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REVAMP OF AN AMMONIA PLANT

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Située a l'extrémité sud du Sous-Continent Indien, Southern Petrochemical Industries Corporation Limited (SOUTH PETRO), une société ISO 9002 a fait marcher un complexe d'engrais depuis 1975. Ayant érigé la première unité d'ammoniac, la plus grosse à une seul train en Asie en 1975, SOUTH PETRO a entrepris de pousser ses installations de fabrication jusqu'à la classe mondiale afin de rester compétitif par modernisation et réhabilitation continues de ses unités. Ayant fait fonctionner son unité pendant plus de deux décennies, il était impératif d'augmenter la vie de l'atelier pour atteindre des niveaux élevés de fiabilité et d'utilisation de capacité de production, réduire la consommation d'énergie et de rester en avant. Pour réaliser cet objectif SOUTH PETRO a constitué un groupe d'ingénieurs qui ont analysé différentes sections de l'unité, identifié des goulots d'étranglement et les ont supprimés.

Le remplacement des tubes d'eau de chaudière à chaleur résiduaire par le système à tube de feu, du convertisseur d'ammoniac par une cartouche radiale plus efficace, la réhabilitation totale du reformer primaire s'est fait par phases. Le système de contrôle pneumatique devenait obsolète avec une moindre disponibilité des pièces de rechange et a été remplacé par DDCS. En insistant beaucoup sur l'environnement, l'absorbant dans la section de la séparation du CO_2 a été converti en DEA et une solution de K_2CO_3 promue par Glycine éliminant le métal lourd arsenic. La majeure partie de l'engineering, du planning, de la programmation et de l'exécution a utilisé l'expertise maison ajusté aux conditions et aux besoins de l'unité. Cet exposé décrit les expériences de SOUTH PETRO en cours de réhabilitation et la performance consécutive de l'unité.

Summary

Located at the southern tip of the Indian sub-continent, Southern Petrochemical Industries Corporation Limited (SOUTH PETRO), an ISO 9002 and ISO 14001 company has been operating a fertilizer complex since 1975. Having set up the largest single train ammonia plant in Asia in 1975, SOUTHPETRO has embarked on making its manufacturing facilities world class to stay competitive by continuous modernisation and revamping of the plants. Having operated the plant for over two decades, there was the need to extend the life of the plant to achieve high levels of reliability and capacity utilisation, cut down energy consumption and to stay ahead. To achieve this objective, SOUTHPETRO formed a team of engineers who analysed various sections of the plant, identified bottlenecks and phased them out. Replacement of water tube waste heat boiler with fire tube design, ammonia converter retrofit with a more efficient radial cartridge, total primary reformer revamp were done in a phased manner. The pneumatic control system was becoming obsolete with diminishing availability of spares and was changed over to DDCS. With the strong focus on being eco-friendly, the absorbent in the CO_2 removal section was changed over to DEA and glycine promoted K_2CO_3 solution eliminating the heavy metal arsenic. Most of the engineering, planning, scheduling and execution was done by in-house expertise tailor made to suit the plant conditions and requirements. This paper narrates the experiences of SOUTHPETRO during revamp and subsequent performance of the plant.

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1.0 ABOUT SOUTHPETRO

Southern Petrochemical Industries Corporation Limited is the largest South Indian business conglomerate and has been operating a fertilizer complex at Tuticorin, India, since 1975. The complex has the following production facilities.

Ammonia	1100	TPD
Urea	1600	TPD
Sulphuric acid	470	TPD
Phosphoric acid	165	TPD
Di-ammonium phosphate	1350	TPD
Aluminium fluoride	8	TPD

2.0 THE REVAMP

The ammonia plant is based on ICI steam naphtha reforming process and designed by Davy McKee, UK. SOUTHPETRO's program for modernization envisaged a total revamp of the primary reformer, the associated convection section along with the carbon dioxide removal system. The objective of the revamp is to increase the life expectancy and reduce energy consumption. It was decided to carry out the revamp in two phases.

Phase-I of the revamp aimed at the design change of the reformed gas waste heat boiler, synthesis converter revamp and the control system change to DDCS from the near obsolete pneumatic instrumentation.

In Phase-II, reformer section revamp and CO_2 removal section revamp along with the solution change over eliminating heavy metal arsenic were taken up.

3.0 REVAMP PHASE-I

3.1 THE REFORMED GAS BOILER

The original design of the reformed gas waste heat boiler (RGB) was a water tube type design wherein frequent failures were experienced resulting in significant down time.

The design of the boiler was totally changed over to a fire tube type retaining the steam drum, down comers and raisers. The fouling factor specified for the gas side of the old boiler was 0.001 hr m^2°C/kcal. This high fouling factor might have been required due to fouling from potash promoted catalyst used in primary reformer. When the same fouling factor was applied in the design of the new boiler, the heat transfer area was very high and uneconomical. In consultation with leading process designers, the fouling factor is kept at 0.0004 hr m^2°C/kcal. The twin compartment design with flexible tube sheet was selected. Out of the five risers available, the size of two risers was increased to take care of the additional steam generation possible by lowering the outlet temperature to 360°C from the previous design of 390 °C. To avoid the Boudouard reaction, the intermediate compartment temperature is kept at 600 °C. A bypass valve with axial movement has been chosen for its greater reliability over the butterfly type.

3.2 SYNTHESIS CONVERTER

SOUTHPETRO's original ammonia converter was of cold shot axial flow design. The quench type design was not energy efficient and conversion per pass was also low. A change in the synthesis converter design, especially when linked with a higher active catalyst could lead to improved conversion per pass, greater throughput and a more efficient heat exchange within the converter. The radial flow design offered less pressure drop with a note worthy feature that the new internals were fitted into the HP shell of the original design making the revamp as quick as possible and without major modifications. The conversion per pass had increased from 16% to 20%, which reduced the gas circulation rate and loop pressure. The synthesis gas compressor load and refrigeration compressor load had come down.

3.3 INSTRUMENTATION REVAMP

As pneumatic instrumentation is becoming obsolete, the ammonia plant control system was revamped to the Distributed Digital Control System (DDCS). The system design for conversion, operation and maintenance philosophy was built with in-house expertise.

The plan of action for engineering, procurement and construction of DDCS was arrived at after consultation with process and instrumentation departments. The following changes were done.

- The relay based trip panel (safety shut down system) was changed to programmable logic controller (PLC). The layout was hard wired, electronic based mosaic trip panel. In view of the complexity and criticality of the trip system, a separate triple modular redundant and fault tolerant system of highest reliability has been chosen. Critical trip initiators are triplicated at the field-input levels. PLC is linked to DDCS through a redundant communication gate way.

- A new separate blast proof control room was built to house the **DDCS, PLC** system, air conditioning unit, uninterrupted power supply (UPS) unit and batteries.

- Critical controllers of all the compressors were integrated with DDCS.

- The ammonia plant control system was configured with two separate operating groups for ammonia and auxiliary boilers which were earlier operated from separate control rooms. In the DDCS, both the control systems are merged in the common control room to facilitate integrated operation.

Control room construction, cable duct erection, multi pair cable laying, junction box fixing and application software development constituted major pre-shut down activities. The entire project was executed with in-house expertise. The total conversion of the ammonia plant **DDCS** was done in 38 days and now the plant control system can compete with that of the latest generation plants in terms of control and reliability.

4.0 REVAMP PHASE-II

4.1.0 REFORMING SECTION

4.1.1 FURNACE

The primary reformer was a top fired reformer consisting of 264 tubes placed in 8 rows. 63 burners firing naphtha were placed in nine rows. The 4^{th} and 6^{th} row burners were dual fired with facilities to burn gas.

It was estimated that the average heat flux based on the inner surface of the tube is higher than the normal allowable heat flux for a naphtha–fired reformer. Since the heat flux could not be brought down, the options of increasing the feedstock inlet temperature and pre-reforming were evaluated. But in view of the additional modification involved and the relatively small experience of pre-reforming in ammonia plants at that time this option was set aside.

Since the average heat flux was only just outside the allowable range for a naphtha reformer, modifications were done on the furnace to reduce the extreme values of heat flux in the furnace and bringing the average heat flux nearer to the allowable value for a naphtha reformer.

The heat release per burner was high at 1.74 Gcal/hr. The space between two rows of burners is rather low, at 1,676 mm. There were problems with flame impinging on the tubes and non-uniform firing. The reformer flue gas is collected in coffin boxes and transferred to the duct. The duct exits from the reformer at one end and is not centrally located. Flue gas distribution inside the furnace was not uniform and, as a result, the variation in the pigtail temperatures was as wide as 100 °C. To narrow down the difference, the burners were throttled, and this affected the flame pattern. Hence the number of burners were increased to 90 and the heat release per burner was brought down to 1.3 Gcal/hr. Combustion air distribution was improved by providing constant velocity ducts for individual row air distribution. Modeling of the flue gas distribution was done and based on that coffin port box hole size and number were altered to make flue gas distribution more uniform.

In the old design, the side walls and floor of the furnace were lined with refractory bricks and the roof with hanging bricks. Heat loss was high and damage had been observed on the refractory bricks. In the revamp, the entire side wall refractory was replaced. Ceramic fiber insulation was considered for the side walls but not recommended, since the flue gas velocity in the furnace was higher than the maximum limit allowed for the ceramic fiber. The roof insulation was replaced with ceramic fiber modules. The roof to tube gap was covered with a collar seal arrangement made of ceramic fiber cloth.

4.1.2 INLET AND OUTLET SYSTEM

The reformer feedstock header and sub-headers were made of ASTM 106 Gr. B and designed for 458 °C. The material of construction was not suitable for service, according to the modified Nelson curve, and in view of the age of the headers, they were replaced. The new header was made of P-11 material and the sub-headers were sized and oriented to improve the distribution.

In the old design, the reformer-gas transfer main was provided with an incolloy liner on the hot face of the refractory to prevent erosion. The velocity of the gas in the main was 39 m/s. The incolloy liner had wrinkles and increased the pressure drop. The reformer outlet transfer main was therefore replaced by one with higher inner diameter of 580 mm and the velocity of the gas in the main has come down to 29 m/s making the refractory resistant to erosion and the new main was designed without incolloy liner.

4.1.3 REFORMER FLUE GAS HEAT RECOVERY SYSTEM

The flue gas exit reformer passes through a flue gas boiler and then to the coils meant for superheating the steam generated in the reformed gas boiler and the process steam to reformer. After that, the flue gas exchanges heat with the combustion air in an air preheater.

The convection coils had given trouble free service for 20 years and predicting their residual life was difficult. Since the replacement of the reformer tubes in 1988 with thin walled tubes, flue gas exit temperature had come down and it was possible to attain a steam temperature of 462 °C only from the convection superheated coils against the design of 482 °C. Considering the above and also the need for superheating the extra quantity of steam to be generated in reformed gas boiler, the coils were replaced with increased surface area.

The old air preheater was of rotary type and the air leakage across the seals was high at 25%. Provision of additional radial seals brought down the leakage rate to about 15%. The air leakage limited the availability of combustion air to the reformer. Tubular air presenters and plate-type exchangers have been considered and on account of its compactness and lower pressure drop, the plate-type exchanger was installed during the revamp. The exchanger was provided with “air curtains” to have uniform temperature at the cold end so as to have protection against corrosion.

4.1.4 SECONDARY REFORMER

Cracks were observed at the burner tip whenever the burner was inspected. Back chamfering of the holes to avoid flame back-up did not solve the problem. In the revamp, the burner was replaced with an improved nozzle type design based on computational fluid dynamics modeling.

The catalyst volume was reduced from 29 m^3 to 24 m^3 to increase the mixing space. To compensate for the volume reduction, the more active four-hole catalyst was loaded. At the bottom of the bed, instead of alumina lumps, ceramic balls were used to reduce carry-over of catalyst and refractory particles to down stream equipments.

To meet the process air demand, an additional process air compressor of reciprocating type has been installed and to run parallel to the existing centrifugal compressor.

4.1.5 METHODOLOGY OF PRIMARY REFORMER REVAMP

Scope of work of the primary reformer revamp meant that in reality almost 60% of the reformer was to be rebuilt in a short span of 45 days. Meticulous planning was essential for the successful execution of the revamp without any time over run. A plan of action was formulated to counter the specific problems likely to be encountered during erection. The erection procedure had to be comprehensive covering all aspects of erection. All the procedures and schedules were decided after several rounds of discussions with erection contractors, operation and execution personnel and with the plant designers.

As per the erection procedure independent groups were made to work on different parts of the reformer. Each group was self-directed and was responsible for its own progress. Mutual co-ordination between groups ensured that the project progress envisaged during the erection procedure was achieved.
Given below is the roll of various groups planned for the revamp in a nutshell:

1.	Operation	Safe handing over of jobs, ensuring safe working conditions, catalyst handling, pre-commissioning, commissioning and start up.
2.	Jobs at reformer top	inlet system, burners, burner piping, burner air ducting, furnace roof, removal of reformer tubes, Roof removal and re-installation
3.	Jobs at reformer bottom	Outlet pigtails cutting and welding, RG mains removal and re-installation
4.	Jobs inside furnace	Furnace scaffolding, renewal of side panels, renewal of refractory, re-installation of tubes, ceramic fiber lining of roof.
5.	Convection section	Removal of old convection box, assembly of new convection box, steam lines re-routing, **APH** dismantling and re-erection, replacement of air mains
6.	Secondary reformer	Renewal of refractory, replacement of collecting header, refractory bake out
7.	Process naphtha heater	Renewal of refractory, erection of single pass convection coil and refractory bake out
8.	Inspection	Quality control checks

All these were schemed and finalised keeping the start up of the plant in mind. The schedule gave due consideration to the space constraint likely on the reformer top in view of the deployment of large number of manpower and materials on reformer top. The erection procedure was frozen well ahead of the scheduled beginning of the plant shut down activities and was made available to all the working personnel so as to eliminate any ambiguity on technical grounds.

4.1.6 PREFABRICATION

In order to minimize the work during turnaround, an extensive prefabrication schedule was prepared and completed so that in situ work during turnaround was reduced to a minimum.

The constant velocity ducts for combustion air were prefabricated in such a way to have them erected by positioning and bolting. All the fuel naphtha, fuel gas and atomizing steam header piping were prefabricated. The individual pieces of the reformed gas mains were prefabricated.

Number of innovative procedures were developed that resulted in reduction in time required for all these construction activities. It had been originally planned to carry out the revamp keeping the reformer tubes in position. However, it was generally felt that leaving the tubes in position would considerably slow down the progress of refractory work on side walls and would lead to congestion in the furnace. Further, extensive welding had to be carried out on the furnace arch plate for fixing it and also to fix up the anchors for the ceramic roof, which may cause damage to the tube.

A decision was therefore taken to remove all the tubes along with the catalyst from the furnace and to keep protected elsewhere so that more working space could be made available in the furnace. This also helped in gaining the time normally required for extraction of the catalysts by using vacuum extractors. The removed tubes, were moved to a safe storage yard, where two small cranes were deployed to lift and tilt the tubes upside down to discharge the catalyst.

The decision was very critical because while saving the time required for catalyst extraction, the design of the arch plate was to be changed to minimize prefabrication work and to reduce the quantum of insitu welding. In the original design, the arch plate was of split construction so that it could be positioned without disturbing the tubes.

The new convection box of the flue gas heat recovery system was pre-assembled and erected after lifting out the old convection box using a single crane. Removal of reformer tubes from the furnace ensured that the extraction of the old convection box no longer remained in the critical path and the dismantling and erection of the convection coils were carried out as individual components.

Another interesting example is the planning of the secondary reformer refractory relining. The original design of the vessel was a three layered construction. Relining the vessel as per the original design and specification was expected to take 70 days. A two layered lining was studied to reduce the time but was not pursued because of the reliable performance of the three layered design. It was then decided to retain the three layered configuration, the first two layers would be gunnited in-site and the hot face to be cast. Even with this arrangement, the total time required to reline the vessel was expected to be 60 days.

To crash the schedule further, the bake out of the lining to expel the moisture was taken for detailed analysis. Investigations were carried out to check the possibility of avoiding bake out of lining using a separate burner and carry out the bake out as part of the start up process by controlled heating with nitrogen circulation. However to keep in line with the general practices in the industry, it was decided to carry out the bake out using a separate burner. To stick to the schedule, the refractory lining at the top of the vessel was left as such since it was found to be in good condition on inspection and did not warrant replacement. Also casting a 6” thick layer of the hot face refractory over the old refractory at the bottom dome strengthened it at that place.

All these helped to gain a very significant time advantage. It became essential that the CO_2 section revamp and solution change over had to go along with the primary reformer revamp to complete the project as scheduled.

4.2.1 CO_2 REMOVAL SECTION

The original CO_2 removal section was based on potassium carbonate promoted with arsenic trioxide. The main problems with that system were sludge formation in the bottom bed of the absorber and handling of the toxic arsenic. To overcome these problems and also to reduce energy consumption, Giammarco Vetrocoke's two-stage regeneration technology with dual activated solution containing glycine and diethanolamine is adopted. The schematic of the arsenic based and glycine based processes are shown in Figures 1 and 2. Though other processes were also considered during the initial stages, the modifications that had to be done to the existing plant to accommodate the other processes were capital intensive. Hence processes other than GV were not considered for implementation.

In the CO_2 removal section, the solution changeover process required the following activities to be carried out.

- Draining of the entire arsenic based GV solution
- Washing the entire section with 5% NaOH solution
- Washing with hot DM water
- Discharging the packing of all the beds
- Sandblasting of the vessel internals
- Installing of the new internals
- Charging of new packing
- Solution preparation for passivation
- Solution preparation to the desired concentration.
- Static and dynamic passivation

As arsenic was not compatible with the new solvent, thorough cleaning of the system free off arsenic was absolutely essential. A series of washings were envisaged to free the system off arsenic. Three key issues were absolutely critical in this process.

1. Estimating the quantity of arsenic contaminated effluent.
2. Storing and subsequently treating the waste effluent
3. Ensuring that the effluent generated is in line with the estimation.

Two tanks namely storage tank and disposal tank were available, the former for storing solution drained from the system during plant trip outs. The storage tank was required to be free of arsenic so as to prepare fresh solution for the switch over. When the plant was running itself, the storage tank was isolated and delinked from the process after converting the disposal tank as the storage tank. Adequate precautions were taken to ensure that there is no possibility of mix up of contents in either of these tanks.

The hold up solution from the system was drained to the disposal tank of 400 m^3 capacity. As the I and II bed packings in the absorber normally contain more sludge, it was decided to discharge these packing first so that the load would have washing reduced. Slip plates were provided at the gas inlet to the absorber so as to avoid gas entry when the two beds were in removed condition, lean and semi lean pumps were run to establish solution circulation from absorber to regenerators. For the caustic soda wash, concentrated lye was injected directly to the system and was diluted within the system to get the required concentration. Also as the total effluent generated from the washings was estimated, a 700 m^3 RCC tank at site was located and lined up to receive these tower washings directly through a pump.

The tower internals in both absorber and two regenerators were to be changed for the new system. New additional nozzles for the reboilers of high-pressure regenerator and the semi lean sump of low-pressure regenerator was planned and provided in phase – I revamp. Stress relieving had been done and considering this fact, additional jobs and modifications in the tower internals had to be planned devoid of any further requirement of stress relieving. The four bed random packing configuration of the absorber was not adequate for the new solvent and structured packings were recommended in absorber, to have better contact between gas and the liquid. This also required removal of distributor trays, their support grids and supporting ‘I’ beams.

The distributor trays were supported on tray support rings (TSR) and had to be ground flush to position the new packing structures. Grinding to such a close level was not practical and gas cutting was done very carefully to avoid any contact with the shell that might result in disturbing the grain structure. Gas cutting was done leaving a 10 mm projection and subsequently ground to 2-3 mm. Earlier to check the heat transfer rate and temperature rise in the absorber shell while cutting the TSR by gas, a mock up piece was made ready in a 30 mm thick X 1 mm long base plate. It was confirmed that the raise in the temperature in the walls was around 150-160 °C only.

Also to ensure that the vessel is devoid from traces of arsenic, it was decided to use the technique called “Grit Blasting”. This is similar to sandblasting except that instead of sand, very fine iron balls are used. This technique was more effective compared to sandblasting. Once the grit blasting of the vessel was completed, the stress relieved packing support grid I beams were positioned, over which the support grid was positioned and above which the structured packing was stacked. The bottom two beds of packings involved the normal packing changeover procedure.

4.2.2 REGENERATORS

The earlier system made use of both the regenerators operating in parallel at the same pressure. The two-stage regeneration process required one regenerator to be operated at high pressure and another at low pressure. Since both the regenerators were of the same height, the advantage of flow by gravity could not be availed between the regenerators and flow could be effected by pressure difference only. All the lines and control valves connecting the two regenerators were designed to offer minimum pressure drop. Modifying the spare manholes already present in the vessel made appropriate locations for injection of lean and semi lean sump nozzles. Also since the HP regenerator was to be loaded with 65% of rich solution, its original rich solution feed gallery distribution trays designed for 50% of rich solution were found to be insufficient. Hence the feed gallery slots size was accordingly increased to accommodate the higher solution flow rates and the distributor tray hole diameter size was also increased to avoid solution flooding in the trays.

An ejector was used to boost up the LP regenerator CO_2 pressure using the HP regenerator outlet CO_2 as the motive fluid. This ejector, along with the new exchangers for overhead CO_2 cooling was mounted on a special structure erected for it.

A masonry lift of 60 m height was erected in between the two regenerators after incorporating all the safety systems and doing a load test for 1500 kg prior to commissioning. This lift was quite helpful in carrying the material /manpower required for the job and also the packing to the top of regenerators.

The operation of discharging the packing from the vessels was suitably planned such that at any point of time, packing would be discharged only from any one of the regenerator beds. Segregation of the discharged packing was done to select the good packing for recharging and disposal of the rest. Some beds were to be charged with new packing. The entire operation was done with care and avoiding any mix up.

The section was successfully commissioned after carrying out static and dynamic passivation activities.

4.3 CONVERSION & METHANATION SECTION

The gas from the outlet of methanator was used to preheat the methanator feed inlet gas followed by a high pressure boiler feed water heater and final cooler using cooling water before compression in the synthesis gas compressor. As the methanator outlet temperature was around 330 °C, there was an opportunity to increase the boiler feed water temperature to 220 °C from 180°C, if the two exchangers at the exit of methanator were interchanged. The boiler feed water heater was placed first and the methanator feed inlet heater was placed next as illustrated in Figure 3. As the temperature inlet of the second exchanger became reduced, the size of the exchanger was increased suitably to have the same heat transfer rate. This resulted in increased heat recovery by the boiler feed water reducing oil consumption in boilers. The heat duty across the final cooler became reduced due to drop in the inlet temperature from 180 °C to 100 °C resulting in less heat rejection to the cooling water system and reducing the heat flux across the exchanger thereby minimizing the mechanical failures.

5.0 POST COMMISSIONING EXPERIENCE

After completion of all the revamp activities, the plant was smoothly started. The precautions that were taken during pre-commissioning namely the cleanliness and good quality jobs executed ensured that there were no post-commissioning hiccups like choking, flange leaks, etc. The arsenic from the CO_2 removal system was found to be completely removed as only 230 ppm of arsenic was found in the circulating solution against the permissible limit of 1000 ppm. There were a few problems that were faced in the plant which are enumerated here.

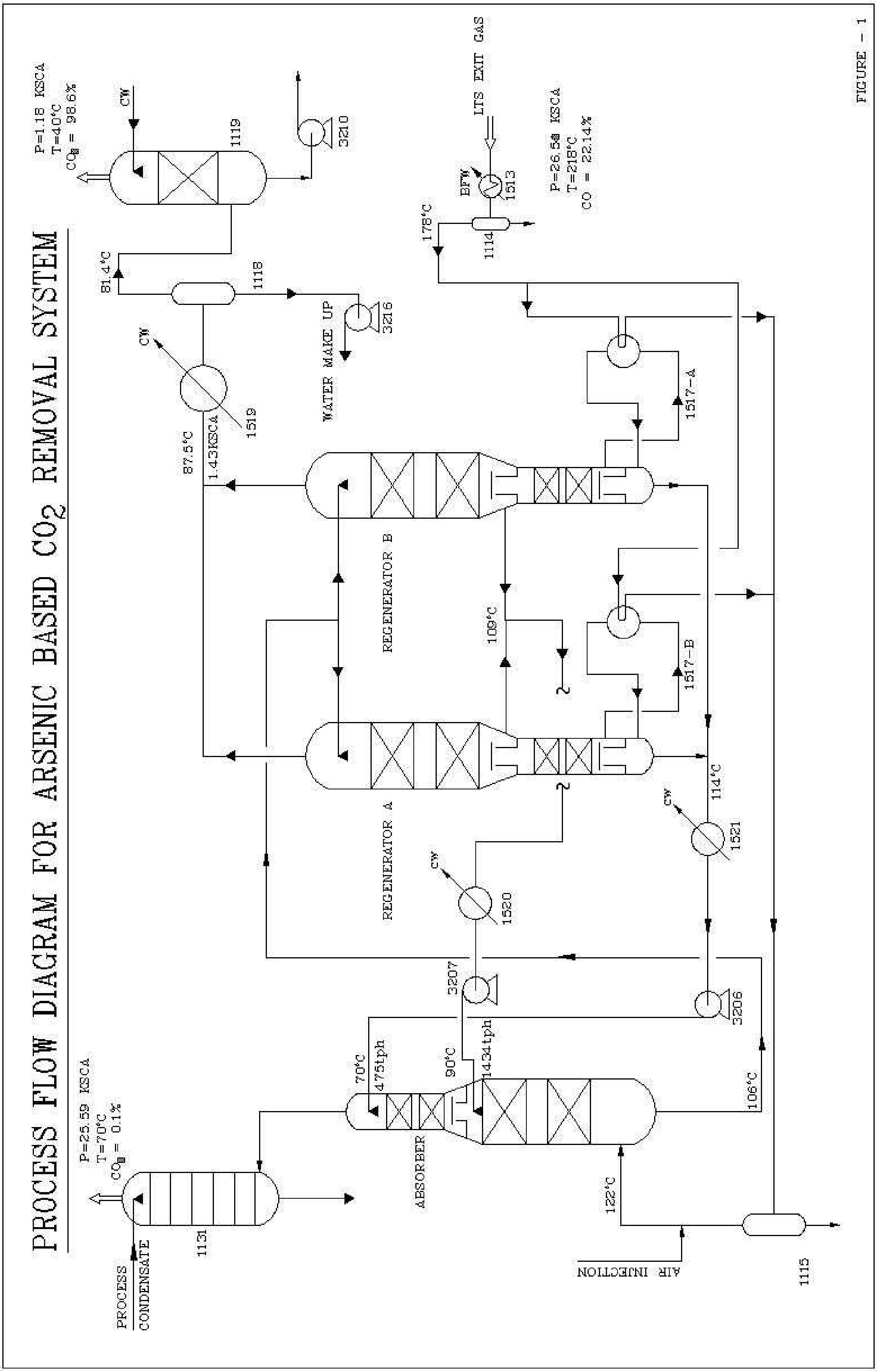
- There was a problem of maldistribution of combustion air to the burners in primary reformer resulting in poor flame condition especially in the end rows. The problem was analysed to be insufficient combustion air pressure available at the wind box of these burners in spite of a higher combustion air pressure available at the header. The major reason was identified to be the pressure drop offered by the bellows placed in the air duct of the individual burners. The bellow was of two layered construction and when the bellows were squeezed due to the expansion of the ducts, the inner layer sulked in while the outer layer converged out. This resulted in reduction in the available cross sectional area causing additional pressure drop. Misalignment in the duct connecting the bellows was also considered to be a cause for the above problem. To overcome this, the supports near the end ducts were cut and the headers were jacked up by about 10-15 mm so as to reduce the strain on the bellows. There was a slight improvement in the air distribution and correspondingly in the flames but still the flames were not satisfactory. Additional service air was lined up by providing a temporary air hose through the ignition port of the burner so as to have a reasonably good flame. During a planned shut down these bellows were completely replaced with a modified and improved design eliminating the pressure drop across the bellows. However, the flame condition in the end row burners needs to be improved. This was done to certain extent by diverting more combustion air to the end row burners after throttling the dampers of individual burners in other rows and by suitably adjusting the secondary air gap of the end row burners. Presently the furnace is operated with a high level of 25% excess air and detailed study has been made and improvements in the duct work have been planned to eliminate the problem of combustion air maldistribution.

- Few problems were faced in the CO_2 removal system. During passivation and subsequent operation during start up, it was observed that the temperatures at the exit of two parallel reboilers were different indicating preferential flow across the reboilers. To maintain the temperature deviation within limits, the gas inlet valve to the reboiler was throttled to have same vapour temperature. Hot water flushing was done by admitting hot water to the base of the reboilers but the temperature difference did not narrow down. Raising of plant load normalized the temperature deviation recorded at lower loads.

- A 14” line has been provided to transfer semi lean solution from HP to LP regenerator. There was a limitation to transfer the semi lean solution from HP to LP in spite of opening the bypass valve of the level control valve in the transfer line fully. Reduced semi lean injection was resulting in poor regeneration and increased energy consumption and plant load was becoming limited. The problem was reasonably overcome by increasing the pressure of HP regenerator and reducing the pressure of LP regenerator. This has however resulted in excessive flashing and increased loading of the LP regenerator resulting in carry over of solution to the overhead knock out pot especially at loads very close to maximum throughput. The problem is expected to be solved by increasing the solution transfer line size to 20” down stream of the LCV to reduce the pressure drop and to increase the solution transfer rate from HP to LP regenerator. The details of modifications to the line can be learnt from figure 4.

6.0 CONCLUSION

After the revamp, a new lease of life is given to the plant. Apart from reduction in specific energy consumption, the revamp has enabled the two decade old SOUTHPETRO’s ammonia plant to compete with the latest generation plants in terms of reliability and economy.



PROCESS FLOW DIAGRAM FOR ARSENIC BASED CO2 REMOVAL SYSTEM
P=1.18 KSCA
T=40°C
CO2 = 98.6%
CW
1119
3210
LTS EXIT GAS
BFW
1513
P=26.5 KSCA
T=218°C
CO = 22.14%
178°C
1114
81.4°C
1118
WATER MAKE UP
3216
CW
1519
87.5°C
1.43KSCA
1517-A
REGENERATOR B
109°C
1517-B
REGENERATOR A
114°C
CW
1521
CW
1520
3207
3206
70°C
475tph
90°C
1434tph
106°C
P=25.59 KSCA
T=70°C
CO2 = 0.1%
ABSORBER
122°C
1131
PROCESS CONDENSATE
AIR INJECTION
1115
FIGURE - 1

PROCESS FLOW DIAGRAM FOR GLYCINE BASED CO_2 REMOVAL SYSTEM

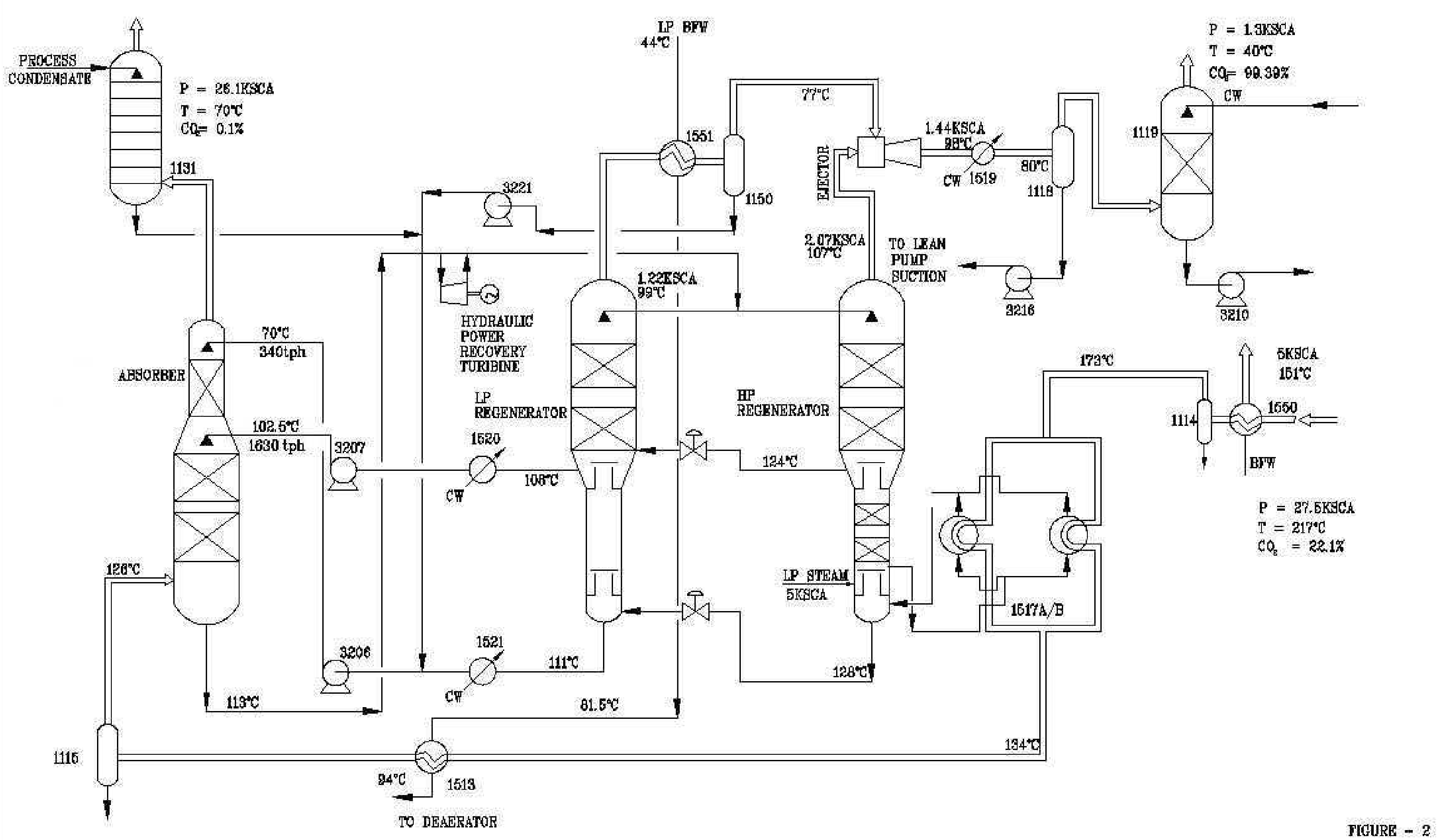


FIGURE - 2

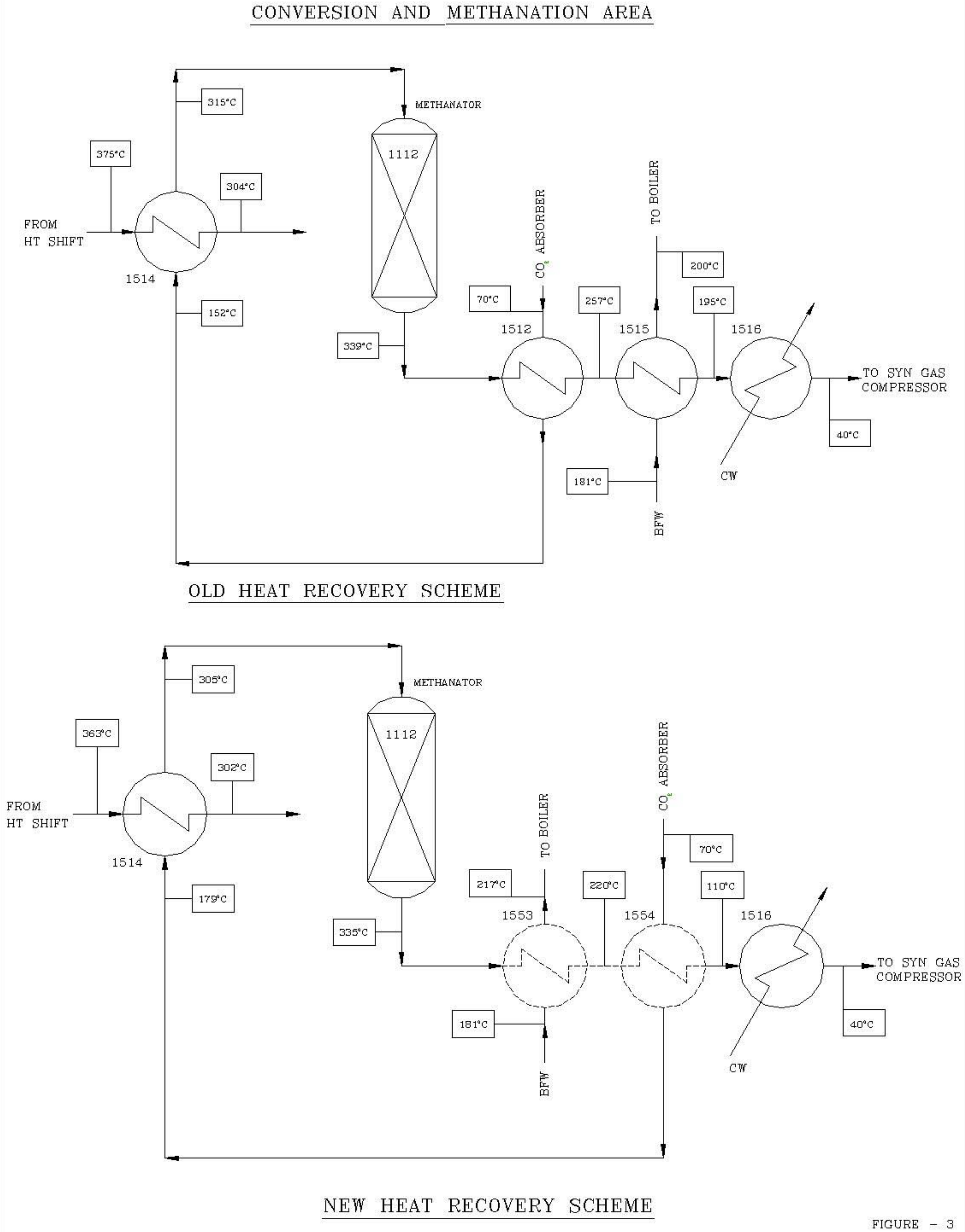

CONVERSION AND METHANATION AREA
METHANATOR
1112
315°C
375°C
304°C
FROM
HT SHIFT
1514
152°C
339°C
CO_2 ABSORBER
70°C
TO BOILER
200°C
257°C
195°C
1512
1515
1516
TO SYN GAS
COMPRESSOR
40°C
181°C
CW
BFW
OLD HEAT RECOVERY SCHEME
METHANATOR
1112
305°C
363°C
302°C
FROM
HT SHIFT
1514
179°C
335°C
TO BOILER
CO_2 ABSORBER
70°C
217°C
220°C
110°C
1553
1554
1516
TO SYN GAS
COMPRESSOR
181°C
40°C
CW
BFW
NEW HEAT RECOVERY SCHEME

FIGURE – 3

SEMILEAN SOLUTION LINE MODIFICATION FROM HP REGENERATOR TO LP REGENERATOR

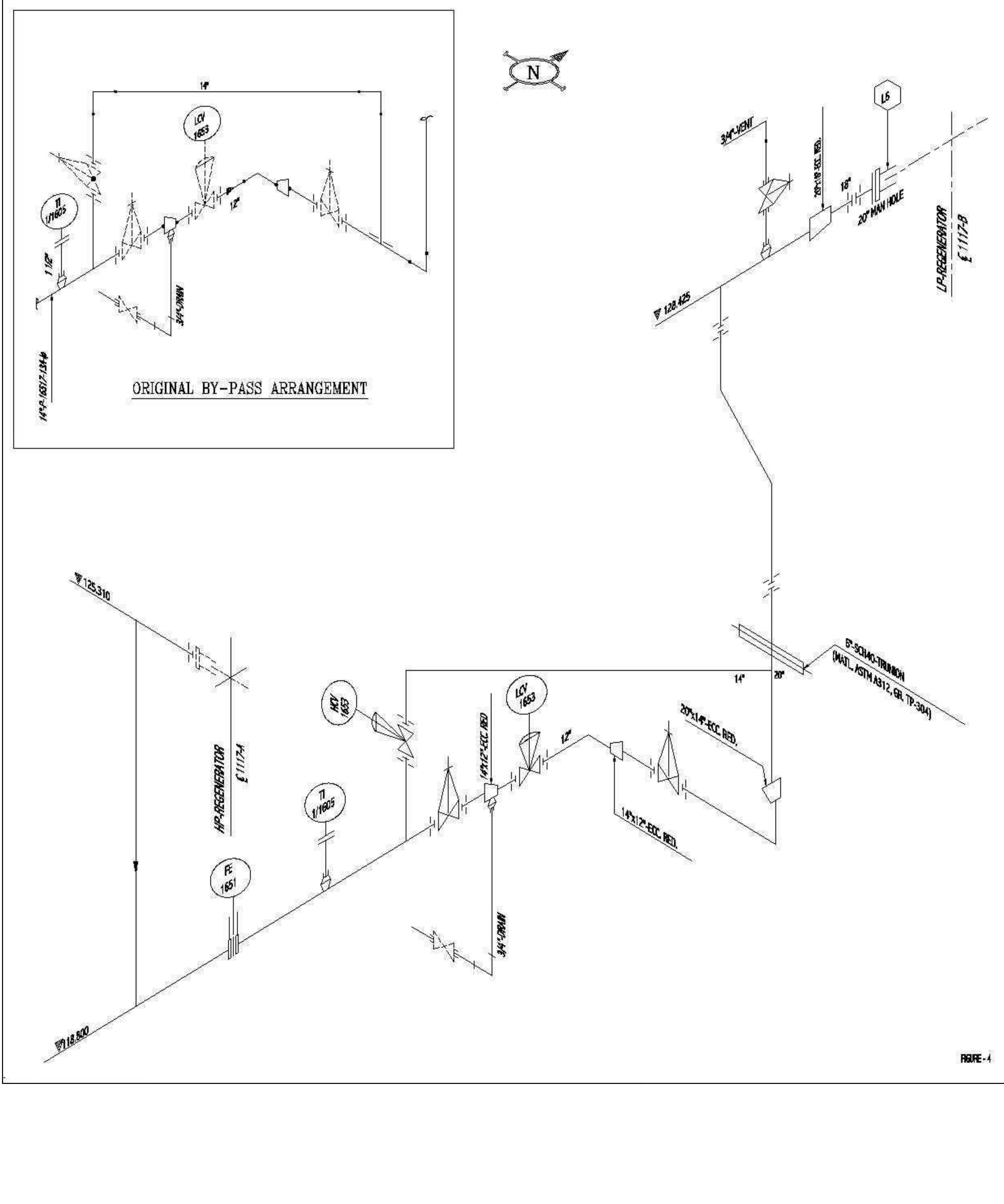


FIGURE - 4