of the heater is 85.5KW , equivalent to 73530 kcal/Hr. Total rating is split into two ratings; 57 kW and 28.5 kW. The automatic control of tail gas temperature, leaving the heater, is achieved by putting on and off three of the heating elements (making up 28.5 kW energy).

The heater is made explosion proof by static press--urising the cable chamber with cylinder nitrogen. A pressure gauge (PI-205) is provided on the cable chamber to check the pressure of nitrogen in it. A pressure relieving device (PSV-204) is provided on this chamber for over pressure protection.

If the skin temperafure of the heating element is more than 300°C, TSH-148 will give an alarm. TM-146 indicates temperature of gases at the exit of the regeneration heater.

5.5 Activation of the bed: The gases after being heated to 220°C entersinto either of the drying vessels. Timer can be adjusted to get the desired service cycle period for adsorption.

Activation of the bed (say of R2) comprises of the following steps:

(a) Depressurisation of bed by opening KV-120.9 .
(b) Reactivation of bed by passing hot tail gas.
(c) Cooling of the bed by switching off the heater.
(d) Repressurisation of the drying vessel by the other vessel by opening KV-120.11. PDSL-123 indicates differential pressure across the two drying vessels at the time of balancing.

Regenerant gas is passed from top to bottom of the Drying vessel, i.e. in counter current direction of the main flow. This is preferred over co-current regeneration for achieving better regeneration level.

6. WATER SEPARATION: The temperature of the regeneration gases coming from drying vessels is indicated in TI-163 (Normally 150°C). TSL-197 will give an alarm below 25°C, whenever the beds of any of the vessels is cooled by putting off the heater E4.

Water-laden-gases enter into the water Separator (B4) . The gases leaves the Separator at the top and meets the main tail gas line downstream of KV 120.12. Since the operation of adsorption and regeneration involves many steps like cooling, warming, pressurising, depressurising, so temperature of the gases leaving the Separator keeps on varying and is in the range of 50°C to 90°C.

In the initial period, the gas mixture, coming out of the adsorber, will be relatively cool and hence moisture will separate out. As the regeneration continues, the exit gas temperature will rise and water will not separate.

Water from the Separator goes to Florentin-pot (B-5) via a Strainer (FC B4) and automatic trap (PG B4). Any gases which are dissolved in water will be separatedhere and blown-off at a safe height through the cold flare(vent.) Water from the pot(B-5) is drained-off in the sewer under water seal.

7. REMOVAL OF DUST FROM THE GAS:

The gas stream coming out of the Drying Vessels (R1/R2) may contain adsorbent dust produced by attriation of gas and adsorbent bed. This dust is removed in a Drying Unit Filter F1. Whenever the pressure drop across the filter is excessive, it can be bypassed for cleaning purpose. PI-152 indicates pressure of the gas at the exit of the filter while PDI-153 indicates pressure drop across the filter. When the pressure drop across the filter exceeds 0.05 kg/cm^2, PDAH-153 will give an alarm. Temperature of gas stream, leaving F1, is indicated by TI-102.D.

8. SEPARATION OF HYDROGEN (COLD BOX)

The gas coming out of the filter is clean dry and free of ammonia and is ready for sending to the COLD BOX (Cryogenic Unit).

8.1 Composition of gas, at the exit of the filter F1 is analysed by a chromatograph AR-142 (sampling point AP-142.3) . Anticipated composition is given below:

Gas		Mole %
H_2	...	63.4
N_2	...	21.11
A	...	4.19
CH_4	...	11.30
		100.00

Entrainment of ammonia and moisture traces to the cold-box are dangerous because water and ammonia hav high freezing points (0°C and -77.7°C respectively), and will freeze in the cold box thereby choking the valves. Hence ammonia content, at the exit of filter F1 can be analysed by the analyser AR-136(sampling point AP-136B).

8.2 Conditions of gas entering into cold-box.

Flow: 9778 NM^3 /HR

Pressure: 46.86 kg/cm^2a.

Temperature: 10°C to 25°C.

8.3 Heat Exchange: The gas enters the warm end of the Cryogenic Exchanger E-1 and gets cooled to -36.3°C (as indicated by TI-102J) by reverting inert gas and product hydrogen stream. An additional cooling of 3.7°C is achieved by a Refrigeration Unit.(X1). So gases, at -36.3°C enters into the Cooler (E2) of Refrigeration Unit (X1) and comes out at -40°C as indicated by TI-102G. Details of Refrigeration unit is discussed in paragraph 9.0. The cooled gases at -40°C enter the cold end of the Cryogenic Exchanger (E1) for further cooling to -190°C by revert gas stream.

The main aim in the cold-box is to recover maximum hydrogen and nitrogen which can be recycled to the syn-loop of ammonia plant. Recovery of nitrogen facilitates lesser supply of nitrogen (in the form of air) in the secondary reformer to achieve the desired ratio of $H_2:N_2$. From the Process Efficiency curve, it is evident that lower the cold-end temperature, lesser will be the hydrogen and nitrogen recovery and greater will be the inerts rejection. To achieve maximum hydrogen and nitrogen the warmest possible temperature is preferred but to achieve maximum argon and methane rejection, coldest possible temperature shoul be preferred. So a comprise is needed for operation. Temperature control can be obtained with the help TV-183. Lesser the letdown from TV-183 higher will be the temperature in B1.

So temperature of the stream coming out of the cryogenic Exchanger (E1) and going to the Gas separator(B1) is controlled.

8.4 Gas separation: A mixture of liquid from the Cryogenic Exchanger (E1), enters into the Gas Separator(B1). A relief valve PSV-177 and a temperature indicator TI-183 have been provided in the line from the exchanger E1 to the Gas Separator(B1). The liquid collects at the bottom of the separator while the gases escape out from the top. The concentration of the components in the liquid can be found out by the Chromatograph KJS-142 (Sampling point AE 142.4). LIC -185 controls the level in the Gas Separator(B1).

The liquid at -190°C is further cooled to -192.7°C by throttling to 4.55 kg/cm^{2}a from 46.3 kg/cm^{2}a by LV-185. An additional throttling value HCV-186 is provided in the downstream of LV-185. HCV-186 is only necessary during start-up in order to treat a maximum gas flow when there is no liquid. So the purpose of HCV-186 is to accelerate cooling down and achieve the required cooling in the shortest possible period. TV-183 controls the temperature of the fluid stream from E1 to B1 by allowing a portion of hydrogen stream from B1 to throttle down to tail gas stream. The line after the LV-185 going to Injection Separator (B2) is jacketed and a small portion of product hydrogen is passed into the jacket. This provision is made to avoid chances of methane freezing. A small flow of product hydrogen stream at 8°C is introduced in the jacket of tail gas, provided on downstream of LV-185, through HCV-184. It will join tail gas in B2. PSV-181 is provided to protect overpressuring of B-2. Helium has lower boiling point than hydrogen and hence it will escape alongwith hydrogen from B1.

After throttling of the liquid, a part of the liquid will be flashed-off into vapour phase. The liquid and vapours are separated into the Injection-Separator(B2). TI-102H indicates the temperature of fluids in B-2.

Both, liquid and vapour, from B_2 are reverted to exchanger E1, separately. This is done to ensure complete vapourisation of liquid and to avoid unequal temperature distribution at the bottom of E1.

Reverted tail gas and product hydrogen streams cool the incoming purge gas as explained earlier.

8.5 Breathing of Cold-Box: Cryogenic-exchanger (E1), Gas Separator (B1) and Injection and Separator(B2) and all the interconnecting piping are enclosed into a box known as Cold Box. The idea of having a cold box is to house all equipments/piping, operating under cryogenic conditions in a mass of lagging (insulating) material, such as perlite or mineral wool. In this way, separate lagging of all cryogenic equipments is avoided and the overall heat leakage to these equipments is minimised.

Breathing of Cold-Box is done to have a positive pressure inside Cold-Box to avoid air penetration. Air entry may lead to ice formation on the external surface of cold box equipments which is undesirable.

Normally inert gases with low dew points are preferred for pressurising the Cold-Box. The selection of inert gas depends on the lowest temperature, encountered in the system. For IFFCO Cold-box, nitrogen can be used to pressurise and accordingly a provision is made to introduce nitrogen to pressurise the Cold-box. A self-regulated control valved PCV-191 is provided which maintains a slight positive pressure in the Cold-box. FI-199measures the flow of nitrogen.

Nitrogen is not available on a continuous basis and hence an alternate source is to be considered for purging. Product hydrogen or tail gas can be considered as alternate source for purging. Since tail gas contains substantial quantity of methane, it is less preferred to product hydrogen stream as there are chances of methane solidifying on the cold-box piping. Product hydrogen stream is proposed as an alternate arrangement for purging the cold box. PCV-190 and FI-192 are provided on the product hydrogen line for purging. It is proposed to maintain pressure at 150 mm H_2O in the Cold-box. PSV-198 protects the cold-box from over pressure and also allows a slight leakage of purge gas thereby maintains a positive flow in system.

8.6 Streams out of Cold-Box: Tail gas and hydrogen product streams come out of the cryogenic Exchanger-E1.

8.6.1 Product hydrogen stream:

(a) Conditions:
Flow: 6001 NM^3/Hr.
Pressure: 46.3 kg/CM^2a.
Temperature: $8^o$to 23^oC.

(b) Composition: The composition of the gases in the stream is analysed by the chromatograph KJS-142 (sampling point AP 142.1)

Gas	% Mole.
H_2	93.2
N_2	6.0
Inerts	0.8
	100.0

The flow of the gas is metered by FI-173. TI-102 E indicates temperature of the gas. PIC-137 controls the pressure of the gas pressure in the cold-box. The entire PGR plant will be tripped if the pressure of the outlet hydrogen (PSH-137) stream increases beyond 49 Kg/cm^2g, thereby shutting off the value PV-137 and diverting the feed gas to the tail gas header via HCV-178. PI-179 indicates pressure of the gas in the downstream of the let-down valve HCV-178.

8.6.2 Tail Gas Stream:

(a) Conditions:

Flow: 2977 NM^3/Hr.

Pressure: 4.39 kg/cm^2a.

Temperature: 8°C to 23°C

(b) Composition: The composition of the gases in the stream is analysed by Chromatograph KJS-142(sampling point AP 142.2)

Gas	Mole %
H_2	16
N_2	45.2
A	10.2
CH_4	28.6
	100.0

The flow of the tail gas is metered by FI-176. TI-102 F indicates temperature of the gas. PIC-139 controls the pressure of tail gas line .

9. REFRIGERATION UNIT (X1)

For understanding the Refrigeration Unit (X1), refer its P&I diagram. An external refrigeration unit (X1) is provided to supplement the refrigeration effect in the cold-box.

9.1 Principle of Refrigeration:

The refrigeration involves the evaporation of a liquid refrigerant in the evaporator and cools the process stream. The vapour refrigerant is to be reconverted into liquid state for reuse. The refrigerant vapours are compressed and condensed in a condenser. The liquid refrigerant, at high pressure is throttled to the evaporator pressure. Thus it operates on a standard compression-expansion cycle.

9.2 Packaged Refrigeration Unit:

All the equipments of the refrigeration are skid mounted. The advantages of the packed-refrigeration unit are manifold. They are listed below:

(a) It saves on-site labour assembly

(b) It occupies lesser space than "on-site assembly".

(c) Vibration is minimised because of the dampening effect of the large integral unit mass. Vibration being transmitted to the nearby building or equipments from reciprocating compressor or pulsating lines is also eliminated.

(d) No external pipe supports are necessary to support the lines connecting the components, since these lines are supported within the unit.

The capacity of refrigeration unit is 11575 kcal/Hr. (3.83 tons of refrigeration). In the proposed refrigeration system, the refrigerant R-502 is used. It is a fluorochlore hydrocarbon.

Chemically it is an azeotropic mixture of chloro-dieflurомethane ($CHClF_2$) and chloro-pentaflouroethane ($CClF_2CF_3$). This refrigerant is particularly selected to have an atmospheric (a slight positive pressure at) suction of the compressor. The evaporator temperature of -44.5°C corresponds to the evaporator pressure of 1.0910 kg/cm²a and results in a suction pressure of 1.048 kg/cm²a

at the compressor.

Since the suction pressure is slightly above the atmospheric pressure, air penetration in the system is avoided. This has number of advantages.

(a) Accumulation of non-condensibles is avoided thereby avoiding the necessity of purging the noncondensibles to atmosphere at the receiver and in turn loss of refrigerant is controlled.

(b) Ice-formation in the system is avoided which might obstruct the flow of the refrigerant.

(c) Lubricant oil might get contaminated due to the presence of moisture and/or oxygen. This is also avoided. Sub-atmospheric suctions are normally not preferred in this type of refrigeration unit.

9.3 Properties of Refrigerant R-502 and Lubricant Zerice S-68 are given in Table-3 and 4.

9.4 Refrigerant Evaporator (Cooler E2)

The gases coming from the Gas-Exchanger (E1) at -36.3°C (ad indicated by TI-340 and TI-102J) enters into the horizontal cooler (E2) on the tube-side. The refrigerant R-502, coming from the intercooler via Oil Recuperator(F3), enters on the shell side of the finned type cooler E-2. The process gases after giving heat to the refrigerant comes out of the Cooler and reenters into Gas Exchanger-E1. TI-341 and TI-102 indicates the temperature of the exit gas. The temperature of the evaporator is maintained by controlling the vapourisation of the refrigerant. This is done by diverting a portion of vapour refrigerant from Condenser(E7). The flow of vapour refrigerant from Condenser (E7) is controlled by TCV-342. Thus control of the temperature is of continuous nature.

The relief valves-rupture disc combination saves the evaporator from over-pressure. Duplicate Safety-Relief valves PSV-336 and PSV-337 are connected to a three way valve and then a rupture disc PSE-339 is provided at the top. The three-way valve ensures that one side of the safety valve pair is always connected to the vessel. PI-338 indicates leakage of refrigerant from any of the relief valves. The safety-Relief valves will open only enough to allow pressure drop below set pressure and then it will reseat until additional overpressure develops. If the pressure persists to increase, it will remain open. One of the important justification for the dual arrangement is that safety-relief valves may leak on reseating after discharging. This leak may be caused by a solid particle lodged on the seat. The loss of the refrigerant cannot be tolerated. So the rupture disc ensures the prevention of this loss of refrigerant. PI-338 indicates pressure of refrigerant vapours leaking from the Safety-Relief valves. The valve can be removed for repair and cleaning after the process has been switched to the second valve. Each of the valves is capable of relieving the full process requirements.

9.5 Superheating of the refrigerant vapours:-

The refrigerant vapours coming out of the cooler is to be superheated in a Superheater (E8). The vapours at the exit of the cooler E.2 may entrain some of the refrigerant liquid droplets are vapourised in the Superheater(E.8). The liquid refrigerant coming from the Receiver (B6) enters on the shell side of the Superheater(E8) and gives its heat to the stream coming from the cooler E.2.

A dual arrangement of safety-relief valves (PSV-348 and PSV-349) and a bursting disc (PSE-346) has been provided on the Superheater(E-8).

An oil Recuperator F3 is provided through which liquid refrigerant containing most of the entrained oil (not recuperated in Filter F2) is passing. This chills the incoming refrigerant to cooler E-2. Liquid refrigerant with oil meets the vapours from the Cooler E.2 and enters the Superheater(E-8).

9.6 Intercooling:

The cooled refrigerant comes out from the shell-side of the Superheater E8and enters into the Intercooler (B9) via the Float valve (B.8). Refrigerant vapours coming from Superheater (E-8) is separated in the Float valve(B8).

The liquid from the Float Valve (B8) is flashed to the intercooler-(B9).The flashing of the liquid refrigerant leads to a reduction of temperature as well as vapour formation.

A high level alarm LSH-314 is provided for the Intercooler B-9. Level of refrigerant in Interwooler (B9) is controlled by on-off operation of LV-314 which feed refrigerant to Cooler (E2) via Oil Recuperator F3.

A dual arrangement of safety-Relief valves (PSV-315 and PSV-316) and a bursting disc (PSE-318) has been provided on the Intercooler B-9.

9.7 Compression: The Superheated refrigerant vapours enter into the low pressure case of the single acting Reciprocating compressor (C1) driven by a 30 KW motor. TI-306 indicates temperature at the suction of the LP case of compressor . If the suction pressure of the vapourse at the LP case of the compressor is low PAL-300 will give an alarm . LP case discharges the vapours at 4.15 kg/cm^{2}a. TI-307 indicates temperature of the gas, leaving the LP case. The vapours, then go to a Receiver B-7 where mixing with cold vapours coming from Intercooler(B9) takes place. The temperature of the vapours going to HP case will be reduced, thereby lowering down the workdown by the compressor . Superheater reduces the coefficient of performance of the system while cooling down of gas mixture, entering the HP case improves the coefficient of performances. TI-309 indicates temperature of the vapours in the Receiver(B.7). The HP case of the compressor has two vertical cylinders and compress the vapours at about 19.7 kg/cm^{2}g. TI 308 and PI-302 indicate temperature of the vapours at the discharge of HP case respectively . An audio-visual alarms (PAH-302 & TAH-303) will be heard at high discharge pressure and high discharge temperature of the vapours at the HP case of the compressor. The discharge pressure is 19.7 kg/cm^{2}g at 34°C inlet cooling water temperature (TI-324) to the Condenser (E7). Properties of the refrigerant given in Table-3 can help the operator in adjusting the discharge pressure, corresponding to actual cooling water temperature. MO-1 indicates humidity in the refrigerant. Lubricating oil Zerice S.68(ESSO make) is supplied at various points of the compressor with the help of a pump. PI-301 indicates pressure at the suction of the lube oil pump. PDSL-301 is a differential oil pressure controller which monitors the effective lube oil pressure. LP part of the differential pressure controller is above the oil in the tank while HP part of this controller is linked up with lube-oil pump discharge. At low differential oil pressure , an alarm (PDAL-301) will alert the operator. Due to the low temperature encountered in the refrigera- -tion unit, lube oil may choke in the pipe. Heating by steam is provided in the oil tank. TCV-312 controls temperature of oil by controlling flow of steam in the coils, immersed in the oil tank.

9.8 Condensation of compressed vapours:

The compressed vapours may carry some lube oil which is separated in the Oil Separator (F2). Separated oil is recycled back to the lube oil tank. Almost oil-free vapours (containing 50 ppm by weight oil) enter in the shell side of Condenser(E7). Cooling water enters on the tube-side of the Condenser to condense the refrigerant vapours.

FAL-304 gives low-flow alarm of cooling water flow to the Condenser. TI-323 indicates temperature of the inlet cooling water to the Condenser (E7) while TI-324 indicates temperature of the cooling water at the exit of the condenser.

A dual arrangement of Safety-Relief valves (PSV-319 and PSV-320) and a bursting disc(PSE-322) has been provided to protect condenser from overpressure.

The liquid refrigerant from the condenser enters into the Receiver (B.6). Fresh liquid refrigerant can be made-up in the Receiver (B6). Safety-Relief valves (PSV-331 and PSV-332) and a bursting disc (PSE-334) have been provided at the surface of the receiver to save it from over-pressure.

10. HELIUM REMOVAL

Helium, having lower boiling point (-268.9°C at 1 atm.absolute) than the lowest temperature attained in the cold-box (-192.7°C), escapes out of the cold box alongwith hydrogen as described earlier. It will in turn, lead to a build up of helium content in the synthesis loop at an alarming level. To avoid the excessive built-up of helium in the synthesis loop of ammonia plant, helium must be purged out at the rate it enters in synthesis make-up . For attaining a temperature of -190°C in B1, a definite quantity of hydrogen from B-1 is throttled to tail gas stream which is anticipated to take care of helium purging. However on the whole, the concentration of helium in the loop will increase the stabilise at a higher level.

It is necessary even when maintaining the temperature of the tail gas line is not the prime-aim. In case it is not necessary to throttle hydrogen stream through TV-183 for maintaining the desired temperature in B1 it is advisable to purge a small quantity of feed purge gas through FIC-13 (of ammonia plant) in the tail(fuel) gas header.

11. <u>DERIMING:</u> Deriming is a procedure of purging the equipments of the plant as the plant encounters a hazardous gas mixture at cryogenic temperatures. It is a method of purging the equipment, operating at cryogenic temperatures. It is being carried out after the following preliminary operations.

(a) Stoppage of the unit and isolation of the circuits.

(b) Exchanger E2 to be emptied of the refrigerant which will be stored in the Receiver(B.6)

(c) Cold-Box to be drained and all the gases left are vented in the cold flare.

(d) Circuits to be depressurised.

Nitrogen, an inert gas, is proposed for deriming.

Conditions of Nitrogen.

Flow: 400 NM^3/Hr.

Pressure 8 kg/cm^2a.

Temperature : 20°C to 40°C

Dew point = -20°C to -40°C

Heating medium used in the Heater E5, is 3.5 kg/cm^2g.steam. The temperature of the nitrogen used in the deriming should not exceed 80°C as the material of the compact exchanger (E1) cannot withstand higher than 80°C.

First of all deriming of cold-end of E1 is done. When the temperature TI-102 G reaches the ambient the whole cold-part of exchanger E1 is cleared. This means , incoming lines to B1 and refrigeration unit are derimed. Later the warm end of E1 is derimed. Next the tail gas path and product hydrogen path are derimed. During the entire deriming period, dew point of nitrogen should be maintained as low as possible. For ready reference in Table-5, conversion of dew point at atmospheric pressure to dew point under pressure is given. With nitrogen flow rate of 400 NM^3/Hr, heated at 80^oC, the total duration of deriming is not expected to exceed 30 hours, out of which nearly 25 hours will be consumed in deriming the cold-end of E1.

12. AMMONIA LIQUOR HANDLING:

12.1 Ammonia liquor tank (172-F).

Nearly 4% (W/W) ammonia liquor collects at the bottom of washing tower. The level control valve LV-134 allows this liquor to flow to Ammonia-Liquor Tank(172-F) which is an atmospheric storage tank. Refer P&I diagram for clear understanding. Because of high pressure in the tower (K1), some quantity of gases (H_2, N_2, Ar & CH_4) will be dissolved in ammonia liquor. The anticipated quantities of gases dissolved in the liquor at the column (K1) outlet are:

Argon = 0.5 NM^3/Hr.
Nitrogen= 1 NM^3/Hr.
Methane = 1.2 NM^3/Hr.
Hydrogen = 3NM^3/Hr.

The solubilities of nitrogen, hydrogen, argon and methane in ammonical liquor solution of 3 to 5% (w/w) strength under partial pressure of 1.03 kg/cm^2a are given in following Table-6 in $NM^3/100\ M^3$ solution.

TABLE-6: SOLUBILITY OF GASES IN 3 TO 5% NH_3 SOLUTION AT ATMOSPHERIC PRESSURE

Fluid	Temperature, ^oC			
	5	15	25	40
N_2	2.1	1.7	1.3	1.2
H_2	2.0	1.8	1.7	1.5
Ar	4.6	3.7	3.1	2.4
CH_4	4.7	3.8	3.2	2.4

This table indicates that quantity of dissolved gases vary with temperature which in turn depend on the flow of demineralised water in the tower and the strength of ammonia liquor.

On the downstream of LV-134, dissolved gases will flash out due to lowering of pressure and will find their way to the tank 172-F.

Sufficient anchoring is provided to the inlet pipe to take care of any possible water hammering in the tank. Liberated gases bubble through the liquor in Tank-172F and accumulate at the top portion of the Tank. All these gases constitute a highly inflammable mixture. Hydrogen is the most notorious component as it can be easily ignited with less energy and lesser volume. Because of this reason the tan k 172-F is located near ammonia plant and the liquid, free of gases, is then sent to water treatment plant/effluent tanks. In order to avoid any explosion by the hazardous gases, the empty space should be free of oxygen and therefore blanketting by nitrogen or tail gas coming out of cold-box is proposed . The aim is to maintain oxygen content less than 2%(v/v). As explained earlier, nitrogen is not available on a continuous basis and hence its use for blanketting by nitrogen or tail gas coming out of cold-box is proposed. As explained earlier, nitrogen is not available on a continuous basis and hence its use for blanketting purpose is proposed during start-up only. In normal operation tail gas will be used. Normally the pressure in the tank will be maintained at 22 mm WG. High and low level alarms are provided for the tank. A level indicator to indicate the level of the liquor in the tank is also provided.

An emergency relief valve is provided to vent off all the gases escaping out of LV-134, in case of loss of level in tower (K1). A pressure/vaccum relief valve is provided on the tank whi ch outbreathes the gases in normal course and vents out the flashed gases as described above. It also inbreathes air in case of fall in pressure inside the tank thereby maintaining the pressure inside the tank(172-F). When air is sucked in, precautions should be taken to remove it as early as possible by increasing the flow of blanketting gas, if necessary. Samples of gas mixture from 172-F should be collected and analysed for oxygen content periodically which should be less than 2%(v/v). A manhole with a cover will be provided in the tank. The manhole will open-up when the pressure in the tank reaches 3750 mm WC which is the design pressure of ammonia-liquor tank. This is an additional safety measure over and above the emergency relief valve. Cover with the gasket shell be provided in the manhole to have an effective sealing and preventing leakage of blanketing gas under normal operating pressure of 25 mm WG. Overflow from the tank (172-F) via the lute (filled with oil) will collected in the bunded area and then willbe drained in the sewer, under close watch. In case of high pressure build-up in the tank, the lute seal will break and gas will escape off.

12.2 <u>Ammonia liquor transfer:</u> The ammonia liquor can be pumped to the water treatment plant with the help of a centrifugal pump. Two pumps (172-J/JA) are provided, one of which remains as a standby. The tank bottom is 1.5 m above ground level to provide sufficient NPSH to the pumps. Transfer of ammonia liquor is an intermittent operation and a co-ordination of both the plants are required during the transfer. Pump running light is provided on the main panel to check the pump operation. The pumps normal capacity is fixed at 40m^3/hr, so it will be possible to transfer the required quantity of ammonia liquor to water treatment plant within 15 to 20 minutes. In case quicker transfer is desired, both the pumps may be operated . Blanketting gas valves are designed to cater any transfer rates from these pumps. In case of high build-up of liquor in the tank, facility is provided to send this liquor to effluent tanks. Pump motors are not provided with emergency power.

13. MISCELLANEOUS.

13.1 Pressure Relieving Devices:

Pressure relieving devices, installedin the plant are listed below:

Pressure Relieving Device No.	Line No.	Duty	Set pressure kg/cm^2 a
PSV-106	Gas Exchanger (E.3)	Protects the shell side of Gas Exchange(E.3) from over pressure.	1.077
PSV-111	4"TG02	Protects tubes of Gas-Exchanger (E.3) from over pressure.	57.08
PSV-118	Damper after pumpP1	Protects the discharge line 1½" ED 04 of the pump P.1	57.08
PSV-119	Dampener after Pump P2	Protects the discharge line 1½" ED 04 of pump P.2	57.08
PSV-167	2"NS 02	Protects deriming Heater E1 from overpressure of nitrogen supply.	5.11
PSV-177	3" TG 10	Protects cryogenic-Exchanger E.1 and tubes of the cooler E.2 from refrigeration unit.	57.08
PSV-180	4" RG 02	Protects the tail gas line coming from cold box	6.13
PSV-181	6"RG 01	Protects line 4" RG 02	6.13
PSV-198 A & B	Cold-box	Protects cold-box from over-pressure by breathing gases.	$2.5 g/cm^2$ g to $15 g/cm^2$ g
PSV-204	Regener--ation Heater	Protects Regeneration Heater (E.4) from over-pressure	700 mm W. g.

Pressure Relieving Device No.	Line No.	Duty	Set Pressure $kg/cm^2 a$
PSV-315 PSV-316 & PSE-318	Inter-Cooler (B.9)	Protects intercooler(B.9)	24.47 24.47 14.79
PSV-319 PSV-320 & PSE-322	Condenser (E.7)	Protects the shell of the condenser(E.7)	24.47 24.47 14.79
PSV-331 PSV-332 & PSE-334	Receiver (B.6)	Protects the Receiver(B6) from overpressure.	24.47 24.47 14.79
PSV-336, PSV-337 & PSE-339	Cooler (E.2)	Protects the shell side of the cooler (E.2)	21.41 21.47 14.79
PSV-347	Refrigerant compressor	Protect the compressor from high discharge pressure.	
PSV-348 PSV-349 PSE-346	Superheater E.8	Protect shell side of super-heater E8 from overpressure	24.47 24.47 14.79
Pressure/Vacuum Relief Valve on 172-F		Relieves pressure or inbreaths air from atmosphere	35mm wg. pressure 35mm. water vacuum.
Emergency pressure relief valve on 172-F		Protects 172-F from overpressure	3750mm wg.
Relief valve on Ammonia liquor line 40 NE 01		Protects 40 NE 01 from overpressure	4.03

13.2 Load variation and pressure control.

The load-variation in the plant can be affected by resetting FIC-100 while PIC-137 automatically adjusts the pressure of hydrogen stream out of cold-box and thus adjusts the system pressure. Tail gas pressure is controlled by PIC-139.

13.3 Instrument Power supply.

Instrument power supply is 110 V Ac. All the instruments are designed for fail-safe. Solenoids operated on "deenergised to trip", i.e. when instrument power fails, the solenoids will trip the plant. This system is just opposite to the existing system in ammonia plant in which the solenoids operate on "energised to trip".

13.4 Cold box insulation.

The cold-box will be insulated by Pearlite to reduce heat infiltration inside it. Pearlite constitutes silica (75%) and oxides of aluminium, iron, calcium, sodium and potassium. It is normally crushed to proper grain-size, heated rapidly and expanded. It consists of small aircell which is airtight. Pearlite, for low temperature is to be used at atmospheric pressure. Conduction of heat of Pearlite is very small and the fine grains entering the space among the Pearlite particle are further divided into the smaller gaps, thus preventing the air convection so as to raise the effect of low temperature insulation. Thermal conductivity of pearlite(*0.022 kcal/(m-hr-$^{\circ}$C) at -140°C) is lower than that of rock fibre and glass wool and hence better insulating effect. Safety range of temperature in which pearlite is used is the highest (-250°C to 800°C) . Its use in the cold-box has an additional advantage because it is a free flowing material and hence it is easy to remove from the bottom.

Control valves are located in the cold box which may be required to be attended. At these locations, mineral wool will be filled in so that the control valves can be maintained without emptying out the whole cold box.

13.5 Emergencies.

In case of low pressure of instrument air, the entire plant will be tripped (PSL.194) by isolating the feed gas to the plant and the same is diverted to tail gas header.

Lower cooling water supply to the condenser (E.7) of the refrigeration unit will lead to reduced condensation and increase in pressure of refrigerant in the system. FAL-304 will give an alarm on the main panel.

In case of power failure, motors of the demineralised water pumps (P1/P2) and refrigeration compressor (C.1) and the Regeneration Heater (E.4) will stop. These are interlocked in such a way that the plant will automatically trip.

For any other emergency, a push botton HS-144 B is provided on the main panel to isolate the plant from ammonia plant.

The plant is thus safeguarded against all possible eventualities.

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CHAPTER-4.

Equipment Details.

EQUIPMENT LIST.	Vendors Eqt. No.	IFFCO Eqt. No.
A. MAIL PLANT:		
1. Gas Exchanger.	E 3 with B3	
2. Washing Tower	K1	
3. Drying Vessels	R1/R2	
4. Filter	F1	
5. Water Separator	B4	
6. Florentin Pot	B5	
7. Gas Separator	B1	
8. Injection separator	B2	
9. Cryogenic Exchanger	E1	
10. Regeneiation Heater	E4	
11. Deriming Heater	E5	
12. Pumps	P1/P2	
13. Cold Liquid Vapouriser	E6	
B. REFRIGERATION UNIT		
1. Compressor	C1	
2. Oil Filter	F2	
3. Condenser	E7	
4. Receiver	B6	
5. Superheater	E8	
6. Float valve	B8	
7. Intercooler	B9	
8. Oil Recuperator	F3	
9. Cooler	E2	
10. Intermediate Receiver	B7	
C. AMMONIA LIQUOR HANDLING.		
1. Ammonia liquor tank	172-F	
2. Ammonia liquor Pump	172J/J.A	

EQUIPMENT DETAILS.

1. Gas Exchanger (E3) Incorporating B-3.

1.1 Purpose:

To cool the dimeneralised water by heat exchange from purge gas in order to prevent freezing and also to preserve the cold-effect.

1.2 Design and operating conditions.

1.2.1 Finned Heat Exchanger:

Number of finned tubes: Two of 60.3 mm Outside dia x 3.9 mm thick x 6900 mm long.

	Finned tube side (process gas)	Shell (DM Water)
Operating pressure	47.6 kg/cm^2a	Atmospheric
Design pressure	55. kg/cm^2g	1 kg/cm^2g.
Working temperature	-28.15°C	+ 34°C
Design temperature	+ 20°C	+ 50°C

Dimensions of E3

Inside Diameter = 992 mm . Thickness = 5 mm

Height = 8130 mm

1.2.2 Accessories:

(i) Water Tank (B3A):-

Capacity = 2000 litre.

Diameter = 1500 mm , 5 mm thick

Height = 1700 mm.

(a) Two dimeneralised water inlet nozzles = 25 mm dia.

Manhole = 500 mm (20") diameter.

(b) A level glass LG-110 is provided to see the level in the water tank.

(c) A temperature measuring point (12 mm dia) TI-104 has been provided in B-3 A.

(ii) Water capacity (B-3B):

Capacity = 500 litre.

Dimeter = 992 mm, thickness= 5 mm.

Height = 1000 mm

(a) Demineralised water outlet = 50 mm diameter.

(b) A level glass LG-187 has been provided in the water capacity to see the level of water.

(c) An overflow line of 50 mm diameter.

(d) A temperature connection point of 25 mm diameter (TE-102C).

(iii) Process gas inlet and outlet nozzles = 100 mm Diameter

(iv) Manhole = 500 mm Diameter

(v) A relief valve (PSV-106) = 500 mm Diameter.

(vi) Two sight glasses FG-107 and FG-117 are provided.

(vii) Material of construction: Carbon steel shells of E3 and B-3B are internally epoxy painted. Tubes are made of aluminium to which galvanised fins (80 Micron) are attached. Water tank B3A is of carbon steel.

2. Washing Tower (K1):-

2.1 Purpose: To dissolve ammonia in water, contained in the feed purge gas.

	Pressure	Temperature.
Operating	51 kg/cm^2g	-4^oC
Design	55 kg/cm^2g	$+30^oC$

2.2 Dimensions:

Inside diameter = 564 mm, 90 mm thick.

Shell height = 6400 mm

Overall length from the ground = 7450 mm

2.3 Accessories:

(i) Twelve stainless steel (304-L) trays with downcomers.

(ii) Process gas inlet & Outlet nozzles = 100 mm diameter.

(iii) Demineralised water inlet nozzle= 50 mm diameter.

(iv) Ammonia-liquor outlet nozzle = 75 mm diameter.

(v) A level glass (LG 127) at the bottom portion of tower.

(vi) Moisture eliminator of stainless steel at the top of tower (350 mm diameter and 150 mm height)

2.4 Material of construction: Carbon steel for the vessel which is epoxy pointed from inside water inlet and NH_3 water exit Nozzles are made of 304-L while process gas inlet and outlet nozzles are of carbon steel.

3. DRYING VESSELS (R1 and R2).

3.1 Purpose: To dessiccate water vapours and ammonia in activated alumina and molecular sieve beds by adsorption . Out of two drying vessels, one is under regeneration while other is in service.

3.2 Design and operating conditions:

3.2.1 Process:

	Pressure	Temperature.
Operating	47.1 kg/cm^2a	+ 22°C
Design	55 kg/cm^2g	+ 30°C

3.2.2 Regeneration:

Operating	4.3 kg/cm^2a	220° to 310°C
Design	5 kg/cm^2g	340°C

3.3 Dimensions:

Internal diameter = 1033 mm , 33.5 mm thick.

Height of alumina bed = 840 mm

Volume of alumina packed = 0.704 M^3

Height of molecular sieve bed. = 1040 mm

Volume of molecular sieves packed = 0.873 M^3

Shell (straight) height = 3180 mm

3.4 Accessories:

(i) Inlet purge gas or outlet regeneration gas nozzle = 100 mm. diameter

(ii) Outlet purge gas or inlet regeneration gas nozzle = 100 mm diameter.

(iii) Nozzle for filling up molecular sieve = 150 mm diameter.

(iv) Nozzle for dumping out molecular sieve= 500 mm diameter.

(v) Nozzle for filling up alumina = 150 mm. diameter

(vi) Sampling point for the analysers AP-121, AP 125 = 12 mm. diameter

(vii) Two grids for supporting alumina bed and molecular sieve

(viii) Nozzle for dumping out alumina= 500 mm

(ix) vessels are insulated with insulation. Thickness of 150 mm

3.5 Material of construction: Carbon steel.

4. Filter(F-1):-

4.1 Purpose: To filter the dry gas which may contain adsorbent dust.

4.2 Design and operating conditions:

	Pressure	Temperature.
Operating	47.1 kg/cm^2a	22°C
Design	55 kg/cm^2g	30°C

4.3 Dimensions:

Internal diameter = 361 mm (thickness=14.3 mm).

Shell height = 1300 mm

Overall length from the ground = 2275 mm.

4.3 Accessories:

i) Filter basket

ii) Inlet nozzle for purge gas = 100 mm diameter.

iii) Outlet nozzle for purge gas = 100 mm diameter.

iv) A drain for removing dust from the filter

v) Filter is insulated with insulation thickness of 140 mm.

4.4 Material of construction: Carbon steel for vessel. Filter basket is made of stainless steel with special coating on outside.

5. WATER SEPARATOR (B4):-

5.1 Purpose: To separate water led away by the regeneration gas from the Drying vessels.

5.2 Design and operating conditions:

	Pressure	Temperature.
Operating	4.2 kg/cm^2a	+ 50°C to + 150°C
Design	5 kg/cm^2g	+ 200°C

5.3 Dimensions:

External diameter = 356 mm (Thickness = 4 mm)

Shell height = 800 mm.

5.4 Accessories:

i) Inlet nozzle for regeneration gas = 100 mm diameter.

ii) Outlet nozzle for water free gas = 100 mm. diameter.

iii) A water drain = 12 mm

iv) A level glass (LG-164) for level indication.

v) Water separator is insulated with insulation thickness of 80 mm.

vi) A vortax breaker (plate) of 146 mm Dia x 5 mm thick is provided over the outlet nozzle.

vii) An impingement plate of 150 mm length x 5 mm thick is provided at the inlet nozzle .

5.5 Material of construction: Carbon steel.

6. Florentin Pot (B5):-

6.1 Purpose: To separate the dissolved gases from water .

6.2 Design and operating conditions:

	Pressure	Temperature
Operating	1.033 kg/cm^2a	20^oC
Design	1 kg/cm^2g	20^oC

6.3 Dimensions:

External diameter = 356 mm (thick = 5 mm).
Shell height = 800 mm

6.4 Accessories:

(i) Inlet : for water entering from B-4 = 50 mm diameter.

(ii) Outlet : for gases escaping = 50 mm diameter.

(iii) Drain for draining water into sewers. = 25 mm diameter.

(iv) A vortax breaker (plate) of 146 mm Dia. x 5 mm thick is provided over the outlet nozzle.

6.5 Material of construction: Carbon steel.

7. GAS SEPARATOR (B1):-

7.1 Purpose: To separate the hydrogen rich vapour stream from liquified inerts.

7.2 Design and operating conditions:

	Pressure	Temperature
Operating	45.5 kg/cm^2g	-190^oC
Design	55kg/cm^2	+ 20^oC

7.3 Dimensions:

Internal diameter = 547 mm
Thickness of shell = 14 mm
Shell height =1800 mm
Overall length =2496 mm

7.4 ACCESSORIES.

i) Liquid gas stream inlet nozzle = 75 mm diameter.
ii) Hydrogen rich outlet nozzle = 75 mm diameter
iii) Inert liquid outlet nozzle = 50 mm diameter
iv) Top and Bottom connections for LT-185 and AE 142.4

7.5 Material of construction : Stainless steel.

8. INJECTION SEPARATOR B.2:

8.1 Purpose: To separate the liquid and vapour phases and to revert them in the cryogenic Exchanger (E1).

8.2 Operating conditions:

Operating pressure = 4.55 kg /cm^{2}a
Operating temperature = - 192.7°C

8.3 Dimensions:

Length = 2392 mm
Outside dia. = 219 mm (thickness = 9 mm)

8.4 Accessories:

i) one nozzle for outlet gases = 60 mm OD
ii) one nozzle for outlet liquid = 33 mm OD
iii) one nozzle for inlet liquid and vapour mixture= 168 mm OD

8.5 Material of construction = Stainless Steel.

9. CRYOGENIC EXCHANGER (E1)

9.1 Purpose: To cool incoming feed gas with the help of reverting product hydrogen and tail gas streams. It is divided into two parts; warm end and cold end.

9.2 Make: Stewart Warner Corporation, Belgium.

9.3 Operating and design conditions:

	Pressure, kg/cm^{2}g	Temperature.
Operating	4.5	+ 23°C to -192.7°C
Design	55.0	+ 50°C to -195°C.

9.4 Dimensions:

Straight length = 5825 mm

Rectangular dimensions = 864 mm x 628 mm

	Free volume (space), litres.
Feed gas path	527
Product hydrogen path	432
Tail gas path	789

9.5 Accessories

(a) Inlet nozzle for feed purge gas = 100 mm diameter (NB) .

(b) Outlet product hydrogen nozzle = 80 mm diameter (NB)

(c) Outlet tail gas nozzle = 200 mm diameter (NB)

(d) Injection separator B2 is attached with E1 and forms a part of E1 (for nozzles of inlet and outlet streams of the separator, refer item No.a).

(e) Liquified gas outlet nozzle = 89 mm outside diameter.

(f) Product hydrogen reverting nozzle = 89 mm outside dia.

(g) Nozzle for vapour inlet from B2 = 89 mm OD

(h) Nozzle for liquid inlet fromB2 = 60 mm OD

9.6 Material of construction: Aluminium alloy.

It is a plate type heat exchanger and brazing is adopted for joining plates.

10. REGENERATION HEATER (E.4):-

10.1 Purpose: To heat the tail gas for the regeneration of adsorbent beds of the drying vessels (R1/R2). The heater is made explosion proof by static pressurising the cable chamber with nitrogen.

10.2 Operating and Design conditions:

	Pressure	Temperature.
Operating	4.35 $kg/cm^2 a$	
Design	5 $kg/cm^2 g$	340°C

10.3 Dimensions

Outside diameter = 421 mm

Thickness = 5 mm

Length of shell = 1978 mm

10.4 Accessories:

i) Inlet gas pipe = 100 mm nominal diameter.

ii) Outlet gas pipe = 100 mm nominal diameter

iii) Nine heating elements of 9.5 KW (Total heating power = 73530 kcal/hr) have been provided out of which three can be put on or off for controlling gas temperature.

iv) Power supply is 430 V AC, 3 phase, 50 Hz.

v) Heater is insulated with insulation thickness of 120 mm .

11. DERIMING HEATER (E5)

11.1 Purpose: To heat the nitrogen gas used for purging the cold box.

11.2 Operating and design conditions.

	Gas side	Stream side
Operating pressure	9 $kg/cm^2 a$	4.5 $kg/cm^2 a$
Design pressure	10 $kg/cm^2 g$	4 $kg/cm^2 g$
Operating temperature		+ 160°C
Design Temperature		+ 170°C

11.3 Accessories:

i) Inlet and outlet pipe connections for gas = 50 mm dia.

ii) Inlet and outlet pipe connections for steam=38 mm dia.

iii) The heater is insulated with the insulation thickness of 60 mm .

12. PUMPS (P1 and P2)

12.1 Purpose: To pump demineralised water from the exchanger E3 to washing tower (K-1)

12.2 Operating Details:

Type : Plunger , Triplex , Model 80 HT

Make: Ste Burton Corblin, France.

Minimum = 4.2 m^3/Hr.
Maximum = 5 m^3/Hr.
Pumping temperature = 25 to 34°C
Suction pressure = 0.25 kg/cm^2g
Normal discharge pressure = 47.2 kg/cm^2g
Max. discharge pressure = 51.6 kg/cm^2g
NPSH required = 2.5 m .
Speed = 310 RPM.
Input power (BHP) = 10 KW
Theoretical efficiency = 89%

12.3 Pump Motors (M1/M2)

Type : Induction intrinsically safe motor . 3 Phase.
Make: NGEF, Bangalore
Speed: 1500 rpm.
Outside power= 11 KW
Rated voltage = 430 V.
Speed reduction: By belt.

13. LIQUID VAPOURISER (E.6)

13.1 Purpose: Itis an ambient vapouriser to vapourise liquid inerts separated in the separator B1 and discharge the vapourised gases in the cold-flare.

13.2 Dimensions:
Height of vapouriser above ground = 2927 mm
Length of vapouriser = 2626 mm
Diameter of SS tube (tube is finned by aluminium alloy) = 22 mm.

B. REFRIGERATION UNIT.

Make : YORK FRANCE

1.0 COMPRESSOR (C1)

1.1 Purpose: To compress the refrigerant vapours to the desired pressure so as to achieve condensation of vapours in the condenser.

1.2 Operating conditions:

		L.P. Case	H.P. Case.
Compressor suction			
Temperature Design		$-26^{\circ}C$	$0^{\circ}C$
Pressure:	Normal:	1.047 kg/cm^2a	4.39 kg/cm^2a
	Design:	1.014 kg/cm^2a	4.23 kg/cm^2a
Compressor discharge.			
Temperature: Design		$40^{\circ}C$	$75^{\circ}C$
Pressure:	Normal	4.39 kg/cm^2a	20.33 kg/cm^2a
	Design	4.23 kg/cm^2a	20.18 kg/cm^2a

1.3 Mechanical details.

		LP Case	HP Case
Type		Reciprocating	Reciprocating
No. of cylinders/stage		4	2
Single or double acting		single	single
Piston speed:	Normal	2.38 M/sec.	2.38 M/sec.
	Max. permi--ssible.	4.37 M/sec.	4.37 M/sec.
Piston stroke		75 mm	75 mm

Crank shaft speed: Rated = 950 rpm.

Max. permissible = 1750 rpm.

1.4 Lube Oil System:

Lubricating oil Zerice-S-68 is stored in a 20 litre capacity tank in the bottom portion of the compressor.
A provision of heating the oil by steam has been provided inside the tank to attain a desired temperature of oil.

1.4.1 Oil pump:

Type: Internal Gear.
Flow Rate : 20 litres/min.
Suction pressure= 1.047 kg/cm^2 a
Discharge pressure = 4.076 kg/cm^2 g
Normal operating temperature of oil = $50^{o}C$

1.5 Motor(M3)

1.5.1 Purpose: To drive the reciprocating compressor .

1.5.2 Details:

Type : Induction type squirrel cage with increased safety protection.
Make : NGEF,Bangalore.
Rated voltage = 430 Volts.
Output power = 30 KW
Speed = 950 rpm.
Rated output power at shaft = 29 KW
Normal power consumption = 16 KW
Type of coupling = DISK.

2. OIL FILTER (F2)

2.1 Purpose: To separate the entrained oil from the compressed refrigerant vapours. It consists of a trap having raschig rings.

2.2 Operating and Design conditions:

	Operating	Design.
Temperature, °C	96	100
Pressure, kg/cm^2g	19.3	23

2.3 Dimensions:

Length = 952 mm.

Inside diameter = 200 mm (40 schedule)

Perforated sheet(trap)= 496 mm x 190 mm x 3 mm thick.

Diameter of floating ball = 70 mm.

2.4 Accessories:

(a) Inlet and outlet connections = 25 mm for refrigerant vapours.

(b) Connection for oil reintegration (10 mm)

(c) Connection for Oil drain (10 mm)

(d) Safety valve connection =19mm.

2.5 Material of construction: Carbon Steel.

3. CONDENSER (E7)

3.1 Purpose: To condense the compressed refrigerant for filling it in the cooler (E2)

3.2 Design and operating conditions:

	Tube side (cooling water)	Shell side (Refrigerant)
Operating pressure	3.8 kg/cm^2g	19.3 kg/cm^2g
Design pressure	6 kg/cm^2g	23 kg/cm^2g
Operating temperature	+ 34°C/+38.8°C	+ 48°C
Design temperature	+ 100°C	+ 100°C

Design code: TEMA C and ASME Section VIII Div.1

3.3 Dimensions:

No. of tube passes	=	6
No. of shell passes	=	1
No. of tubes	=	36
Targent to Tangent length	=	3540 mm
Shell OD	=	273 mm . Thickness = 9.27 mm
Tube Diameter	=	19 mm OD, 16 BWG .
Tube pitch(triangular)	=	24 mm
Tube length	=	3050 mm

3.4 Accessories:

(a) One inlet connection for refrigerant vapours = 38 mm
(b) One outlet connection for liquid refrigerant = 25 mm
(c) Inlet and outlet connections for cooling water= 38 mm
(d) One by pass connection for refrigerant vapours= 25 mm
(e) One connection for safety valves = 19 mm.
(f) Two vents = 19 mm
(g) Two drains = 19 mm
(h) Two pressure connections = 10 mm.

3.5 Material of construction : Shell : Carbon steel.
Tubes : Carbon steel.

4. Receiver (B6)

4.1 Purpose: It serves as a storage capacity for the refrigerant.

4.2 Design and operating conditions:

		Operating	Design
Temperature	=	48°C	100°C
Pressure, kg/cm^2 g	=	19.3	23

4.3 Dimensions:

Tongent to tangent length	=	3850 mm
Shell ID	=	407 mm (40 shedule)

4.4 Accessories:

(a) Inlet connection for liquid refrigerant = 25 mm
(b) One safety valve connection = 19 mm
(c) One drain connection = 12 mm
(d) One level connections = 12 mm
(e) One connection for liquid recuperator = 150 mm

One drain (12 mm), one outlet for refrigerant (25 mm) and one level connection (12 mm) are fitted on the liquid recuperator.

4.5 Material of construction: Carbon steel.

5. Superheater(E-8)

5.1 Purpose: To superheat the gases going to the LP case of the compressor by refrigerant coming out of receiver B6.

5.2 Design and operating conditions:

	Tube side	Shell side.
Operating pressure	0.03 kg/cm^2g	19.3 kg/cm^2g
Design pressure	23 kg/cm^2g	23 kg/cm^2g
Operating temperature	$-45^oC/-26^oC$	$+48^oC/+38^oC$
Design temperature	$+ 100^oC$	$+100^oC$

Design code: TEMA C and ASME Section VIII Div.1

5.3 Dimensions:

No. of tube pases = 1
No. of shell passes = 1
Tangent to tangent length = 2100 mm
Shell ID = 167 mm (40 schedule)
Tube diameter = 19.3 mm (BWG=14)
Tube pitch (triangular) = 24 mm
Tube length = 2005 mm
No. of tubes = 19

5.4 Accessories:

(a) Two inlet and outlet connections for gas = 38 mm

(b) Two inlet and outlet connections for liquid = 25 mm.

6. Float valve (B.8)

6.1 Purpose: To let down the condensed refrigerant from 19.0 kg/cm^2g to an intermediate pressure of 2.3 kg/cm^2g.

6.2 Operating and Design conditions:

		Operating	Design.
Temperature	=	+ 38°C	100°C
Pressure, kg/cm^2g	=	19	23

6.3 Dimensions:

Height	=	395 mm
Shell I.D.	=	219 mm Thickness = 8.2 mm
Float valve diameter	=	100 mm

6.4 Accessories:

a) One connection for liquid refrigerant inlet = 25 mm

b) One connection for outlet mixture going to intercooler (B.9) = 13 mm

c) One connection for refrigerant vapours for temperature control of cooler E.2 = 25 mm

d) Two sight glasses = 50 mm diameter.

6.5 Material of construction: Carbon steel.

7. Intercooler (B.9)

7.1 Purpose: To supply liquid refrigerant to the cooler (E2) to cool the process gas.

7.2 Design and operating conditions:

		Operating	Design.
Temperature	=	$-10^{o}C$	$+ 100^{o}C$
Pressure, kg/cm^2g	=	3.2	23

7.3 Dimensions:

Tangent to Tangent length = 746 mm

Shell I.D. = 273 mm (thickness = 9.3 mm)

7.4 Accessories:

i) Connection for the inlet of liquid and vapour mixture of refrigerant = 19 mm

ii) Connection for the vapours going to h.p. case of compressor = 25 mm

iii) Connection for outgoing liquid refrigerant to cooler (E.2) = 13 mm.

iv) Connection for safety valve = 19 mm

v) Connection for float switch = 25 mm

7.5 Material of construction: Carbon steel.

8. Oil Recuperator (F.3)

8.1 Purpose: To recover the unrecovered oil in the filter which gets accumulated in the cooler (E2).

8.2 Operating and design conditions:

	Tube side (Liquid refrigerant) with oil .	Shell side (Liquid refrigerant).
Operating pressure	$0.03\ kg/cm^2g$	$3.2\ kg/cm^2g$
Design pressure	$23\ kg/cm^2g$	$23\ kg/cm^2g$
Hydraulic test pressure (Water)	$34.5\ kg/cm^2g$	$34.5\ kg/cm^2g$
Operating temperature	$-45^{o}C$	$-10^{o}C/-22^{o}C$
Design temperature	$+ 100^{o}C$	$+ 100^{o}C$

8.3 Dimensions:

Length of recuperator	= 2000 mm
ID of shell	= 38 mm (40 schedule)
Length of tube	= 1975 mm
Tube diameter	= 19 mm (80 schedule)

8.4 Accessories:

(a) Inlet and outlet connections for refrigerant with oil = 10 mm

(b) Inlet and outlet connections for liquid refrigerant. = 25 mm.

8.5 Material of construction: Tube and shell both of carbon steel.

9. Cooler (E.2):

9.1 Purpose: To cool the process gas coming from the cold-box from -36.3^oC to -40^oC using refrigerant R-502.

9.2 Design and operating conditions:

	Tube side (Process gas)	Shell side (Refrigerant)
Operating pressure	46.8 kg/cm^2g	0.03 kg/cm^2g
Design pressure	55 kg/cm^2g	20 kg/cm^2g
Hydraulic test pressure	82.5 kg/cm^2g	30 kg/cm^2g
Operating temperature	-36.3^oC to -40^oC	-45^oC
Design temperature	-45^oC to 100^oC	-45^oC to 100^oC

9.3 Dimensions:

Tangent to tangent length	= 4022 mm
Shell OD	= 457.2 mm (9.52 mm thick)
Tubes diameter	= 19 mm (14 BWG)
Tube pitch	= 25 mm
Tubes length	= 3055 mm
No. of tubes	= 80

* No. of tube passes = 2 No. of shell passes = 1

9.4 Accessories:

(a) Two inlet and outlet connections for process gas mixture = 125 mm

(b) Two oil return connections = 10 mm

(c) Refrigerant inlet connection = 38 mm

(d) Connection for refrigerant vapour going to compressor = 38 mm

(e) One safety valve connection = 19 mm

9.5 Material of construction = Carbon steel for steel and tubes.

C. AMMONIA : LIQUOR HANDLING:

1. Ammonia liquor Tank(172-F)

1.1 Purpose: To provide the buffer capacity of ammonia liquor, obtained from Washing Tower (K-1).

1.2 Operating and Design Conditions:

Design pressure:

Internal : 0.357 kg/cm^2g

External : 0.015 kg/cm^2g

Design temperature:

Maximum : 45^oC

Minimum : 1.5^oC

Operating pressure ::::::::: 25 mm W.G.

1.3 Dimensions:

Type: Horizontal

Capacity:

Operating: $20M^3$

Actual : $25 M^3$

ID of the tank : 2.5 m

Straight length of tank : 5.1 m

Material of construction: Carbon steel with epoxy paint to interior surface.

1.4 Accessories.

1. One liquor supply nozzle of 40 mm NB .
2. One liquor outlet nozzle of 150 mm NB.
3. One gas sampling nozzle of 25 mm NB.
4. One blanketing gas supply nozzle of 40 mm NB.
5. An overflow line of 80 mm NB size. This overflow line is immersed in the lute, filled with oil.
6. A manhole of 600 mm NB size. This will burst out when pressure in tank will exceed 3750 mm WG.
7. A drain of 50 mm NB size at the tank base level.
8. A nozzle of 50 mm NB for installing a pressure/vacuum relief valve at the top of the tank.
9. A nozzle of 200 mm NB size for installation of an emergency relief valve.

2. Ammonia Liquor Pump . (172-J/JA).

2.1 Purpose: To pump 4%(w/w) ammonia-water solution (as NH_3) from the tank, 172-F to the ammoniaum hydroxide tank of offsites.

2.2 Pump Details.

Make : AKAY Industries, Hubli.

No. of stages: Single.
Rated capacity: 40 M^3/Hr.
Suction Pressure: 1.12 kg/cm^2a
Discharge pressure: 3.62 kg/cm^2a

Pump speed: 2900 RPM
Hydraulic HP: 3.7
Efficiency: 66.4%
NPSH available: 9.1 m
Pumping temperature: 45°C.

Motor Details:

Make: Siemens.
Type: Explosion proof.
Power: 5.5 KW
Speed: 2900 RPM.

Available power: 415 V e Phase, 50 Hz.

A. MAIN PLANT

1. LIST OF INSTRUMENTS

INSTRUMENT NUMBER	CORDINATES FOR LOCAT--ING INST. ON P&I DIAG.	MOUNTED	PIPE NUMBER & SIZE	DENOTES	NORMAL READING	RANGE OF READING	REMARKS.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.1 Analyzers:							
1. AP-121 (Measured by hygrometer AT-154)	G2	LOCAL	Dryer R1	Moisture content at mid point of dryer R.1	10 v.p.m	0.10 vpm or 0.50 vpm or 0.100 vpm or 0-1000 vpm	Range can be varied by selector switch.
2. AP-125	E2	LOCAL	DryerR2	Moisture content at mix point of dryer R.2	10 vpm	0-10 vpm or 0.50 vpm or 0.100vpm or 0.1000 vpm	Range can be varied by selector switch.
3. AP-136.A	H4	LOCAL	4"TG03	NH_3 content at the exit of washing tower K1	63.40% H_2 21.11% N_4 4.19% A 11.30% CH_4 5 vpm NH_3 Satd.at outlet H_2O	0-300 vpm or 0-1700 vpm (Range can be varied by selector switch)	NH_3 content is measured by ammonia analyser AT-136 Max.NH_3 content = 500 ppm.
4. AP-136.B	E.5	LOCAL	4"TG 07	NH_3 content at outlet of filter F1	63.40% H_2 21.11% N_2 4.19% A 11.30% CH_4 Satd.at outletH_2O	0-300 vpm or 0-1700 vpm.	NH_3 content can be measured by ammonia analyser AT-136.

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Instrument Number	Cordinates for locat-ing inst. on P&I Diag.	Mounted	Pipe Number & Size	DENOTES	Normal Reading	Range of Reading.	Remarks.
5. Sampling point No. AP-142.1	B. 7	LOCAL	3"HG02	Compo. of H_2 stream . out of PGR Plant.	93.2% H_2 6% N_2	5-95% H_2 5-60% N_2 0.4-20% A 0.4-40% CH_2	Normal continuous analysis.
6. Sampling point No. AP-142.2	B. 7	LOCAL	8"RG02	Compo.of tail gas out of PGR plant.	16% H_2 45.2% N_2 10.2% A 28.6% CH_4	5-95% H_2 5-60% N_2 0.4-20% A 0.4 - 40% CH_4	Normal continuous analysis.
7. Sampling point No. AP-142.3	E4	LOCAL	4"TG07	Compo.of gas at exit of filter F1.	63.4% H_2 21.11% N_2 4.19% A 11.30% CH_4	5-95% H_2 5-60% N_2 0.4-20% A 0.4-40% CH_4	Can be hooked up to the chromatograph .
8. Sampling point No. AP-142.4	A2	LOCAL	Gas Separa-tor	Compo.of Liquid at exit of B1	16% H_2 45.2% N_2 10.2% A 28.6% CH_4	5-95% H_2 5-60% N_2 0.4-20% A 0.4-40% CH_4	Can be hooked up to the chromatograph.

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.2 FLOW:							
9. FIC-100	K6	MAIN PANEL	3" TG01	Flow controller of purge gas feed to the plant	10,000 NM^3/Hr.		
10. FI-115	J3	Main Panel	4" TG 03	Flow of water in to washing tower K1	4000 lit/Hr.		
11. FI-149	F5	Local	4"RG02	Flow of gas coming to heater E4	800 NM^3/Hr.		
12. FI-173	C7	MAIN PANEL	3"HG 02	Flow of H_2 stream going out of cold box.	6000 NM^3/hr.		
13. FI-176	C7	Main Panel	8" RG02	Flow of tail gas out of cold box	3777 NM^3/Hr.		
14. FI-192	C6	LOCAL	½"	Flow of H_2 for breathing	5 NM^3/Hr.		
15. FI-199	C6	Local	½"	Flow of N_2 for breathing	5 NM^3/hr.		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.3 Pressure.							
16. PI-114	K4	MAIN PANEL	4" TG02	Pr. of gas at the outlet of heat exchanger E3	47.3 kg/cm^2g.	0-80 kg/cm^2g	
17. PI-130	K1	Local	2"ED02	Pr. at the suction of pump P1	0.9 kg/cm^2a	-1 to +3 kg/cm^2g	
18. PI-131	K1	Local	1½"ED04	Pr. at the delivery of pump P1	48.2 kg/cm^2a	0 to 100 kg/cm^2g	
19. PI-132	K2	Local	2"ED02	Pr. at the suction of pump P2	0.9 kg/cm^2a	-1 to +3 kg/cm^2g	
20. PI-133	J1	Local	1½"ED04	Pr. at the delivery of pump	48.2 kg/cm^2a	0 to 100 kg/cm^2g	
21. PIC-137	C7	Main Panel	3" HG 02	Pr. Controller of H_2 stream out of cold box.	46.3 kg/cm^2a		
22. PIC-139	C7	Main Panel	8"RG02	Pr. controller of tail gas out of cold box	4.43 kg/cm^2a	-	

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
23. PI-143	H6	Local	3"TG01	Pr. of treated gas into PGR Plant.	130 kg/cm^2g	0 to 250 kg/cm^2g	
24. PI-150	E5	Local	4"RG02	Pr.of tail gas entering in regen. heater	3.35kg/cm^2g	0 to6kg/cm^2g	
25. PI-152	F4	Local	4"TG07	Pr.of Purge gas after filter F1	45.85kg/cm^2g	0 to 100kg/cm^2g	
26. PDI-153	F4	Main Panel	4"TG06	Pr.of gas going to filterF1	46.86kg/cm^2a	0 to50kg/cm^2g	
27. PI-155	G3	Local	4"TG05	Pr.of gas at outlet of dryerR1	46 kg/cm^2g	0 to 100kg/cm^2g	
28. PI-156	E3	Local	4"TG05	Pr.of gas at outlet of dryer R2	46 kg/cm^2g	0 to 100 kg/cm^2g	
29. PI-166	G1	Local	2"NS01	Pr.of inert gas to deriming heater	8 kg/cm^2g	0 to 16 kg/cm^2	

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
30. PI-179	G7	Local	8"	Pr. of H_2 gas which can go to tail gas after HCV178	2.2 kg/cm^2g	0 to 6 kg/cm^2	
31. PI-182	A3	Main Panel	3"HG01	Pr. of gas going to cold box from B1	46.5kg/cm^2a	0 to 80kg/cm^2	
32. PCV-190	C6	Main Panel	$\frac{1}{2}$"	Pr. of H_2 going for breathing	46.3 kg/cm^2g	-	
33. PCV-191	C6	Panel	$\frac{1}{2}$"	Pr. of N_2 gas for breathing	8 kg/cm^2a	-	
34. PI-193	C6	Local	4"TG01	Pressure of breathing gas going to cold-box	0.015 kg/cm^2g	0 to 0.04 kg/cm^2g	
1.4 TEMPERATURE.							
35. TI-102	K5	Main Panel	4"TG01	Temp. of treated gas entering in heat exch. E3	-28^oC to -15^oC		
36. TI-104	L4	Local Panel	Water Capacity B 3-A	Temp. of water in B3-A	25^oC	0^o-60^oC	
37. TI-128	K1	Local	$1\frac{1}{2}$"ED04	Temp. of water after pumpP1.	19^oC	-5 to + 60^oC	

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
38.TI-129	J1	Local	$1\frac{1}{2}$" ED04	Temp. of water after pump P2	19°C	-5°C to + 60°C	
39.TI-146	G5	Local	4"RG03	Temp.of tail gas coming out of regeneration heater	311°C	0-400°C	
40.TM-157	G3	Local	4"TG05	Temp.at exit of dryer R1	25°C	-5°C to 60°C	
41.TI-158	E3	Local	4"TG05	Temp.at exit of dryer R2	25°C	-5°C to 60°C	
42.TI-162	G1	Local	4"TG03	Temp.of gas at exit of wash--ing tower-K1	20°C	-5°C to 60°C	
43. TI-163	E1	Local	4" RG04	Temp. of regener--ant gases going to water separa-tor B4	150°C	0°C to 200°C	
44.TI-170	E0	Local	2"NS01	Temp.of inert gas to deriming heater	143°C	0 to 200°C	
45. TIC-183	A3	Main Panel	3"TG 10	Temp. of stream going to B.1	-190°C	-	

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.5 LEVEL.							
46 LIC-134	H2	Main Panel	Washing Tower K1	Level controller in washing tower K1	-	-	
47. LIC-185	B7	Main Panel	2"RG01	Level controller of gas sepr.B1	-	-	

Instrument Number. (1)	Cordinates For Locating Inst. on P&I Diagram. (2)	Mounted (3)	Pipeside & No. (4)	Denotes (5)	Setting Point (6)
1.1 ANALYSER					
1. ASH -136	H4	PANEL	4" TG 03	High NH_3 content at exit of washing tower	10 vpm of ammonia.
2. ASH-142-1	A7	Local & Main Panel	3" HG 02	High inert contents in H_2 stream out of PGR Plant.	More than 6% N_2 5.4% Ar. 0.4% CH_4
3. ASH-142-2	A7	Local & Main Panel	8" RG 02	High H_2 content in tail gas	More than 16% H_2
4. ASH-154	E4	Local & Main Panel	Dryer R_1 & R_2	Water content at mid point of dryer high.	3 vpm water.
1.2 Flow					
5. FSL-115	J3	At the back of panel	1½"ED04	Low flow of water in washing tower-K1	2 m^3/hr.
6. FSL-149	F5	Local	4"RG02	Low flow of regenera--ting gases to heater	1000 NM^3/hr.

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(1)	(2)	(3)	(4)	(5)	(6)
1.3 Pressure.					
7. PSL-122	G3	Local	4" TG05	Low pressure in gas line at exit of dryer R1	3.2kg/cm^{2}g
8. PDSL-123	F3	Local	Dryer	Pr.differential low in balancing line of dryers.	0.2kg/cm^2
9. PSL-124	E3	Local	4"TG05	Low pr.in gas line at exit of dryer R2	3.2kg/cm^{2}g
10. PSL-126	J2	Local	1½"ED04	Low pr.of water pr. at inlet of washing tower tripping the plant.	Less than or equal to 46 kg/cm^{2}g
11. PSH-137	C7	Local	3"HG02	High pressure of H_2 gas out of cold box	49kg/cm^{2}g
12. PDSH-153	F4	Behind the Panel	4"TG06	Pressure drop across filter high.	0.05 kg/cm^2
13. PSL-194	J1	Local	1"AI01	Pr. of instrument air low	Less than or equal to 4 kg/cm^{2}g
1.4 Temperature.					
14. TSL-116	J3	Local	4" TG02	Low temp. of gas entering in washing tower K-1	-10°C
15. TSH-135	H4	Local	4"TG03	High temp. of gas at the outlet of washing tower	More than 20°C
16. TSL-147	F5	At the back of Panel.	4" RG 03	Low temp. of gases after reg. heater.	200°C
17. TSH-147	F5	At the back of Panel.	4" RG 03	High temp. of gases after reg. heater	240°C

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(1)	(2)	(3)	(4)	(5)	(6)
18. TSH-148	F5	Local	-	Resistence temp. of E_4 high	300°C
19. TSL-197	E1	Local	4"RG 04	Temperature of water laden gas going to water sepr. B_4-low	25°C
1.5 LEVEL.					
20. LSL-105	L2	Local	2"ED03	Low level of washing tower in water capacity B-39	300 mm Water.
21. LSH-134	H_2	At the back of panel	Washing tower	High level of water in washing tower.	1350 mm.
22. LSHH-134	H_2	At the back of panel	Washing tower	Extra high level of water in washing tower.	1450 mm
23. LSL-134	H_2	Located at the back of panel	Washing tower K1	Low level of water in washing tower	500 mm.
24. LSLL-134	H_2	Located at the back of panel	Washing tower K1	Extra low level in washing tower which will trip the PGR Plant.	0 mm.

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Instrument Number (1)	Mounted (2)	Denotes (3)	Normal Reading. (4)	Range of Reading. (5)
1.1 PRESSURE:				
1. PI-300	Behind the Panel.	Pressure of refrigerant into l.p. case of compressor	0.04 kg/cm^2g	-1 to 25 kg/cm^2g
2. PI-301	Behind the Panel .	Pressure of oil at the oil pump discharge.	2.5 kg/cm^2g	-1 to 25 kg/cm^2g
3. PI-302	Behind the Panel.	Pressure of the H.P. case of compressor.	18.8 kg/cm^2g	-1 to 25 kg/cm^2g
4. PI-305	Local	Discharge pr. of l.p. case refrigerant.	3.2 kg/cm^2g	-1 to 25 kg/cm^2g
5. PI-315	Local	Pressure just before bursting disc of intercooler B.9		
6. PI-321	Local	Pressure just before bursting disc of condenser	0 kg/cm^2g	-1 to 25 kg/cm^2g
7. PI-333	Local	Pressure just before bursting disc. of receiver B-6	0kg/cm^2g	0/16kg/cm^2g
8. PI-338	Local	Pressure just before bursting disc. of cooler E2	0kg/cm^2g	0/16 kg/cm^2g

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(1)		(2)	(3)	(4)	(5)
1.2	TEMPERATURE:				
9.	TI-306	Local	Temp. of refrigerant suction to l.p. case of compressor	-26°C	-60°C to 40°C
10.	TI-307	Local	Temp. of refrigerant at discharge of l.p. case.	39°C	0°C to 160°C
11.	TI-308	Local	Temp. of refrig. at discharge of L.P. case.	96°C	0°C to 160°C
12.	TI-309	Local	Temp. of refrig. at the suction of H.P. case of compressor.	22°C	0°C to 160°C
13.	TI-323	Local	Temperature of C.W. at the exit of condenser E.7	39°C	0°C to 160°C
14.	TI-324	Local	Temperature of CW at the inlet of condenser E.7	34°C	0°C to 160°C
15.	TI-335	Local	Temperature of refrigerant going to evaporator E2 at the outlet of oil recuperatorF3	-22°C	-66°C to 40°C
16.	TI-340	Local	Temperature of process gases inlet to cooler E2	-36.3°C	-60°C to 40°C
17.	TI-341	Local	Temperature of process gases at exit of coolerE2	-40°C	-60°C to 40°C
18.	TIC-342	Panel	Temperature control of refrigerant in the cooler	-40°C	-50°C to -25°C

2. SET POINTS OF ALARMS AND TRIP.

INSTRUMENT NUMBER	MOUNTED	DENOTES	SETTING POINT.
1.1 FLOW:			
1. FSL-304	Panel	Low flow of CW to the condenser E7 trips the unit.	3.5 m^3/hr.
1.2 PRESSURE.			
2. PSL-300	Panel	Low pressure of refrigerant to l.p. case of the compressor	-0.25 kg/cm^2 g
3. PDSL-301	Panel	Low differential pressure in the oil lines tothe compressor shuts down the unit	2 kg/cm^2 g
4. PSH-302	Panel	High discharge pressure of refrigerant from the H.P. case of compressor trips the compressor C1.	20.5 kg/cm^2 g
1.3 TEMPERATURE			
5. TSH-303	Panel	High temperature of the refrigerant from the H.P. case of compressor shut down the unit.	120°C
1.4 LEVEL.			
6. LSHH-313	Panel	Extra low level in the inter-cooler B.9	-
7. LSH-314	Panel	Low level in the intercooler B.9	60 mm.

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C. HANDLING.

LIST OF INSTRUMENTS.

Instrument Number.	Mounted	Pipe No.	Denotes	Normal Reading	Range of Reading.
LI-181	Local	172-F	Level of ammonia liquor in the tank.	1250 mm (50%)	200 mm to 2000 mm
LA-182	Panel	172-F	High level alarm in the tank	1950 mm from bottom (set pressure)	-
LA-183	Panel	172-F	Low level alarm in the tank.	250 mm from bottom (set pressure)	-
PI-251	Local	172-F	Pressure of the blanketing gas after control valves	25 mm WG	0.50 mm WG.
Pi-254	Local	172-F	Pressure in the tank.	25 mm WG	0-50 mm WG
PA-255	Panel	172-F	Alarm for low pressure in tank.	(set pressure)	0-50 mmWG
PA-256	Local	172-J	Discharge of Pump	2.6kg/cm^{2}g	0-6 kg/cm^{2}g
PI-257	Local	172-JA	-do-	-do-	-do-

MATERIAL BALANCE

EASIS: FEED PURGE GAS AT $-23^{o}C$ AND 130 KG/CM^2G

STREAM	FLOW IN KG MOLES/HR.							Average Mol. Wt. dry basis	Operating Temp. °C	Operating Pressure kg/cm^2g.
	H_2	N_2	Ar	CH_4	NH_3	H_2O	TOTAL			
MOL. WEIGHT	2.016	28.013	39.948	16.043	17.031	18.015				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Feed gas to the gas Exchanger E3	276.568	92.085	18.292	49.30	9.905	-	446.15	10.821	-28	47.6
Purge gas at the exit of E3 and inlet to K1.	276.568	92.085	18.292	49.30	9.905	-	446.15	10.821	-4	47.3
Demineralised water to B3A	-	-	-	-	-	277.546	277.546	18.015	25 to 34	-
Demineralised water inlet to washing Tower K1	-	-	-	-	-	223.744	277.546	18.015	3	48.2
Ammonia liquor from washing tower K1 (4.03% W/W as NH_3)	-	-	-	-	9.905	222.919	287.451	-	10	47.27
Gas exit of K1 and inlet to drying vessels R1/R2.	276.568	92.085	18.292	49.30	5 vpm	0.825	437.597	10.676	+5	47.10
Gas exit of R1/R2	276.568	92.085	18.292	49.3	-	-	436.245	10.443	+10	46.96

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Gas inlet to cryo-genic ExchangerE1.	276.568	92.085	18.292	49.3	-	-	436.245	10.443	+10	46.80
Liquiefied gas from B1 to B2	8.52	74.982	17.095	48.15	-	-	148.747	24.020	-190	46.50
Product Hydrogen injection to tail gas stream via TV-183	18.427	1.176	0.082	0.079	-	-	19.764	3.777	-190	46.5
Product Hydrogen from gas separatorB1	268.048	17.104	1.197	1.15	-	-	287.499	5.274	-190	46.5
Product Hydrogen stream from E1 to syn.gas compressor 103.I	249.621	15.928	1.115	1.071	-	-	267.735	5.274	8	27.2
Tail gas stream out of B1	26.947	76.158	17.177	48.229	-	-	168.511	21.646	8	4.43
Tail gas going for Regeneration of R1/R2	5.708	16.131	3.638	10.215	-	-	35.692	21.646	8	4.39
Tail gas out of water separator B4	5.708	16.131	3.638	10.215	-	*	35.692	21.646	50 to 90	4.19
Tail gas stream to the Reformer Furnace	26.947	76.158	17.177	48.229	-	-	168.511	21.646	8	4.13

* Quantity of water will change with respect to time.

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TECHNICAL INFORMATION.

TABLE NO.	Description .
1	Specifications of Activated Alumina
2.	Specifications of Molecular Sieves.
3.	Properties of Refrigerant Zerice S-68.
4.	Properties of Lubricant Zerice S-68
5.	Data onDew Point of a Gas Vs.Moisture content.

TECHNICAL INFORMATION.

DIAGRAMS .

DRAWING NO.	DESCRIPTION.
1. 07 3173 XX-02-00-0-01 Reva	Process Flow sheet
2. 07 3173 A3-014-02 Rev. a	Notice for Diagram. (Abbreviations used in P&I diagrams).
3. 07-3173 A0-014-1 Rev.J	P&I Diagram of the Plant.
4. 07-3173 A0-671-4 Rev. E	P&I Diagram of Refrigeration Unit.
5. 01 DC 01250 Rev.0	P&I Diagram for Ammonia Liquor Tank.
6. 07 3173 A1-015-02 Rev. C	Plot Plan
7. Document No. 07 3173 XX-02-10-5-01 Rev. 0	Process Efficiencies.

TABLE-1.

SPECIFICATIONS OF ACTIVATED ALUMINA.

Size: 5 to 10 mm

Density: 1.17×10^3 kg/m^3

Bulk Density: 737.43 kg/m^3

Heat of adsorption: 1 to 1.3 times the latent heat of condensation of water.

TABLE -2

SPECIFICATIONS OF MOLECULAR SIEVES.

Nominal Pore diameter :	5 Angstromes
Form :	1.5 mm or 3 mm (dia) cylindrical pellets.
Molecules adsorbed :	Molecules with an effective diameter less than 5 angstreams.
Molecules Excluded :	Isoparaffins: Molecules with an effective diameter greater than 5 angstroms.

Crushing strength:

For 3 mm dia cylindrical pellets = 5-6 kg.
For 1.5 mm dia cylindrical Pellets = Approx. 2.5 - 3.0 kg.

Loss on attrition = Less than 0.5%
Bulk Density(Fully exposed basis): 0.73-0.75 kg/litre.

Water Adsorption capacity (Wt.%) : 21-22
at 23 mm Hg g and $30^{o}C$.

Heat of adsorption : 1000 kcal /kg H_2O

Specific Heat : 0.24 kcal/kg^{o}C

PROPERTIES OF REFRIGERANT - R-502

1.	CHEMICAL FORMULA	:	Azcotropic-mixture of 48.8% (wt) of chlorodifluorometh are ($CHClF_2$) & 51.2%(wt) chloropentaflouroethane ($CClF_2CF_3$).
2.	MOLECULAR WEIGHT	:	111.6
3.	COLOUR	:	COLOURLESS
4.	ODOUR & DETECTION	:	FAINT ethereal odour. Leaks readily detected with a halide leak detector.
5.	FLAMMABILITY	:	Non flammable.
6.	TOXICITY	:	Very low - toxic
7.	NORMAL BOILING POINT AT 1 ATMOSPHERE	:	$-45.6^{\circ}C$
8.	CRITICAL TEMPERATURE	:	$90^{\circ}C$
9.	CRITICAL PRESSURE	:	43.52 Kg/cm^2a
10.	CRITICAL DENSITY	:	558.6 Kg/m^3

11. THERMAC CONDUCTIVITY :

(a)	SATD.LIQUID AT $-15^{\circ}C$	=	0.077 Kcal/(hr.m.°C)
(b)	SATD LIQUID AT $30^{\circ}C$	=	0.055 Kcal/(hr.m.°C)
(c)	VAPOUR AT SATURATION PRESSURE AT $-15^{\circ}C$	=	0.00804 Kcal/hr.m.°C)
(d)	VAPOUR AT 1 ATM AND AT $30^{\circ}C$	=	0.010274 Kcal/hr.m.°C

12. VISCOSITY :

(a)	SATD LIQUID AT $-15^{\circ}C$	=	0.334 cp
(b)	SATD LIQUID AT $30^{\circ}C$	=	0.240 cp
(c)	VAPOUR AT SATN. PR. AT $-15^{\circ}C$	=	0.0112 cp
(d)	VAPOUR AT 1 ATM AND AT $30^{\circ}C$	=	0.0131 cp

13. Properties of saturated refrigerant and superheated refrigerant are given in Table-3.1 and 3.2, respectively in following pages. These are extracted from properties of commonly-used Refrigerants, published by Air-conditioning and Refrigeration Institute, USA (1967 Edition).

PROPERTIES OF SATURATED REFRIGERANT (R-502)

TEMP. °C	SATURATION PRESSURE Kg/cm^2 a	SPECIFIC VOLUME M^3/Kg		DENSITY Kg/m^3		ENTHALPY Kcal/Kg		
		LIQUID	VAPOUR	LIQUID	VAPOUR	SENSIBLE	LATENT	VAPOUR
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-50.	0.8374	6.625×10^{-4}	0.2014	1512.32	4.9648	-2.5632	43.0622	40.4990
-49.44	0.8606	6.631×10^{-4}	0.1964	1507.36	5.0928	-2.4242	42.9955	40.5713
-48.88	0.8845	6.644×10^{-4}	0.1915	1505.76	5.2224	-2.2796	42.9232	40.6436
-48.33	0.9084	6.65×10^{-4}	0.1868	1504.0	5.3526	-2.1406	42.8565	40.7159
-47.77	0.9330	6.656×10^{-4}	0.1822	1502.4	5.488	-1.9960	42.7842	40.7882
-47.22	0.9576	6.663×10^{-4}	0.1778	1500.64	5.626	-1.8515	42.7119	40.8604
-46.66	0.9836	6.669×10^{-4}	0.1734	1499.04	5.7664	-1.7125	42.6452	40.9327
-46.11	1.0096	6.681×10^{-4}	0.16924	1497.28	5.9088	-1.5679	42.5729	41.005
-45.55	1.0363	6.688×10^{-4}	0.1652	1495.52	6.0544	-1.4289	42.5006	41.0717
-45.	1.0638	6.694×10^{-4}	0.16123	1493.92	6.2016	-1.2899	42.4339	41.144
-44.44	1.0912	6.7×10^{-4}	0.15741	1492.16	6.3536	-1.1454	42.3616	41.2163
-43.88	1.1193	6.706×10^{-4}	0.15369	1490.4	6.5072	-1.0008	42.2894	41.2886
-43.33	1.1481	6.7188×10^{-4}	0.15008	1488.8	6.664	-0.8618	42.2226	41.3608
-42.77	1.1777	6.725×10^{-4}	0.14657	1487.04	6.8224	-0.7122	42.1504	41.4331
-42.22	1.2079	6.731×10^{-4}	0.14316	1485.28	6.9856	-0.5727	42.0781	41.5054
-41.66	1.2388	6.7375×10^{-4}	0.13985	1483.52	7.1504	-0.42812	42.0058	41.5777

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-41.11	1.2698	6.75×10^{-4}	0.13663	1481.92	7.3184	-0.2891	41.9335	41.6444
-40.55	1.3014	6.7563×10^{-4}	0.13351	1480.16	7.4912	-0.1446	41.8612	41.7167
-40.	1.3338	6.7625×10^{-4}	0.13046	1478.4	7.6656	0.000	41.7890	41.789
-39.44	1.3675	6.775×10^{-4}	0.12751	1476.64	7.8432	0.1146	41.7167	41.8612
-38.88	1.4005	6.781×10^{-4}	0.12464	1474.88	8.024	0.28912	41.644	41.9335
-38.33	1.4350	6.787×10^{-4}	0.121844	1473.12	8.208	0.4337	41.5760	42.0058
-37.77	1.4702	6.794×10^{-4}	0.119125	1471.36	8.3952	0.5727	41.4998	42.0725
-37.22	1.5060	6.8062×10^{-4}	0.11648	1469.6	8.5856	0.7228	41.422	42.1448
-36.66	1.5419	6.8125×10^{-4}	0.113913	1467.84	8.7792	0.8674	41.3497	42.2171
-36.11	1.5791	6.8187×10^{-4}	0.11141	1466.08	8.976	1.0119	41.2774	42.2894
-35.55	1.6171	6.83125×10^{-4}	0.10898	1464.32	9.176	1.1509	41.2052	42.3561
-35.	1.6551	6.8375×10^{-4}	0.1066	1462.58	9.3808	1.3010	41.1273	42.4284
-34.44	1.6944	6.8437×10^{-4}	0.104293	1460.8	9.5888	1.4456	41.0550	42.5006
-33.88	1.7338	6.85625×10^{-4}	0.10205	1459.04	9.7984	1.5846	40.9828	42.5674
-33.33	1.7746	6.8625×10^{-4}	0.099862	1457.28	10.0144	1.7347	40.9049	42.6396
-32.77	1.8154	6.8688×10^{-4}	0.097731	1455.52	10.232	1.8793	40.8326	42.7119
-32.22	1.8576	6.881×10^{4}	0.095656	1453.6	10.4544	2.0238	40.7548	42.7786
-31.66	1.8997	6.8875×10^{-4}	0.09364	1451.84	10.68	2.1684	40.6825	42.8509

TABLE - 3.1

PURGE GAS RECOVERY PLANT

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-31.11	1.9433	6.89375×10^{-4}	0.091669	1450.08	10.9088	2.3130	40.6047	42.9176
-30.55	1.9876	6.9062×10^{-4}	0.08975	1448.32	11.1424	2.4631	40.5268	42.9899
-30	2.0326	6.9125×10^{-4}	0.087881	1446.4	11.3792	2.6076	40.449	43.0566
-29.44	2.0783	6.925×10^{-4}	0.086063	1444.64	11.6192	2.7522	40.3767	43.1289
-28.88	2.1247	6.9313×10^{-4}	0.084287	1442.88	11.864	2.89676	40.2988	43.1956
-28.33	2.1718	6.9375×10^{-4}	0.082556	1440.96	12.1136	3.0469	40.2210	43.2679
-27.77	2.2196	6.95×10^{-4}	0.080868	1439.2	12.3664	3.1914	40.1432	43.3346
-27.22	2.2689	6.9563×10^{-4}	0.079225	1437.28	12.6224	3.3416	40.0654	43.4069
-26.66	2.3181	6.9687×10^{-4}	0.077619	1435.52	12.8832	3.4861	39.9875	43.4736
-26.11	2.3687	6.975×10^{-4}	0.076056	1433.6	13.1488	3.6362	39.9097	43.5459
-25.55	2.420	6.981×10^{-4}	0.0753	1431.84	13.4176	3.7808	39.9318	43.6126
-25.	2.4721	6.994×10^{-4}	0.07304	1429.92	13.6912	3.9254	39.754	43.6794
-24.44	2.5248	7.0×10^{-4}	0.07159	1428.16	13.9696	4.0755	39.6762	43.7516
-23.88	2.5789	7.013×10^{-4}	0.07017	1426.24	14.2512	4.2256	39.5928	43.8184
-23.33	2.6338	7.019×10^{-4}	0.06879	1424.32	14.5376	4.3702	39.5149	43.8851
-22.77	2.6893	7.031×10^{-4}	0.06744	1422.56	14.8288	4.5203	39.4371	43.9574
-22.22	2.7456=	7.0375×10^{-4}	0.06612	1420.64	15.1248	4.6704	39.3537	44.0241
-21.66	2.8025	7.05×10^{-4}	0.06483	1418.72	15.424	4.8150	39.2758	44.0908

TABLE - 3.1

PURGE GAS RECOVERY PLANT

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-21.11	2.8609	7.056×10^{-4}	0.06358	1416.8	15.7296	4.9651	39.1924	44.1575
-20.55	2.9109	7.069×10^{-4}	0.06235	1415.04	16.0384	5.1152	39.1090	44.2242
-20.	2.9804	7.075×10^{-4}	0.06115	1413.12	16.352	5.2653	39.0312	44.2965
-19.44	3.0416	7.088×10^{-4}	0.05998	1411.2	16.672	5.4154	38.9478	44.3632
-18.88	3.1034	7.094×10^{-4}	0.05884	1409.28	16.9952	5.66	38.8700	44.430
-18.33	3.1660	7.106×10^{-4}	0.05773	1407.36	17.3248	5.710	38.7866	44.4967
-17.77	3.230	7.113×10^{-4}	0.05663	1405.44	17.6576	5.8602	38.7032	44.5634
-17.22	3.2947	7.125×10^{-4}	0.05557	1403.52	17.9968	6.0104	38.6198	44.6301
-16.66	3.3601	7.138×10^{-4}	0.05453	1401.6	18.3408	6.1605	38.5364	44.6968
-16.11	3.4268	7.144×10^{-4}	0.05351	1399.68	18.6896	6.3106	38.4530	44.7636
-15.55	3.4950	7.156×10^{-4}	0.05251	1397.76	19.0432	6.4607	38.3696	44.8303
-15.	3.5632	7.163×10^{-4}	0.05154	1395.84	19.4016	6.6108	38.2862	44.897
-14.44	3.6335	7.175×10^{-4}	0.05059	1393.92	19.7664	6.7610	38.1977	44.9582
-13.88	3.7039	7.181×10^{-4}	0.04966	1392.	20.136	6.9111	38.1138	45.0249
-13.33	3.7756	7.194×10^{-4}	0.04875	1390.08	20.512	7.0612	38.0304	45.0916
-12.77	3.8487	7.206×10^{-4}	0.04786	1388.16	20.8928	7.2169	37.8414	45.1583
-12.22	3.9225	7.213×10^{-4}	0.046994	1386.08	21.28	7.367	37.8525	45.2195
-11.66	3.9978	7.225×10^{-4}	0.046144	1384.16	21.672	7.517	37.7691	45.2862

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-11.11	4.0737	7.2375×10^{-4}	0.045313	1382.24	22.0688	7.6728	37.6801	45.3529
-10.55	4.1503	7.2438×10^{-4}	0.0445	1380.16	22.472	7.8174	37.5967	45.4141
-10.	4.2284	7.256×10^{-4}	0.0437	1378.24	22.8816	7.9730	37.5078	45.4808
- 9.44	4.3076	7.2688×10^{-4}	0.04293	1376.32	23.2976	8.1287	37.4188	45.5475
- 8.88	4.3880	7.275×10^{-4}	0.04216	1374.24	23.7184	8.2788	37.3298	45.6087
- 8.33	4.4695	7.2875×10^{-4}	0.04141	1372.32	24.1456	8.4290	37.2409	45.6698
-7.77	4.5525	7.3×10^{-4}	0.04069	1370.24	24.5792	8,5846	37.1519	45.9590
-7.22	4.6362	7.3063×10^{-4}	0.03997	1368.32	25.0192	8.7348	37.0630	45.7977
-6.66	4.7205	7.3188×10^{-4}	0.039269	1366.24	25.464	8.8904	36.974	45.8644
-6.11	4.8070	7.3313×10^{-4}	0.038588	1364.16	25.917	9.0406	36.8850	45.9256
-5.55	4.8942	7.3438×10^{-4}	0.037913	1362.24	26.376	9.1962	36.7905	45.9868
-5.	4.9821	7.350×10^{-4}	0.037256	1360.16	26.840	9.3464	36.7016	46.0479
-4.44	5.0714	7.3625×10^{-4}	0.036613	1358.08	27.3120	9.5076	36.6070	46.1146
-3.88	5.1621	7.375×10^{-4}	0.035981	1356.16	27.7904	9.6577	36.5181	46.1758
-3.33	5.2542	7.3875×10^{-4}	0.035369	1354.08	28.2752	9.8134	36.4236	46.2370
-2.77	5.3477	7.3938×10^{-4}	0.034763	1352.0	28.768	9.9691	36.3290	46.3593
-2.22	5.4419	7.4062×10^{-4}	0.034169	1349.92	29.2672	10.1248	36.2345	46.3593
-1.66	5.5375	7.4188×10^{-4}	0.03359	1347.84	29.7728	10.2749	36.1456	46.4204
-1.11	5.6338	7.4313×10^{-4}	0.033019	1345.76	30.2848	10.4306	36.0510	46.4816
-0.55	5.7323	7.4438×10^{-4}	0.032463	1343.68	30.8048	10.5862	35.9565	46.5428
0	5.8314	$7.4563.10^{-4}$	0.031913	1341.60	31.3328	10.7419	35.8564	46.5984

TABLE - 3.1
PURGE GAS RECOVERY PLANT

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0.55	5.9319	7.4625×10^{-4}	0.03138	1339.52	31.8672	10.8976	35.7619	46.6595
1.11	6.0339	7.475×10^{-4}	0.03086	1337.44	32.4096	11.0533	35.6677	46.7207
1.66	6.1365	7.4875×10^{-4}	0.03034	1335.36	32.96	11.2145	35.5673	46.7818
2.22	6.2413	7.5×10^{-4}	0.02984	1333.28	33.5168	11.3646	35.4728	46.8374
2.77	6.3468	7.5125×10^{-4}	0.02934	1331.2	34.0816	11.526	35.3727	46.8986
3.33	6.4542	7.525×10^{-4}	0.02886	1329.12	34.6544	11.6816	35.2726	46.9542
3.88	6.5626	7.5375×10^{-4}	0.02838	1326.88	35.2352	11.8372	35.1781	47.0154
4.44	6.6723	7.55×10^{-4}	0.027913	1324.8	35.824	11.9929	35.0780	47.0710
5.	6.7834	7.5625×10^{-4}	0.027456	1322.72	36.4208	12.1542	34.9780	47.1321
5.55	6.8959	7.575×10^{-4}	0.02701	1320.48	37.0272	12.3098	34.8779	47.1877
6.11	7.0098	7.5875×10^{-4}	0.02657	1318.4	37.64	12.4655	34.7778	47.2433
6.66	7.1223	7.6×10^{-4}	0.02614	1316.16	38.2624	12.6268	34.6722	47.2989
7.22	7.2418	7.6125×10^{-4}	0.02571	1314.08	38.8928	12.7874	34.5721	47.3545
7.77	7.3613	7.625×10^{-4}	0.02529	1311.84	39.5328	12.9427	34.4664	47.4101
8.33	7.4800	7.6375×10^{-4}	0.02489	1309.76	40.1808	13.1049	34.3664	47.4713
8.88	7.600	7.65×10^{-4}	0.02449	1307.52	40.8384	13.2606	34.2607	47.5213
9.44	7.720	7.6625×10^{-4}	0.02409	1305.28	41.504	13.4218	34.1557	47.5769
10.	7.8464	7.675×10^{-4}	0.02371	1303.04	42.1792	13.5775	34.055	47.6325
10.55	7.9730	7.6875×10^{-4}	0.02333	1300.96	42.864	13.7388	33.9494	47.6881
11.11	8.0996	7.7×10^{-4}	0.02296	1298.77	43.5584	13.9	33.8437	47.7437

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
11.66	8.2261	7.7125×10^{-4}	0.02259	1296.48	44.2624	14.0612	33.7325	47.7938
12.22	8.3527	7.725×10^{-4}	0.02223	1294.24	44.976	14.2225	33.6269	47.8494
12.77	8.4863	7.7375×10^{-4}	0.02188	1292.	45.70	14.3837	33.5157	47.8994
13.33	8.6198	7.7563×10^{-4}	0.02154	1289.76	46.432	14.5450	33.410	47.955
13.88	8.7534	7.7688×10^{-4}	0.0212	1287.52	47.176	14.7006	33.3044	48.0050
14.44	8.8870	7.7813×10^{-4}	0.02086	1285.28	47.9296	14.8619	33.1932	48.0551
15.	9.0276	7.7938×10^{-4}	0.02054	1282.88	48.6944	15.0231	33.082	48.1051
15.55	9.1612	7.8063×10^{-4}	0.02021	1280.64	49.4688	15.1899	32.9708	48.16072
16.11	9.3018	7.825×10^{-4}	0.0199	1278.4	50.2544	15.3512	32.8596	48.2108
16.66	9.4425	7.8375×10^{-4}	0.01959	1276.16	51.0512	15.5180	32.7428	48.2608
17.22	9.5901	7.85×10^{-4}	0.01928	1278.76	51.8576	15.6737	32.6316	48.3053
17.77	9.7307	7.8625×10^{-4}	0.01898	1271.52	52.6768	15.8349	32.5204	48.3553
18.33	9.8784	7.8813×10^{-4}	0.01969	1269.12	53.5072	16.0017	32.4037	48.4054
18.88	10.0260	7.8928×10^{-4}	0.0184	1266.88	54.3488	16.1685	32.2869	48.4554
19.44	10.1807	7.9063×10^{-4}	0.01811	1264.48	55.2032	16.3297	32.1702	48.4999
20.	10.3283	7.925×10^{-4}	0.01784	1262.08	56.0688	16.4965	32.0534	48.5499
20.55	10.4830	7.9375×10^{-4}	0.01756	1259.84	56.9456	16.6578	31.9366	48.5944
21.11	10.6377	7.95×10^{-4}	0.01729	1257.44	57.8352	16.819	31.8199	48.6389
21.66	10.7924	7.9688×10^{-4}	0.017025	1255.04	58.7392	16.9858	31.6976	48.6834

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
22.22	10.9541	7.9813×10^{-4}	0.01676	1252.64	59.6544	17.1526	31.5808	48.7334
22.77	11.1088	8.0×10^{-4}	0.01651	1250.24	60.5824	17.3194	31.4585	48.7779
23.33	11.2705	8.0125×10^{-4}	0.01626	1247.84	61.5232	17.4862	31.3362	48.8224
23.88	11.4392	8.0313×10^{-4}	0.01601	1245.44	62.4784	17.6474	31.2138	48.8613
24.44	11.6009	8.0438×10^{-4}	0.01576	1242.88	63.4464	17.8142	31.0915	48.9058
25.	11.770	8.0625×10^{-4}	0.01552	1240.48	64.4288	17.9810	30.9692	48.9502
25.5	11.9384	8.075×10^{-4}	0.01529	1238.08	65.424	18.1478	30.8413	48.9892
26.11	12.1072	8.0938×10^{-4}	0.01505	1235.52	66.4352	18.3146	30.719	49.0336
26.66	12.2759	8.1125×10^{-4}	0.014825	1233.12	67.4592	18.4814	30.5911	49.0726
27.22	12.4517	8.125×10^{-4}	0.0146	1230.56	68.496	18.6482	30.4632	49.1115
27.77	12.6274	8.1438×10^{-4}	0.014375	1228.16	69.5536	18.8150	30.3354	49.1504
28.33	12.8032	8.1563×10^{-4}	0.01416	1225.6	70.624	18.9818	30.2075	49.1893
28.88	12.986	8.175×10^{-4}	0.01394	1223.04	71.7104	19.1542	30.0740	49.2282
29.44	13.1618	8.1938×10^{-4}	0.01373	1220.64	72.8112	19.321	29.9462	49.2672
30.	13.3446	8.2125×10^{-4}	0.01353	1218.08	73.9296	19.4934	29.8127	49.3061
30.55	13.5344	8.225×10^{-4}	0.013325	1215.52	75.064	19.6602	29.6793	49.3394
31.11	13.7172	8.2438×10^{-4}	0.01312	1212.8	76.2144	19.8325	29.5458	49.3784

Temp.	Saturation Pressure	Specific volume		DENSITY KG/M^3		ENTHALPY		
^oC	KG/CM^2 a	LIQUID	VAPOUR	LIQUID	VAPOUR	SENSIBLE	LATENT	VAPOUR
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
31.66	13.9071	8.2625×10^{-4}	0.012925	1210.24	77.3824	19.9993	29.4124	49.4117
32.22	14.0969	8.2813×10^{-4}	0.012725	1207.68	78.568	20.1606	29.2734	49.4451
32.77	14.2867	8.3×10^{-4}	0.01254	1205.12	79.7696	20.3440	29.1344	49.4784
33.33	14.4836	8.3108×10^{-4}	0.01235	1202.4	80.9974	20.5108	29.0096	49.5118
33.88	14.6804	8.3375×10^{-4}	0.01216	1199.84	82.2304	20.6832	28.8620	49.5452
34.44	14.8773	8.3563×10^{-4}	0.01198	1197.12	83.488	20.8556	28.7174	49.5730
35	15.0742	8.375×10^{-4}	0.0118	1194.4	84.7664	21.0279	28.5784	49.6063
35.55	15.2781	8.3938×10^{-4}	0.01162	1191.68	86.0624	21.2003	28.4338	49.6341
36.11	15.4820	8.4125×10^{-4}	0.01144	1189.12	87.3792	21.3726	28.2893	49.6619
36.66	15.6859	8.4313×10^{-4}	0.01128	1186.4	88.7152	21.545	28.1447	49.6897
37.22	15.8968	8.45×10^{-4}	0.0111	1183.52	90.0736	21.7174	28.0002	49.7175
37.77	16.1077	8.4688×10^{-4}	0.01094	1180.8	91.4512	21.8897	27.8556	49.7453
38.33	16.3186	8.4875×10^{-4}	0.01077	1178.08	92.8528	22.0621	27.7055	49.7676
38.88	16.5296	8.5063×10^{-4}	0.01063	1175.2	94.2736	22.24	27.5554	49.7954
39.44	16.7475	8.5313×10^{-4}	0.01045	1172.48	95.7184	22.4124	27.4052	49.8176
40	16.9655	8.55×10^{-4}	0.01029	1169.6	97.1856	22.5047	27.2551	49.8398
40.55	17.1834	8.5688×10^{-4}	0.01013	1166.72	98.6768	22.7626	27.0994	49.8621
41.11	17.4084	8.5938×10^{-4}	0.009981	1163.84	100.192	22.935	26.9493	49.8843

TABLE-3.1
PURGE GAS RECOVERY PLANT ....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
41.66	17.6264	0.6125×10^{-4}	0.009831	1160.96	101.7312	23.213	26.78008	49.901
42.22	17.8584	0.6375×10^{-4}	0.009681	1158.08	103.296	23.2853	26.6324	49.9177
42.77	18.0833	0.6563×10^{-4}	0.009531	1155.2	104.8864	23.4632	26.4878	49.9399
43.33	18.3154	0.6813×10^{-4}	0.009380	1152.16	106.5024	23.6411	26.3155	49.9566
43.88	18.5474	0.70×10^{-4}	0.00925	1149.28	108.144	23.8135	26.1542	49.9677
44.44	18.7794	0.725×10^{-4}	0.009106	1146.24	109.8144	23.9914	25.993	49.9844
45	19.0185	0.75×10^{-4}	0.008969	1143.2	111.512	24.1693	25.8262	49.9955
45.55	19.2575	0.7688×10^{-4}	0.008831	1140.16	113.24	24.3472	25.6594	50.0066
46.11	19.4966	0.7938×10^{-4}	0.008694	1137.12	114.9952	24.5252	25.4926	50.0177
46.66	19.7216	0.8188×10^{-4}	0.008563	1133.92	116.781	24.7031	25.3258	50.0289
47.22	19.9880	0.8438×10^{-4}	0.008431	1130.88	118.5984	24.881	25.159	50.0344
47.77	20.2340	0.8688×10^{-4}	0.0083	1127.68	120.4464	25.0589	24.9811	50.04
48.33	20.4879	0.8938×10^{-4}	0.008175	1124.48	122.3264	25.2368	24.8087	50.0456
48.88	20.7411	0.9188×10^{-4}	0.00805	1121.28	124.2384	25.4148	24.6364	50.05112
49.44	20.9942	0.9438×10^{-4}	0.007925	1118.08	126.1856	25.5982	24.4584	50.0567
50	21.2473	0.9688×10^{-4}	0.0078	1114.88	128.160	25.7762	24.2805	50.0567

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TEMP. °C	ABSOLUTE PRESSURE = 0.984 kg/cm^2 a SAT'N TEMP=46.65°C		ABSOLUTE PRESSURE = 1.125/kg/cm^2 a SAT'N TEMP. = -43.783°C	
	Specific volume M^3/kg	Enthalpy Kcal/kg.	Specific volume M^3/kg	Enthalpy Kcal/kg.
Saturation	0.173	40.933	0.153	41.299
-51.11	-	-	-	-
-48.33	-	-	-	-
-45.56	0.174	41.094	-	-
-42.78	0.177	41.5	0.154	41.450
-40	0.179	41.906	0.156	41.861
-37.22	0.181	42.317	0.158	42.273
-34.44	0.183	42.729	0.160	42.684
-31.66	0.186	43.146	0.162	43.101
-28.88	0.188	43.563	0.164	43.518
-26.11	0.190	43.985	0.166	43.941
-23.33	0.193	44.408	0.168	44.363
-20.55	0.195	44.830	0.170	44.786
-17.77	0.197	45.258	0.172	45.214
-15	0.197	45.687	0.174	45.648
-12.22	0.202	46.115	0.176	46.076
-9.44	0.204	46.548	0.178	46.509
-6.66	0.206	46.988	0.180	46.949
-3.88	0.208	47.427	0.182	47.388
-1.11	0.211	47.866	0.184	47.827
1.66	0.213	48.305	0.186	48.272
4.44	0.215	48.750	0.188	48.717
7.22	0.218	49.200	0.190	49.162
10	0.220	49.645	0.192	49.612
12.77	0.222	50.101	0.194	50.062
15.55	0.224	50.552	0.196	50.518
18.33	0.227	51.007	0.198	50.974

TEMP. °C	ABSOLUTEPRESSURE =0.984 $kg/cm^2 a$ SAT'N TEMP= 46.65°C		ABSOLUTEPRESSURE = 1.125 $kg/cm^2 a$ SAT'N TEMP.=43.783°C.	
	Specific volume M^3/kg	Enthalpy kcal/kg.	Specific volume $M^3/kg.$	Enthalpy kcal/kg.
21.11	0.229	51.463	0.200	51.430
23.88	0.231	51.925	0.202	51.891
26.66	0.233	52.386	0.204	52.353
29.44	0.236	52.853	0.206	52.82
32.22	0.238	53.320	0.208	53.287
35	0.240	53.787	0.210	53.754
37.77	0.242	54.254	0.212	54.22

TEMP

Temp.	Abs. Pressure = 3.94 kg/cm^2 a Satn. temp. = 12.11^{o}C		Abs. Pressure = 4.22 kg/cm^2 a Satn. Temp. = -10.07^{o}C		Abs. Pressure = 4.50 kg/cm^2 a Sat'n. Temp. = -8.13^{o}C	
^{o}C	Specific volume m^3/kg	Enthalpy Kcal/kg	Specific Volume m^3/kg	Enthalpy kcal/kg	Specific volume m^3/kg	Enthalpy kcal/kg.
Saturation	0.0468	45.23	0.0438	45.47	0.04114	45.69
-17.77	-	-	-	-	-	-
-15	-	-	-	-	-	-
-12.22	-	-	-	-	-	-
-9.44	0.0474	45.66	0.0309	45.58	-	-
-6.66	0.0481	46.11	0.0446	46.03	0.0415	45.94
-3.88	0.0487	46.57	0.0452	46.48	0.04203	46.39
-1.11	0.0494	47.02	0.0458	46.94	0.0426	46.85
1.66						
4.44	0.0506	47.94	0.0470	47.85	0.0437	47.31
7.22	0.0513	48.40	0.0476	48.32	0.0443	48.23
10	0.0519	48.86	0.0482	48.78	0.0487	48.69
12.77	0.0525	49.32	0.0487	49.24	0.0454	49.16
15.55	0.0532	49.78	0.0493	49.71	0.0460	49.57
18.33	0.0538	50.25	0.0499	50.18	0.0465	50.10
21.11	0.0540	50.72	0.0505	50.65	0.0471	50.57
23.88	0.0550	51.19	0.0511	51.11	0.0477	51.05
26.66	0.0556	51.66	0.0517	51.59	0.0482	51.52
29.44	0.0563	52.14	0.0523	52.07	0.0488	52.00
32.22	0.0569	52.61	0.0528	52.55	0.0493	52.48
35	0.0575	53.09	0.0534	53.03	0.0498	52.95
37.77	0.05809	53.58	0.0540	53.51	0.0504	53.44
40.55	0.0587	54.05	0.0546	53.99	0.0593	53.92
43.33	0.0593	54.54	0.0551	54.48	0.0515	54.41
46.11	0.0599	55.03	0.0557	54.96	0.0520	54.89
48.88	0.0605	55.51	0.0563	55.45	0.0526	55.38
51.67	0.0611	56.00	0.0568	55.94	0.0531	55.88
54.44	0.0617	56.50	0.0574	56.43	0.0536	56.37
57.22	0.0623	56.98	0.0580	56.92	0.0542	56.86
60	0.00044	57.48	0.0585	57.42	0.0547	57.36
62.78	0.00106	57.98	0.0591	57.92	0.0552	57.86
65.56	0.0641	58.47	0.0597	58.42	0.0558	58.36
68.33	0.0648	58.97	0.0623	58.92	0.0563	58.86
71.11	0.0653	59.48	0.0608	59.43	0.0568	59.36
73.89	0.0659	59.98	0.0614	59.93	0.0573	59.87
76.67	-	-	-	-	0.0579	60.38

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Temp. °C	Abs. Pressure 16.87 kg/cm²a Temp. 39.77°C		Abs. Pressure =17.23 kg/cm²a Tem. = 40.66°C		Abs. pressure = 17.58 kg/cm²a Temp. 41.54°C	
	Specific vo,. m^3/kg	Enthalpy kcal/kg	Specific m^3/kg	Enthalpy kcal/kg	Specific volume m^3/kg.	Enthalpy kcal/kg.
Satn.	0.0106	49.80	0.0104	49.87	0.0100	49.90
40.55	0.0108	50.16	-	-	-	-
43.33	0.0110	50.20	0.0103	50.46	0.0892	50.30
46.11	0.0113	51.35	0.0106	51.06	0.0915	50.91
48.88	0.0115	51.93	0.0109	51.66	0.0937	51.52
51.67	0.0118	52.51	0.0111	52.25	0.0108	52.12
54.44	0.0120	53.09	0.0113	52.84	0.0110	52.71
57.22	0.0122	53.66	0.0115	53.54	0.0112	53.30
60	0.0124	54.23	0.0118	54.00	0.0114	53.88
62.78	0.0126	54.80	0.01197	54.58	0.0117	54.47
65.56	0.0129	55.37	0.0122	55.15	0.0119	55.04
68.33	0.0131	55.93	0.0124	55.72	0.0121	55.62
71.11	0.0133	56.50	0.0126	56.30	0.0123	56.19
73.89	0.0135	57.06	0.0128	56.86	0.0125	56.76
76.67	0.0137	57.62	0.0130	57.43	0.0127	57.33
79.44	0.0139	58.18	0.0132	58.00	0.0129	57.90
82.22	0.0141	58.74	0.0134	58.56	0.0130	58.47
85	0.0143	59.30	0.0134	59.13	0.0132	59.04
87.78	0.0145	59.86	0.0137	59.69	0.0134	59.60
90.56	0.0146	60.43	0.0139	60.26	0.0136	60.18
93.33	0.0148	60.99	0.0141	60.82	0.0138	60.74
96.11	0.0150	61.55	0.0143	61.39	0.0140	61.31
98.89	0.0152	62.11	0.0145	61.96	0.0141	61.88
101.67	0.0154	62.67	0.0147	62.52	0.0143	62.44
104.44	0.0156	63.23	0.0148	63.08	0.0145	63.01
107.22	0.0157	63.80	0.0150	63.65	0.0147	63.58
110	0.0160	64.36	0.0152	64.22	0.0148	64.15

Temp. °C	Abs. Press. = 18.28 kg/cm² a, Satn. Temp. = 43.25°C		Abs. Press. = 18.98 kg/cm² a, Satn. Temp. = 44.92°C		Absolute pressure = 19.69 kg/cm² a, Saturation Temp. = 46.54°C.	
	Specific Vol. m³/kg.	Enthalpy kcal/kg	Specific volume m³/kg.	Enthalpy kcal/kg	Specific volume m³/kg.	Enthalpy Kcal/kg
Sat'n	0.00941	49.96	0.00899	49.996	0.0086	50.03
43.33	0.00942	49.97	-	-	-	-
46.11	0.00968	50.61	0.0091	50.27	-	-
48.89	0.00993	51.23	0.0094	50.92	0.0088	50.59
51.67	0.01020	51.84	0.0096	51.55	0.0091	51.25
54.44	0.0104	52.45	0.0098	52.18	0.0093	51.89
57.22	0.0106	53.05	0.0100	52.79	0.0095	52.51
60	0.108	53.64	0.0102	53.39	0.0097	53.13
62.78	0.0110	54.23	0.0105	53.99	0.0100	53.74
65.56	0.0113	54.82	0.0107	54.59	0.0102	54.35
68.33	0.0115	55.40	0.0109	55.18	0.0104	54.95
71.11	0.0117	55.98	0.0111	55.77	0.0106	55.55
73.89	0.0119	56.56	0.0113	56.36	0.0108	56.14
76.67	0.0120	57.14	0.0115	56.94	0.0109	56.73
79.44	0.0122	57.71	0.0117	57.52	0.0111	57.32
82.22	0.0124	58.29	0.0119	58.10	0.0113	57.91
85	0.0126	58.86	0.0120	58.67	0.0115	58.49
87.78	0.0128	59.43	0.0122	59.25	0.0117	59.07
90.56	0.0130	60.00	0.0124	59.83	0.0118	59.65
93.33	0.0132	60.58	0.0126	60.40	0.0120	60.23
96.11	0.0134	61.14	0.0127	60.98	0.0122	60.81
98.89	0.0135	61.72	0.0129	61.55	0.0124	61.39
101.67	0.0137	62.29	0.0131	62.13	0.0125	61.97
104.44	0.0138	62.86	0.0132	62.71	0.0127	62.54
107.22	0.0140	63.43	0.0134	63.28	0.0129	63.12
110	0.0142	64.00	0.0136	63.85	0.0130	63.7

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Temperature	Absolute pressure = 20.39 kg/cm^2 a, Temperature = 48.12 ^oC		Absolute pressure = 21.09 kg/cm^2 a, Temperature = 49.66 ^oC	
	Specific volume m^3/kg.	Enthalpy kcal/kg.	Specific volume m^3/kg	Enthalpy kcal/kg.
Sat'n	0.00823	50.05	0.00788	50.06
43.33	-	-	-	-
46.11	-	-	-	-
48.89	0.0083	50.24	-	-
51.67	0.0086	50.92	0.0081	50.57
54.44	0.0088	51.58	0.0083	51.25
57.22	0.0090	52.23	0.0086	51.92
60	0.0093	52.86	0.0088	52.58
62.78	0.0095	53.49	0.0090	53.21
65.56	0.0097	54.10	0.0092	53.85
68.33	0.0099	54.72	0.0094	54.47
71.11	0.0100	55.32	0.0096	55.09
73.89	0.0103	55.92	0.0098	55.70
76.67	0.0105	56.52	0.0100	56.31
79.44	0.0106	57.12	0.0102	56.91
82.22	0.0108	57.71	0.0103	57.51
85	0.0110	58.30	0.0105	58.10
87.78	0.0112	58.89	0.0107	58.70
90.56	0.0113	59.48	0.0109	59.29
93.33	0.0115	60.06	0.0110	59.88
96.11	0.0117	60.64	0.0112	60.47
98.89	0.0118	61.23	0.0114	61.05
101.67	0.0120	61.80	0.0115	61.64
104.44	0.0122	62.39	0.0117	62.23
107.22	0.0123	62.97	0.0118	62.82
110	0.0125	63.55	0.0120	63.40

TABLE -4

SPECIFICATIONS OF SYNTHETIC LUBRICANT .

Brand name : ZERICE S-68

Manufacturer : ESSO

Properties:

1. Density at 15°C = 0.865
2. Colour = 1
3. Kinemetic viscosity
   a) at 40°C = 63.6 cst.
   b) at 100°C = 6.5 cst.
4. Flash point (cleveland open cup) = 186°C
5. Gloud point = - 12°C
6. Floculation point = Less than - 60°C
7. Pour point = -33°C
8. Aniline point = 72.8°C
9. Neutralisation Number (Mineral acidity) = Traces.
10. Copper corrosion (3 hours at 100°C) = Slightly tarnished.
11. Di-electric Breakdown (voltage of insulating liquids) = 57 K.V.

TABLE-5.

DATA ON DEW POINT OF A GAS VS. MOISTURE CONTENT

Dew Point of Gas at Atmospheric pressure °C	Vapour pressure of Ice at Dew point at Atmospheric pressure.	Dew point of gas at 8Kg/Cm^{2}a °C	Moisture content of gas , vpm.
-70	0.00194	-55.56	2.55
-68	0.00261	-53.04	3.43
-66	0.00349	-50.73	4.59
-64	0.00464	-48.44	6.1
-62	0.00614	-46.10	8.1
-60	0.00808	-43.76	10.63
-58	0.0106	-41.43	13.95
-56	0.0138	-39.12	18.16
-54	0.0178	-36.82	23.42
-52	0.0230	-34.46	30.26
-50	0.02955	-32.10	38.89
-48	0.0378	-29.74	49.74
-46	0.0481	-27.40	63.30
-44	0.0609	-25.05	80.14
-42	0.0768	-22.7	101.1
-40	0.0966	-20.34	127.12
-38	0.1209	-17.98	159.10
-36	0.1507	-15.60	198.33
-34	0.1873	-13.25	246.51
-32	0.2318	-10.89	305.10
-30	0.2859	-8.50	176.33
-29	0.317	-7.38	457.28
-28	0.351	-6.16	462.10
-27	0.389	-4.90	512.10
-26	0.430	-3.78	566.11

Dew point of Gas at Atmospheric pressure °C	Vapour pressure of Ice at Dew point at Atmospheric pressure	Dew point of gas at 8Kg/Cm²a °C	Moisture content of gas, vpm.
-25	0.476	-2.57	626.71
-24	0.526	-1.37	692.58
-23	0.580	0.18	763.74
-22	0.640	1.14	842.82
-21	0.705	2.42	928.52
-20	0.776	3.95	1022.10
-19	0.854	5.21	1124.95
-18	0.939	6.59	1237.1
-17	1.031	7.95	1358.4
-16	1.132	9.33	1491.7
-15	1.241	10.70	1635.6
-14	1.361	12.09	1794
-13	1.490	13.48	1964.4
-12	1.632	14.89	2152.0
-11	1.785	16.28	2354.2
-10	1.950	17.68	2572.4
-9	2.131	19.09	2812.0
-8	2.326	20.50	3070.0
-7	2.537	21.92	3349.3
-6	2.765	23.34	3651.4
-5	3.013	24.77	3980.0
-4	3.230	26.20	4334.5
-3	3.568	27.63	4717.0
-2	3.880	29.074	5131.5
-1	4.217	30.52	5579.6
-0	4.579	31.97	6061.5

L'AIR LIQUIDE
75, QUAI D'ORSAY 75007 PARIS

Service émetteur / Issued from: DCVM. DE ST

Affaire Numéro: IFF-CU 07-3173

Numéro du document — Format Groupe N° d'ordre Rev.: A3 1014 ... 2 0

NOTICE for DIAGRAM 108

PIPING – Summary from AL Standards n° GR 132-01 & GR 132-12

- main process line
- secondary or utility line
- pneumatic signal
- electric signal
- capillary tubing
- hydraulic signal
- AREA A / AREA B — area boundary
- CUST. R / AL SUPPLY — limit of supply
- cold box limit
- blockhouse limit
- change of line number
- change of piping class
- slope of piping
- n° of typical connection (Std RG 350-14)
- sewer
- gutter or pit
- flow entering the sheet
- flow getting out of the sheet
- underground line
- overhead utility line
- underground utility line
- flow entering the unit
- flow getting out of the unit
- underground lines
- flanges
- blind flange
- plug
- cap
- reducer
- automatic trap
- strainer
- conical filter
- restriction orifice
- spectacle blind
- blind
- BS special plug
- FS special fitting
- BR special fitting and plug
- hose
- expansion joint (any type)
- fire proof section
- insulating junction
- flame arrestor

D	deriming	R	analysis	CV	check valve
P	drain	G	gauge	ATM	blow off
V	manual valve	E	vent		

- insulation
- limit of insulation (the valve is excluded)
- CC heat conservation
- CF cold conservation
- PP protection of personnel
- PG prot.° against freezing
- PA sonic protection
- PG electric tracing
- PG steam tracing
- ... insulated pipe
- Supply with main equipment.

INSTRUMENTATION SYMBOLS and IDENTIFICATION according to ISA Standard n° S.5.1 and AL Standards GR 132-41 & GR 132-13

- locally mounted
- mounted on the central board
- mounted behind the central board
- mounted on local board
- single connection with a computer
- double connection with a computer
- (I) interlock (see special diagram)
- pneumatic cylinder with adjustable thrust
- diaphragm actuator
- pneumatic cylinder
- (S) solenoid actuator
- hydraulic cylinder
- actuator with positioner

FC	fail closed	valve position if failure of power supply
FI	fail indeterminate	
FO	fail open	
FL	fail locked	

- valve (any type)
- gate valve
- globe valve
- plug valve
- ball valve
- three way valve
- butterfly valve
- check valve
- expansion valve
- gate valve with drilled disc (ø = hole)
- globe valve with pressure upon the disc
- tight butterfly valve
- safety valve
- rupture disc

Letter	FIRST LETTER: Initiating variable	FIRST LETTER: modifier	SUCCEEDING LETTERS: Readout or function	SUCCEEDING LETTERS: modifier
A	Analysis		Alarm	
B	Burner-Flame			
C	Conductivity		Control	
D	Density	Differential		
E	Voltage		Primary element	
F	Flow rate	Ratio		
G	Gaging		Glass	
H	Hand			High
I	Current		Indicate	
J	Power	Scan		
K	Time or time schedule		Control station	
L	Level		Light	Low
M	Moisture Humidity			Middle intermediate
N				
O			Orifice	
P	Pressure		Point	
Q	Quantity-Event	Integrate		
R	Radioactivity		Record-Print	
S	Speed-Frequency	Safety	Switch	
T	Temperature		Transmit	
U	Multivariable		Multifunction	Multifunction
V	Viscosity		Valve-Damper-Louver	
W	Weight-Force		Well	
X				
Y			Relay-Compute	
Z	Position		Drive-Actuate-Final control elem.t	

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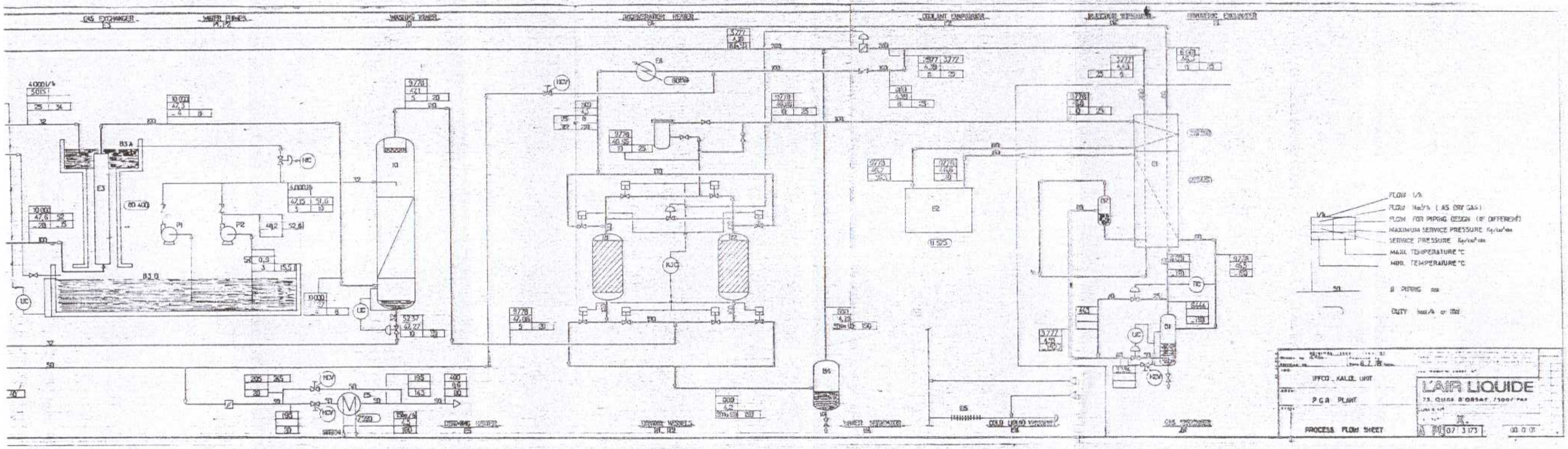
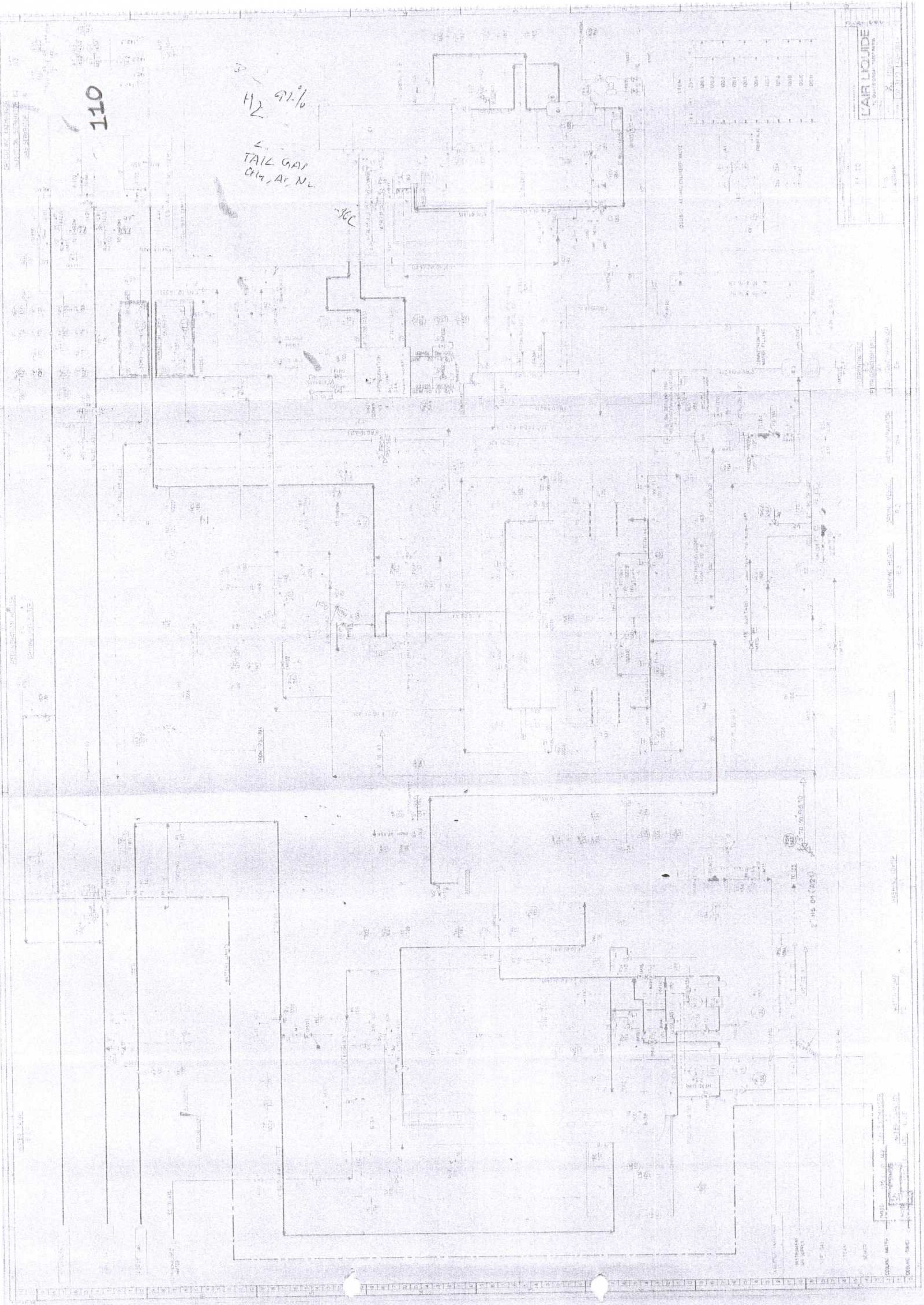
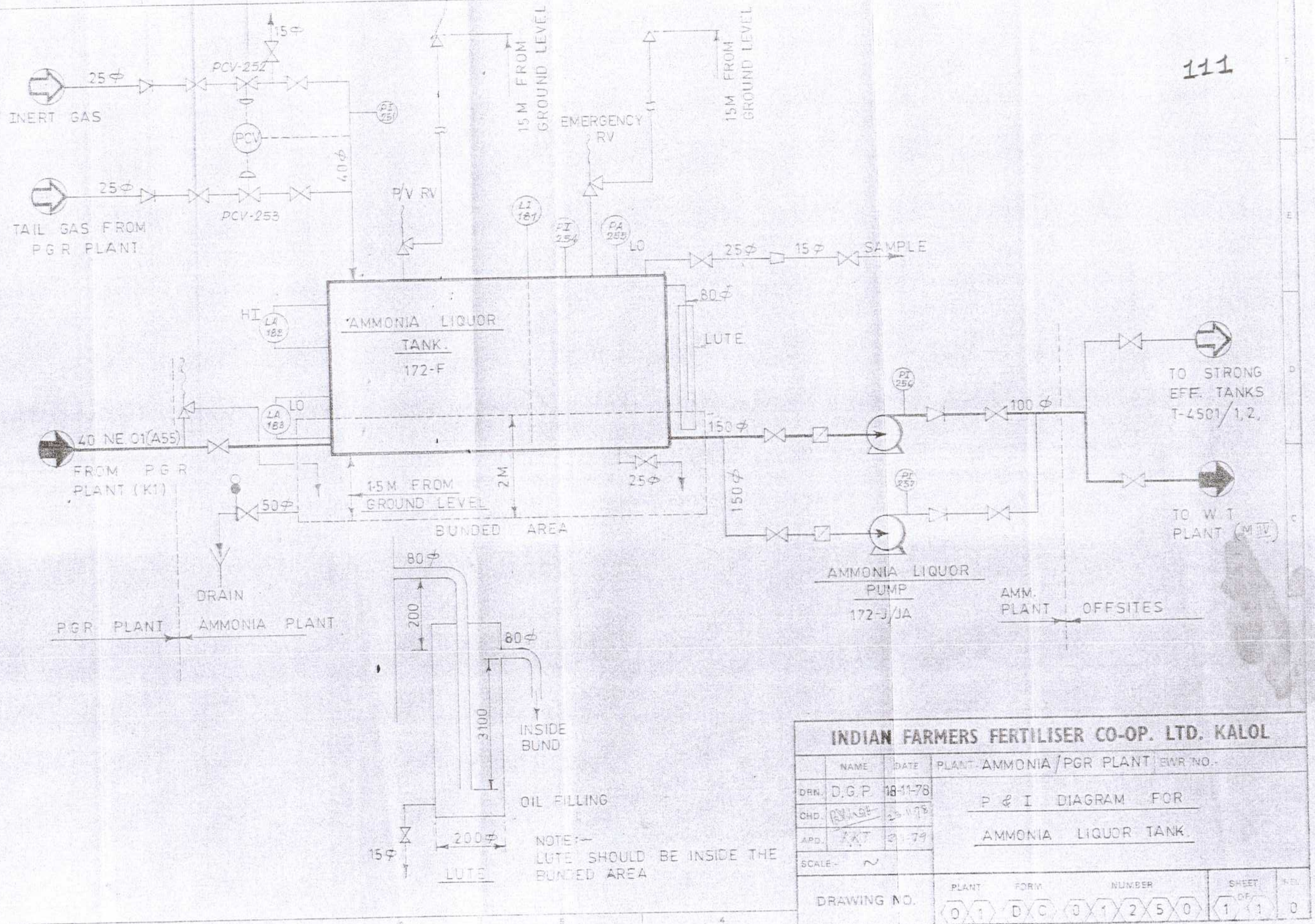
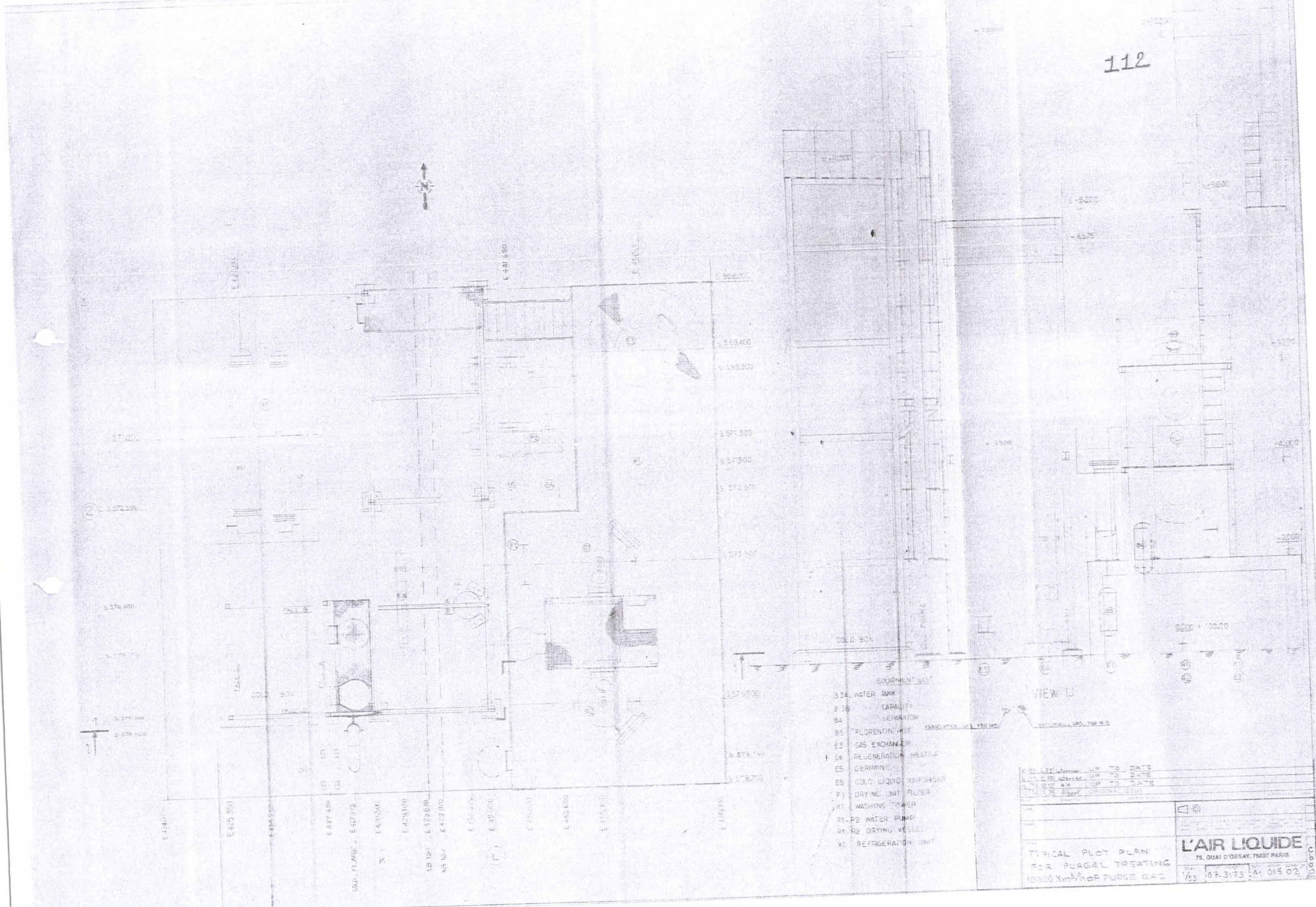
Page 1/1


GAS EXCHANGER
WATER PUMPS
WASHING TOWER
COOLANT EVAPORATOR
FLOW l/h
FLOW Nm³/h (AS DRY GAS)
FLOW FOR PIPING DESIGN (IF DIFFERENT)
MAXIMUM SERVICE PRESSURE
SERVICE PRESSURE
MAXI. TEMPERATURE °C
MINI. TEMPERATURE °C
Ø PIPING mm
DUTY
IFFCO _ KALOL UNIT
P G A PLANT
PROCESS FLOW SHEET
L'AIR LIQUIDE
75, Quai d'Orsay, 75007 Paris



110
H2 97%
TAIL GAS
CH4, Ar, N2
L'AIR LIQUIDE


INERT GAS
25 ϕ
PCV-252
15 ϕ
PCV
TAIL GAS FROM
P G R PLANT
25 ϕ
PCV-253
40 ϕ
PI 251
P/V RV
15M FROM
GROUND LEVEL
EMERGENCY
RV
15M FROM
GROUND LEVEL
LI 181
PI 254
PA 255
LO
25 ϕ
15 ϕ
SAMPLE
HI
LA 182
AMMONIA LIQUOR
TANK.
172-F
80 ϕ
LUTE
LO
LA 183
40 NE 01(A55)
FROM P G R
PLANT (K1)
150 ϕ
25 ϕ
1.5 M FROM
GROUND LEVEL
2M
BUNDED AREA
50 ϕ
DRAIN
PGR PLANT
AMMONIA PLANT
150 ϕ
PI 256
PI 257
100 ϕ
AMMONIA LIQUOR
PUMP
172-J/JA
TO STRONG
EFF. TANKS
T-4501/1,2.
TO W T
PLANT (M IV)
AMM.
PLANT
OFFSITES
80 ϕ
200
80 ϕ
3100
INSIDE
BUND
OIL FILLING
15 ϕ
200 ϕ
LUTE
NOTE:-
LUTE SHOULD BE INSIDE THE
BUNDED AREA
INDIAN FARMERS FERTILISER CO-OP. LTD. KALOL
NAME
DATE
PLANT: AMMONIA / PGR PLANT
EWR NO.-
DRN. D.G.P. 18-11-78
CHD. 23.11.78
APD. K.K.T.
P & I DIAGRAM FOR
AMMONIA LIQUOR TANK.
SCALE - ~
DRAWING NO.
PLANT 01
FORM DC
NUMBER 01250
SHEET 1 OF 1
REV. 0


EQUIPMENT LIST
B.34 WATER TANK
B.36 CAPACITY
B4 SEPARATOR
B5 FLORENTIN POT
E3 GAS EXCHANGER
E4 REGENERATION HEATER
E5 DERIMING
E6 COLD LIQUID VAPORISER
F1 DRYING UNIT FILTER
K1 WASHING TOWER
P1-P2 WATER PUMP
R1-R2 DRYING VESSEL
X1 REFRIGERATION UNIT
VIEW
COLD BOX
UP TO DATE
UP TO DATE
UP TO DATE
ORIGINAL ISSUE
TYPICAL PLOT PLAN
FOR PURGAL TREATING
10000 Nm3/h OF PURGE GAZ
L'AIR LIQUIDE
75, QUAI D'ORSAY, 75007 PARIS
1/33
07-3173
A1 015 02