International Fertilizer Industry Association

IFA Technical Conference

Venice, Italy

2-4 October 1990

International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
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REVAMPING OF AMMONIA UREA FERTILISER COMPLEX - EXPERIENCE AT SHRIRAM FERTILISERS & CHEMICALS, KOTA, INDIA

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Fertiliser unit of Shriram Fertilisers was commissioned in 1969. This consisted of an ammonia plant of 450 metric tons/day and an urea plant of 700 metric tons/day.

The capacity utilisation in first five years was 106%.

Plant was expanded on debottleneck basis to 600 metric tons/day of ammonia and 1000 metric tons/day urea in 1974. Capacity utilisation for the first three years after expansion was only 77% of enhanced capacity.

To improve the capacity utilisation revamping trouble shooting programme was introduced. Capacity utilisation of 104% was achieved in 1985-86.

Current capacity utilisation is also 104% of enhanced capacity.

As a first step in the revamping/trouble shooting programme, separate files on all critical equipments with flow sheets and battery limits were prepared.

Actual operating conditions were compared with those in design. Extensive intrumentation was provided to facilitate measurement of operating parameters like pressure, temperature, flow etc. Based on this, revamping of ammonia urea fertiliser complex was undertaken.

During the capacity debottlenecking in 1974, the major areas which were augmented are outlined below:-

AMMONIA PLANT

- Addition of 120 metric tons/day ammonia synthesis loop.
- Installation of additional compressors for process air, synthesis gas and CO_2.
- Addition of pumps for naphtha, Benfield solution & boiler feed water.
- Replacement of potash based Topsoe catalyst by more active potash-free RKNR Topsoe catalyst in primary reformer.
- Steam naphtha coil in convection section of primary reformer furnace was augmented.

There were no changes done in primary reformer tubes, burners, secondary reformer, reformed gas boilers, HTS, LTS and Benfield CO_2 removal system.

UREA PLANT

- Addition of carbamate decompsotion heater, carbamate condenser crystallizer condensers, desorber column, ammonia feed pump and high pressure carbamate pump, centrifuge.
- Equipment such as conveyor air blower, prilling bucket, urea remelting pump & heater were replaced by higher capacity ones.

The same urea reactors, crystallizers, prilling tower ID fans were retained.

From the exhaustive trouble shooting studies which were carried out by an in-house team, the following major areas were identified for improving availability of the plant and increasing the plant throughput.

AMMONIA PLANT

i) Process

- Naphtha prefractionation system
- Carbonate deposition on methanator catalyst
- Fouling of reformed gas boilers
- CO_2 absorption system
- Naphtha desulphurisation facility
- Water treatment
- System pressure drop

ii) Equipment

- Reformer tubes
- Refrigeration capacity
- Fuel knock-out pots
- Reformer ID fan
- Reformer burners
- Reformed gas boiler
- Process air compressor limitation
- Replacement of materials of construction for critical equipment
- Treatment of compressor foundations

UREA PLANT

i) Process

- Recovery from ammonical water

ii) Equipment

- Mixer
- Urea reactors
- Prilling tower ID fan
- Prilling scraper
- Carbamate pump

Itemwise details are given below.

AMMONIA PLANT

PROCESS

NAPHTHA PREFRACTIONATION SYSTEM

Though this system was originally provided, it was not felt necessary to take the system into line due to good quality of naphtha that was being received (sulphur less than 10 ppm).

Naphtha linkage for our plant was changed to another refinery processing varying quality of crude petroleum. Due to presence of high boilers in this naphtha, deteriorating effect was experienced on the primary reformer catalyst and choking of fuel naphtha lines.

It was therefore felt necessary to make preparations for commissioning of prefractionation system. This system was taken in line in 1978.

The system consists of two prefractionation columns in series. Crude naphtha is fed to the first column and bottoms of the first column are fed to the second column. The following three product streams are obtained:

- Process naphtha : Top of first column
- Reformer fuel : Top of second column
- Preheater fuel : Bottom of second column

As a result of the above system, process naphtha no longer contains any high boilers and gummy compounds. The problem of choking of reformer fuel line has practically disappeared. This resulted in increased availability of reformer burners.

CARBONATE DEPOSITION ON METHANATOR CATALYST

Problem of carryover of hot potassium carbonate from CO_2 absorber had been frequently observed. This would result in carbonate deposition on the downstream methanator catalyst thereby impairing its performance. Temporary relief in methanator pressure drop used to be obtained by back-blowing the methanator with process gas.

With the commissioning of additional separator in parallel with the original separator, problem of carryover has been overcome.

FOULING OF REFORMED GAS BOILER

Carryover of the refractory and catalyst dust resulted in fouling of reformed gas boilers and the consequent inadequate cooling led to higher than maximum permissible gas temperature to RG boilers and inlet to HTS. This caused serious constraint in production.

Analysis of the foulant dust collected from the reformed gas boilers indicated that it contained predominantly alumina and lesser quantities of nickel and silica.

Possible sources of the dust were from the following:

- Erosion of the refractory in the transfer line which transports the main process gas from primary to secondary reformer at increased load.
- Erosion of secondary reformer refractory by process gas bypassing the catalyst bed due to high pressure drop at increased load.
- Attrition of catalyst at increased velocity.

The following remedial measures have been implemented:

i) Transfer Line: Original refractory arrangement consisted of insulating castable insulating bricks and high alumina refractory bricks. This arrangement was replaced by pre-cast annular rings of hot face castable (consisting of about 96-97% alumina) with proper expansion joints. Also stainless steel shrouds were provided inside the pre-cast annular rings.

ii) Secondary Reformer: As a short term solution, extensive relining of secondary reformer was done. Proper curing of refractories was carried out during plant start-up after completing the re-lining work. As a result of the above, the extent of fouling has reduced substantially. Refractory remains reasonably healthy even after 2-3 years of operation.

As a long term solution, we are considering replacement of secondary reformer vessel by a higher diameter secondary reformer.

As for RG boiler, abundant precaution to overcome production loss was taken by implementing the following:

- Outlet tube sheet of RG boiler no.1 and both tube sheets of RG boiler no.2 were refractory lined and suitable ferrules were also provided. Gas bypass line was refractory lined.

  Gas bypass valve of higher temperature rating was provided. We can now go up in temperature exit no.1 boiler to about 650°C and exit no.2 boiler to 450°C.

- Spray tower packed with SS-304 packings was installed at HTS inlet. Water was sprayed in the process gas to maintain the desired HTS inlet temperature.

The above modifications had the following advantages:

- Plant load reduction was avoided.

- Heat not exchanged in reformed gas boilers was recovered in medium pressure boiler (exit HTS) and heat exchangers (such as BFW preheater, HPC reboiler etc.) between LTS and absorber.

  Between two periods of boiler cleaning, the average BFW spray was about 5 m.tons/hr. This resulted in heat recovery of 3.2 MKcal/hr. and equivalent 14 K steam generation of 5.8 m.tons/hr.

  Thus the heat lost in fouled HP boilers was recovered as 14 K steam in downstream equipment.

  This, however, has increased the steam draw from the off-site boilers.

CO_2 ABSORPTION SYSTEM

It was observed that stable operation was not possible at plant loads higher than 570 m.tons/day ammonia (i.e. 95% load). At higher loads, problems of high CO_2 slip and liquid hold-up in the system were encountered. At 95% load, actual CO_2 slip was 3 to 4 times the design value of 0.1%.

Stablised operation of CO_2 absorption system with designed CO_2 slip of 0.1% at 103% load could be achieved by replacing ceramic intallox saddles by SS pall rings in the packed beds of the absorber. Bigger HPC solution cooler was also provided to achieve the designed temperature of 90°C at inlet to the absorber.

NAPHTHA DESULPHURISATION FACILITY

Sulphur poisoning of primary reformer catalyst was experienced even while analysis of sulphur content in process naphtha inlet to primary reformer showed less than 0.05 ppm compared to 0.2 ppm maximum permitted.

This was attributed to presence of sulphur compounds such as thiophenes which are reported to be difficult to hydrogenate as well as detect by standard Raney-Nickel method.

Corrective actions successfully implemented were:

- Increasing sulphur content from 0.05-0.1 to 5-10 ppm in the outlet of primary desulbhurisation unit i.e. desulphurisation naphtha tank. This helped in keeping Co-Mo bed in secondary desulphurisation in the more active sulphided state. This helped in hydrogenating difficult sulphur compounds.

- Also the secondary desulphurisation catalyst volumes were increased by installing a new vessel and Co-Mo catalyst volume was increased from

7.4 to 20.2 M^3 and ZnO was increased from 9 to 16.4 M^3.

Sulphur poisoning has not occurred since then.

WATER TREATMENT

The quality of cooling water in ammonia plant was not satisfactory and resulted in fouling and corrosion in heat exchangers. To overcome this problem, cooling water treatment with organophosphonates was started in September 1984, to control scaling and corrosion and also chlorine to control microbiological growth.

For this treatment pH is maintained between 7.0 to 7.5, total phosphates between 20 to 30 mg/l and chlorides are kept below 50 mg/l. The control parameters are given on next page. The treatment has been found to be quite effective as indicated by followings:

Corrosion Rate

Corrosion rate measurement of carbon steel coupons indicates low corrosion rate of the order of 1 mpy and copper test coupons indicates corrosion rate 5 mpy.

Heat Transfer Coefficient

Performance of heat exchangers is very good as the declining of heat transfer coefficient rate has decreased. Whenever any heat exchanger was opend, practically no fouling has been observed.

Cycles of Concentration

We have been able to maintain cycle of concentration between 2 & 3. However after starting chemical treatment chloride contents are now maintained below 50 ppm.

Basis of Chemical Treatment Control Parameters

Recirculation Cooling Water

- pH	: 6.5-8.0 (preferably 7-7.5)
- Total imorganic phosphate as (PO_4)	: 15-20.0 mg/l
- Total phosphate as (PO_4)	: 20.0-30.0 mg/l
- TBC/ml	: 0.1 x 10^6 per ml (max.)
- Turbidity (NTU)	: 50.0 max.
- Conductivity (Micromhos/cm)	: 2500 max.
- Chloride as Cl	: 50 mg/l max.
- Calcium as $CaCO_3$	: 400 mg/l max.
- Silica as SiO_2	: 100 mg/l max.
- Cycle of concentration	: 2.0-5.0

Make up Water

- pH	: 6.8-8.0
- Turbidity (NTU)	: 5.0 max.
- Total alkalinity	: 120 mg/l max.
- Calcium hardness	: 70 mg/l max.
- Chloride as Cl	: 20 mg/l max.(actual)
- Conductivity (Micromhos/cm)	: 400 max.
- Residual Alumina (as Al_2O_5)	: 0.02 mg/l max.

Water Analysis before Treatment

- pH	: 6 to 9.25 (normal 8.5)
- Conductivity	: Less than 500 micromhos/cm
- Total alkalinity	: 100 - 300 ppm
- Total hardness	: 50 - 170
- NO_2	: Less than 50 ppm
- TDS	: Less than 400 ppm
- $KMnO_4$	: 10 - 20

SYSTEM PRESSURE DROP

Pressure drop from inlet of reformer tubes to suction of synthesis gas compressors was found to be higher at 10.4 compared to design 9 Kg/cm^2G at 600 MTPD ammonia. Lower suction pressure resulted in lowering synthesis gas compression capacity which became a production bottleneck.

An extensive pressure drop survey of the entire system was undertaken. Evaluation of pressure drop data helped in identifying areas of high pressure drop.

The globe valve in the pipe line from trim heater to methanator heat exchanger was replaced by a higher size and this resulted in reducing the system pressure drop by about 1.0 Kg/cm^2G.

In addition, the gate valve and the pipe line from methanator heat exchanger to trim heater was replaced from 6" to 8" size. This reduced the system pressure drop by about 0.01 Kg/cm2G further.

The above gave substantial relief and presently synthesis gas compressor capacity is no longer a production constraint and we have operated at 104% plant loads during Winter.

In order to have sustained plant operation at 104% during Summer months also, capacity of existing synthesis gas compressors has been increased by 7 and 11% for circulator and make-up side respectively which corresponds to 110-112% ammonia production. This capacity increase has been achieved by carrying out modifications at a nominal cost in cylinder liners, piston, piston rod, rings etc. using the existing electric motors. Capability of compressors at more than 106% ammonia load could not be tested due to limitations in the front-end of the plant.

Synthesis compressor's capacity is adequate upto 110-112% ammonia production.

EQUIPMENT

REFORMER TUBES

Reformer tubes of HK-40 material (25 Cr/20 Ni) were in operation since 1976. Wall thickness was 17.7 mm. It was experienced that reformer operation at 600 MTPD ammonia was not possible without exceeding the maximum permissible tube skin temperature. This was due to high wall thickness and inadequate catalyst loading in the tubes. In addition, there were problems of short life and severe bowing of tubes which are bottom supported.

The tubes were then replaced with superior material of construction i.e. IN-519 (12 Cr/24 Ni/1.5 Nb). New tubes had the same O.D. but lower wall thickness of 15.2 mm. This gave the advantage of 8% additional catalyst volume and reduction in tube skin temperature.

The above contributed in stablising reformer operation at 100% load.

REFRIGERATION CAPACITY

Two numbers Japanese screw compressors, each of 1050 KW rating, were installed in 1969 to meet the refrigeration requirements of 450 MTPD ammonia synthesis loop.

With this refrigeration capacity, plant load could not be increased above 570 MTPD ammonia. Refrigeration shortfall of 600 RT was estimated.

Inadequate refrigeration capacity was overcome by installing 4 nos. indigenously available reciprocating ammonia compressors.

With installation of these compressors, the refrigeration capacity is no longer a production constraint upto 106% ammonia production.

FUEL KNOCK OUT POTS

These pots have packed beds of carbon steel pall rings. Vaporised fuel naphtha - fuel gas mixture for reformer burners passes through these pots. Carryover of high-boilers is separated in these pots, thereby increasing the availability of reformer burners.

REFORMER I.D. FAN

Indigenous reformer ID fan installed during capacity expansion in 1974 gave only about 70% of its rated capacity and also had high vibrations. Inadequate supply of combustion air from this fan resulted in secondary-combustion in the furnace leading to the following problems:

- Primary reformer exit gas temperature of more than 770°C could not be achieved compared to design value of 784°C.
- Excessive heating up of refractories on the roof top in the furnace.
- Overheating of the lower portion of the steam naphtha coil in the Convection Section.

Also, high vibrations of the fan (mounted on the reformer top) caused loosening of the refractory bricks in the furnace ceiling.

As a result of the above, stablised reformer operation was not possible above 95% load.

- This problem was overcome by replacing the fan by an imported one from M/s Dengyosha, Japan. This higher capacity fan is light weight and has very low vibration level.
- Now there is no secondary combustion in the furnace and we are able to obtain 785-790°C primary reformer gas outlet temperature at 104% plant load.

Minor repair of refractories is now needed after a period of two years.

REFORMER BURNERS

All the 252 burners were retained during capacity expansion from 450 to 600 MTPD. Normal and maximum capacity of each burner was 233000 and 260000 Kcal/hr. With these burner capacities, design collector temperatures of 784°C at 600 MTPD could not be achieved. This problem was overcome by replacing 144 burners in the top and middle rows by replacing with new burners (from M/s Air-Oil Co., UK). Normal and maximum capacity of the new burners were 284000 & 300000 Kcal/hr respectively.

REFORMED GAS BOILER

This boiler is installed downstream of secondary reformer. Problems of falling of refractory and failure of weld between tube to tube sheet joints were often experienced at the hot end of the boiler.

Possible causes of failure were:

- Defective technique for applying refractory lining.
- Hydrogen embrittlement at high tube sheet temperature.
- Thick tube sheet design.

Boiler was replaced by 15% extra capacity boiler of modified design. Salient features of the new design were:

- Thin tube sheet concept.
- Providing incolloy ferrules of modified design & also insulation paper between the ferrule and the tube surface.

With the implementation of the above, there has been no failure of tube to tube sheet joint and also refractory at the hot end.

PROCESS AIR COMPRESSOR LIMITATION

The 4000 KW turbo air compressor was installed in 1969 to meet the process air requiremnet of 450 MTPD ammonia.

During capacity expansion in 1974, process air supply was augmented by installing a reciprocating air compressor of 1350 KW rating.

Process air became a serious production constraint after capacity expansion.

It was found that 4000 KW turbo compressor was giving about 92% of its rated output. Surging was also experienced on some occasions in this compressor. Cause of surging and reduced capacity was attributed to clogging of isotherm coolers.

Following remedial actions were taken to improve the compressor performance:

i) Chemical cleaning of isotherm coolers.

ii) Installation of wet scrubbing system at the compressor suction.

iii) Increasing surface area of the suction filter.

i) Chemical cleaning of Isotherm Coolers:

Material of construction of isotherm coolers is given below:

- Cooler bundle is Cupro-Nickle (90% copper + 10% nickle) tubes.
- Tube plate of naval brass (60% copper + 40% tin)
- Fins of pure copper.
- Fins are bonded to tube by soft solder which is 50% lead and 50% tin.

Samples of foulant deposit were tested with many solvents at various temperatures and concentrations in the laboratory to evolve a suitable chemical cleaning programme.

10% caustic soda solution at 70-80^{o}C temperature was found to be most effective.

The compressor manufacturer M/s IHI, Japan informed that though they had no experience of cleaning with 10% caustic soda solution, they did not foresee any problem. However, they suggested to test a specimen for checking the effect on soft solder which was done and found okay.

Chemical cleaning was undertaken and thereafter the compressor regained its capacity. The isotherm coolers are now chemically cleaned on a bi-yearly basis during turnarounds.

ii) Installation of Wet Scrubbing System at the Compressor Suction:

The system was installed to prevent ingress of possible coal dust (from the nearby coal based power plant) in the isotherm coolers. In this scrubber unit, atmospheric air was washed with water over a bed of ceramic packings. Since the water remained in circulation, it helped in lowering air temperature also.

iii) Increasing Surface Area of the Suction Filter:

Surface area was increased for reducing the pressure drop across the filter.

As a result of the above, the compressor has regained its capacity and continues to maintain about 98% of its rated capacity.

Also for further augmentation of process air supply, an additional 440 KW reciprocating air compressor was procured and installed. This is being run only during Summer months.

Process air availability is no longer a production constraint.

REPLACEMENT OF MATERIALS OF CONSTRUCTION FOR CRITICAL EQUIPMENT

Problem of frequent tube leakages was experienced in critical heat exchangers such as water coolers in the ammonia synthesis loop and ammonia condensers.

Leaking tubes caused carbonate precipitation due to ingress of ammonia. This deposition in the heat exchangers led to drop in the overall heat transfers coefficients causing efficiency loss and at times production constraint also.

Plugging of the leaking tubes necessitated premature plant stoppages causing production loss.

Tubes in these heat exchangers were made of carbon steel.

As a remedial measure, carbon steel tubes in water coolers and ammonia condensers were replaced by SS-304 tubes.

There has been no tube leakage since then. Also, water treatment system based on organophosphates has been introduced.

TREATMENT OF COMPRESSOR FOUNDATIONS

Oil spillage on the compressor foundation was found to penetrate along the foundation bolts. It resulted in loosening of foundation bolts vibration and cracks in the foundation. This was overcome by injecting high pressure oil-impervious resin mortar into the foundation by special techniques. The top portion of the foundation bolts were regrouted using the same mortar. Similarly top portion of the foundation was recast with oil impervious grout.

Cracks in the foundation were also repaired by drilling holes and injecting the above mortar with a special high pressure mortar injecting machine.

Thereafter there has been no deterioration in the above mentioned areas. M/s Alpha Kogyo, Japan provided the necessary expertise and special equipment.

UREA PLANT

PROCESS

RECOVERY FROM AMMONICAL WATER

Ammonical water is generated from indirect condensers in evaporation and crystallisation sections. This contains about 6% ammonia.

For ammonia recovery from the above, one more desorber column was added during capacity expansion in 1974.

Bottom effluent from the desorber columns contained 1-3% ammonia (against design of 500 ppm) and total feed was restricted to 16-18 M^3/hr ammonical water against design of 21 M^3/hr. This was due to high 2nd stage pressure (3.9 to 4.1 Kg/cm^2G) and the desorber columns had to work against the 2nd stage pressure.

The above was resulting in about 15 to 18 m.tons of ammonia going in the effluent water.

Following remedial measures have been taken over a period of time. We are now recovering practically the entire ammonia from the effluent water. Residual ammonia content is less than 100 ppm.

1. Surface area in carbamate condensation was augmented by installation of new 2nd stage carbamate condenser. This helped in bringing down the 2nd stage pressure to 3.5-3.7 Kg/cm^2G. This has resulted in additional ammonical water feed (about 20-21 M^3/hr) and also higher throughput of stripping steam to the desorber columns.

2. Additional packed bed of 4 meters height has been added to each of the two desorber columns to further improve the desorber operations.

   This has resulted in additional 6-8 MTPD ammonia recovery.

3. Last year, we have also commissioned new ammonia recovery system with the following salient features:

   - A tall packed bed column (dia 1.15 M & height 25.0 M) with proper reflux system.

   - Ammonia recovery is in the form of weak carbamate solution. Earlier, it was all in the vapour form going to 2nd carbamate decomposition stage. Now recovered ammonia system is pumped as liquid in the Ist stage recovery operating at 20 Kg/cm^2G.

   The new desorption system is operating very satisfactorily. The earlier desorber columns are no longer required to be operated. We are now recovering full 15-18 MTPD of ammonia from this ammonical water.

EQUIPMENT

MIXER

CO_2, NH_3 and carbamate solution are fed to the mixer upstream of the urea reactors. The mixer (with SS lined construction) had a round bottom with entry nozzles also from the bottom.

Frequent leakages were experienced in the mixer from the ammonia entry nozzle.

Repair of these cracks required complete urea plant stoppage for 3 to 4 days

Cause of leakages was found to be sudden cooling of the ammonia inlet portion thereby developing cracks in the welds. This chilling was caused because of sudden stoppage of CO_2 feed when the power tripping occurred for CO_2 compressors operating on state power grid supply. NH_3 and carbamate pumps were on own captive power generation.

Distribution of power supply could not be changed. To overcome the problem, a new mixer of improved design was procured and installed. Salient featured of the new mixer are as follows:

- Overlay instead of liners.
- A flat bottom instead of round bottom.
- Side entry instead of bottom entry.
- Nozzles are of solid SS-316 L instead of SS liner.

The new mixer was installed in 1976 and we have had no problem of cracks since then.

UREA REACTORS

After 6 years of operation, frequent plant stoppages had to be taken to repair weld cracks in the SS liners at the top dished end of urea reactors. SS liners were of petal-type construction at the dished ends.

The original liner thickness was 5 mm. After 6 years of operation, it had thinned down to 3.2-3.5 mm. Possible reason of thinning of SS liner was blockage of urea reactors without passivating air for durations exceeding the recommended 20-24 hours.

Causes of weld failture were inadequate anchoring of liner with CS shell and weld repair on thinned liner plates.

To overcome the problem, new reactors of improved design were installed. Salient features of new reactors are:

- SS overlay instead of SS liners in the top and bottom dished ends.
- Thickness of overlay 10 mm against earlier liner of 5 mm thickness.
- Adequate anchoring in the cylinderical portion of the reactors between SS liner (10 mm thick) and CS shell.
- Increase in the number of weep holes for detection of leakage in the liner portion.
- Innner most portion of carbon steel cladded with SS (3 mm thick).

Cladding of the carbon steel was done for allowing a planned shutdown of the plant to repair any leakage.

Two reactors were installed in the year 1978-79 and 1981-82. Reactor blockage is now done maximum for 24-26 hours.

There has been no urea plant stoppage due to liner leakage since then.

PRILLING TOWER I.D. FAN

During capacity debottlenecking, the same ID fans were retained. Prill temperatures of plus 90°C were observed during the Summer months at an ambient temperature of 45°C. This resulted in the following problems:

- Difficulty in bagging and handling the urea bags due to high temperature.
- Urea hangings of large size from the ceiling and top portion of the walls in the prilling tower. This required frequent stoppages for cleaning in order to avoid possible damage to equipment.

This debottleneck was overcome by installing the higher capacity ID fans (60% higher capacity on the same foundation with increased motor rating). Prill temperature now is 78-83°C at 45°C ambient temperature at 1000 MTPD load.

To bring down the prill temperature further, we are considering to have an after-cooler.

PRILLING TOWER SCRAPER

Single arm scraper (of size approx. equal to tower radius) was provided in the original plant in 1969 in the prilling tower.

The same was retained during capacity debottlenecking from 700 to 1000 MTPD.

While operating at increased capacity, problem of frequent spillage from the downstream belt conveyors, transfer points and vibrating screen (used for separating the oversize urea prills) was experienced. This was due to non-uniform loading from the single arm scraper.

To overcome this problem, 2nd arm (identical to the first arm but without any separate drive) was added to the scraper system.

With double arm scraper, spillage of urea from the conveying and screening system has been eliminated.

CARBAMATE PUMPS

These pumps are of reciprocating type and were to pump the recovered carbamate from 20 Kg/cm^2G to 200 Kg/cm^2G reactor pressure. During capacity debottlenecking, one number carbamate pump of similar type and capacity was added to the already existing 3 nos. pumps.

Frequent pump stoppages had to be taken to attend the leaking plunger packings and manifold valves. This resulted in production loss and also high maintenance expenditure.

As a modernisation step one number centrifugal carbamate pump (from M/s Sundstrand, USA) was installed. The pump is stopped once in about 8 months for necessary inspection.

During start up of the plant and for periods of centrifugal pump inspection and maintenance, the existing recriprocating pumps are operated.

The above arrangement has eliminated urea production loss due to outage of carbamate pump and also substantially reduced maintenance expnditure.

By systematic trouble-shooting and adequate preventive maintenance, it has been possible to achieve marked improvements in capacity utilisation, efficiency improvements and stable operation at high loads in the past five years.

FUTURE PLAN OF ACTION

Modernisation, process improvements and marginal capacity increases are a way of life at Shriram. Listed below are the major areas in which we are currently working:

1. AMMONIA SYNTHESIS CONVERTER BASKET

The existing converter basket (Topsoe's Conventional Axial Type) was installed along with the original plant in 1969. During the last catalyst change, top surface of the basket showed tendency of nitriding, indicating the need of catalyst basket replacement.

A new two-bed radial flow converter basket is being procured from Topsoe

Denmark. The new basket shall have the advantages of lower pressure drop and higher ammonia conversion per pass in the converter.

2. REFORMER TUBES OF IMPROVED MATERIAL OF CONSTRUCTION

There were two problems being faced with the existing reformer tubes; lower life and severe bowing.

Tubes are bottom supported.

For longer life and to avoid tube bowing, reformer tubes of superior material of construction and reduced wall thickness with spring hanger supports are being considered.

With reduced wall thickness, the weight of the new tubes will be lower, which shall necessitate lesser tension on spring support hangers and thus lower the load to be supported on the top of reformer structure. As a result, it shall be possible to instal top hanger support on all the tubes and avoid tube bowings.

The new materials have chemical composition consisting broadly of 25 Cr/ 35 Ni + Nb + Ti + Nr (Micro alloys). These are being marketed under various proprietory names from M/s Kobota, Japan and M/s Manoir Industries, France etc.

3. PRE-REFORMER

Installation of pre-reformer is being considered for augmenting the front end capacity by 12-15% from the existing rated capacity of 600 MTPD ammonia.

Further action shall be decided after proposals from various process licensors are received.

4. UREA PRILL COOLER

In India, our urea product is a premium brand because of very low biuret content (less than 0.5%), uniform prill size.

In our continuing efforts to maintain product quality, we are considering installation of fluidised bed cooler for urea prills prior to bagging.

We are trying to develop in-house design for fluidised bed cooler.

It will have the following advantages:

- Urea product shall be totally dust free.
- Prill temperature of bagged urea will be only about 50-55^{o}C.

We hope fellow members of IFA will benefit from our experience.

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LIST OF EXHIBITS

EXHIBIT- 1

NAPHTHA PREFRACTIONATION SYSTEM

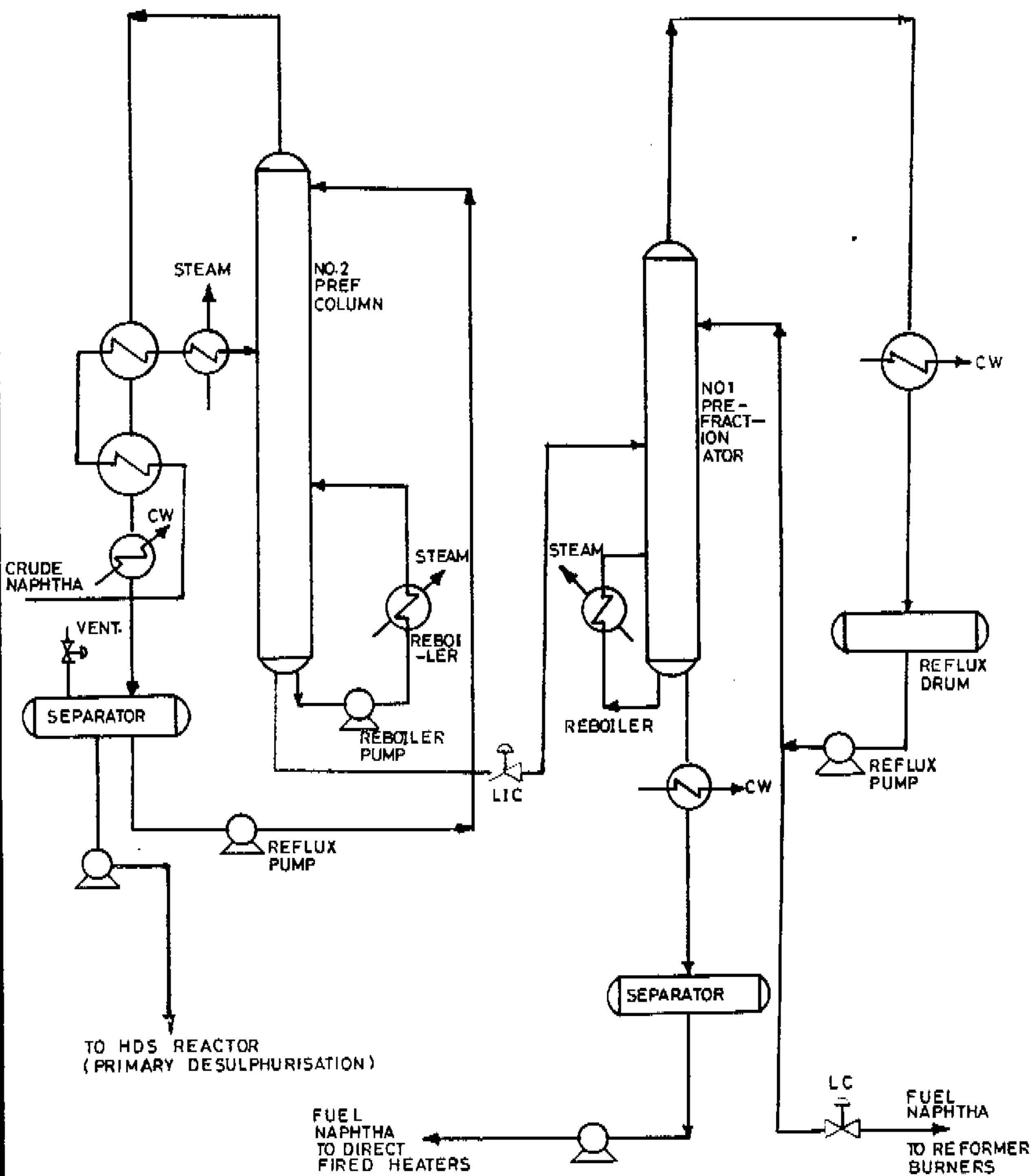


EXHIBIT - 2

NAPHTHA PREFRACTIONATION SYSTEM
TYPICAL NAPHTHA ANALYSIS

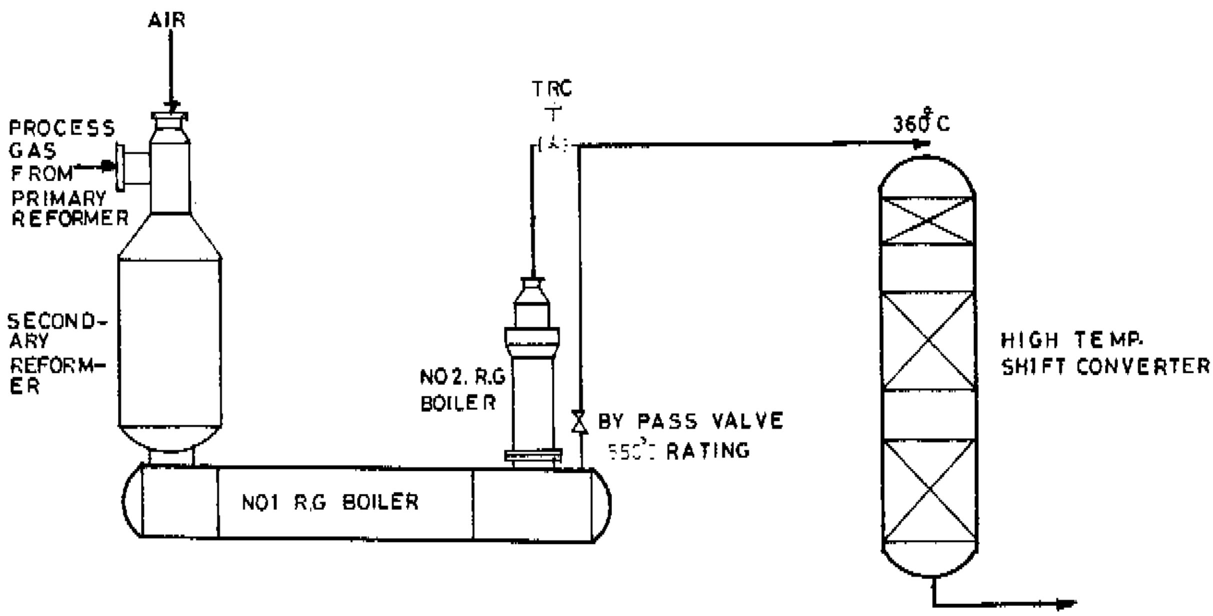
Particulars	Unit	Design	Crude	Process	Reformer Fuel	Preheater Fuel
Distribution	°C					
IBP		28	45	46	55	NA
30%		113	73	73	89	"
50%		124	89	89	99	"
70%		136	103	100	109	"
90%		151	129	125	124	"
FBP		180	145	141	150	"
Sulphur	ppm	1500 max.	40-60	4-6	53	250

NA : Not Analysed.

EXHIBIT-3

COOLING OF REFORMED GAS-SPRAY TOWER

BEFORE



AFTER

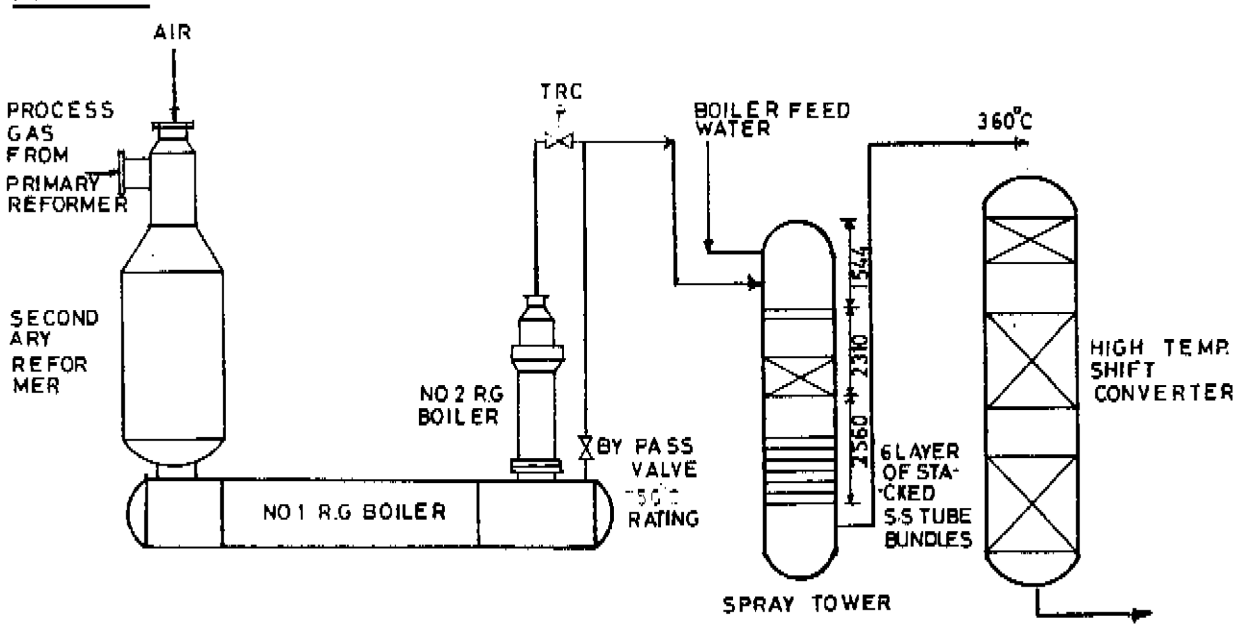


EXHIBIT - 4

TUBE SHEET THICKNESS AND MOC OF HP BOILERS COMPARATIVE DATA

Particulars	No.1 HP Boiler		No.2 HP Boiler	
	Original	Existing	Original	Existing
1. SUPPLIER	Chiyoda, Japan	L & T, Bombay	Chiyoda, Japan	Isgec John Thompson, Calcutta
2. TUBE SHEET				
Inlet - MOC	A-204-GrC	SA-204-GrC	A-204-GrC	A-204-GrB
- Thickness mm	40	28	40	56
Outlet - MOC	A-204-GrC	SA-204-GrC	A-204-GrC	A-204-GrB
- Thickness mm	40	28	50	56

NOTE

Composition (%)	A-204-GrB	A-204-GrC
C	0.20	0.23
Si	0.15-0.3	0.15-0.3
Mn	0.9	0.9
P	0.035	0.035
S	0.04	0.04
Mo	0.45-0.6	0.45-0.6

EXHIBIT -5

CO_2 ABSORBER PACKING REPLACEMENT TYPICAL COMPARATIVE DATA

Parameter	Unit	Design		Before packing replace-ment	After packing replace-ment
		Chiyoda	Benfield		
Column diameter	mm	3300/ 2300	√	√	√
No. of beds	No.	4	√	√	√
Height of each bed					
- Top	mm	5500X2	√	√	√
- Bottom	mm	6500X2	√	√	√
Type & size of packing					
- Top bed	-	1.5"IS	√	1"PPR+ 1.5"IS	1"SS PR
- Bottom bed	-	2" IS	√	2" IS	1.5"SS PR
Volume per bed					
- Top	M^3	23	√	√	√
- Bottom	M^3	55	√	√	√
Plant Load	MTPD	600	√	561	626
HPC solution flows					
- Lean	M^3/hr	210	192	246	210
- Semi-lean	M^3/hr	520	510	512	512
HPC solution temp.					
- Top	^oC	90	√	83	90
- Middle	^oC	114	116.3	113	115
Gas pressure - Absorber inlet	Kg/cm^2G	25.5	24.0	24.9	24.7
Pressure drop across absorber	Kg/cm^2G	0.3	NS	0.21	0.20
CO_2 slip from absorber	% dry Vol.	0.1	0.1	0.37	0.07

NOTES:
IS - Intallox saddles ceramic.
PPR - Polypropylene pall rings
SS PR - Stainless steel pall rings

EXHIBIT-6

TRIM HEATER LINE SYSTEM

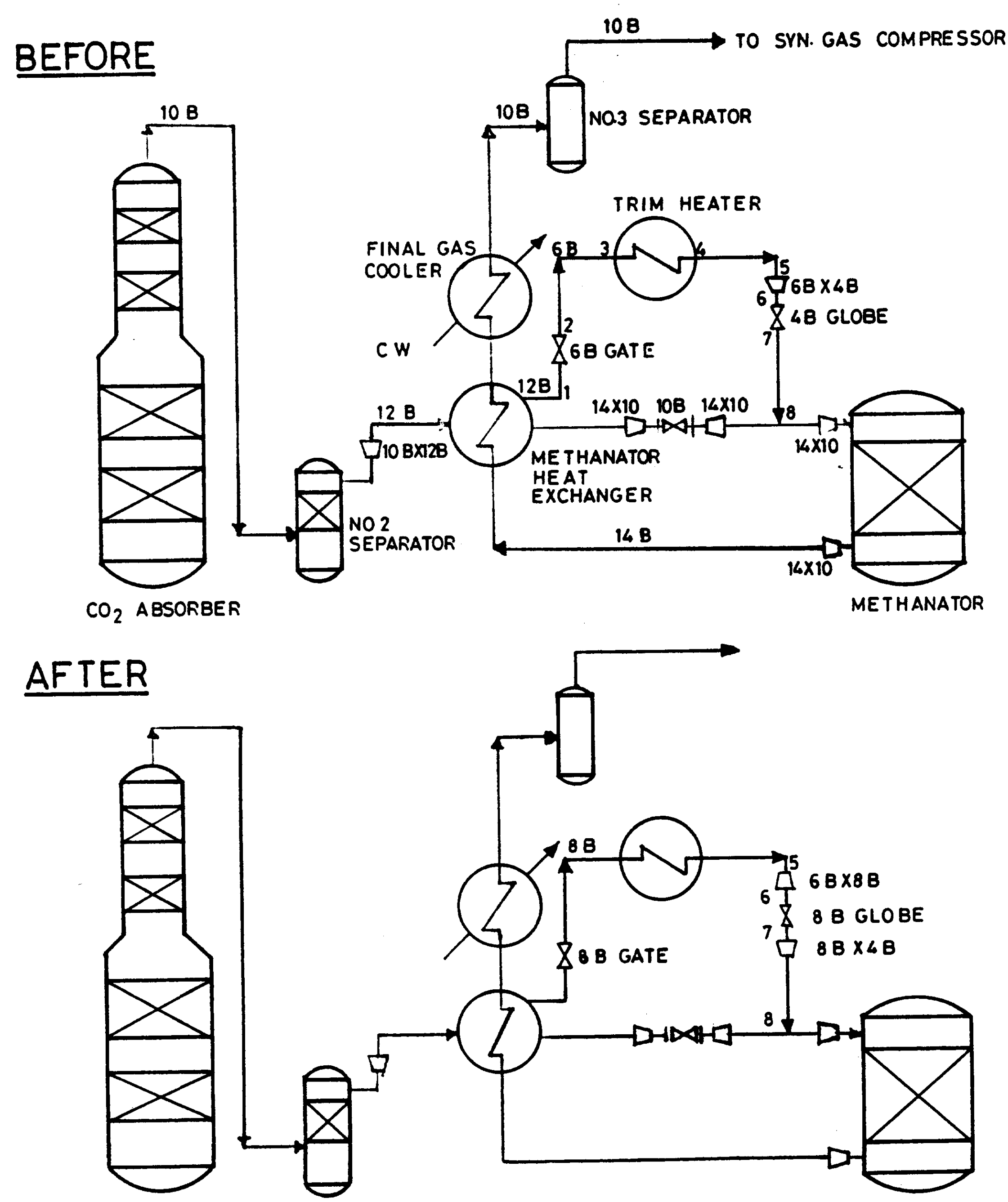


EXHIBIT - 7

COMPARATIVE PRESSURE DROP- BEFORE & AFTER THE MODIFICATIONS IN TRIM HEATER LINE

Segment	Before Modification		After Modification		
			Calculated		Actual
	Velocity M/Sec	Pressure Kg/cm^2	Velocity M/Sec	Pressure Drop Kg/cm^2	Pressure Drop Kg/cm^2
1 - 2	26.5	0.014	26.5	0.014	
2 - 3	26.5	0.060	26.5	0.060	
3 - 4	14.7	0.037	14.7	0.037	
4 - 5	34.8	0.111	34.8	0.111	
5 - 6	78.9	0.045	34.8	0.005	
6 - 7	78.9	0.822	20.2	0.047	
7 - 8	78.9	0.116	78.9	0.175	
TOTAL :		1.205		0.449	0.4

NOTES :
- Segment details are given on the system line diagram.
- In actual practice, pressure drop can be measured only from point 1 to 8.
- Above pressure drop data is for design conditions at 600 MTPD ammonia.

EXHIBIT - 8

COMPARATIVE SYSTEM PRESSURE DROP-BEFORE & AFTER MODIFICATIONS IN TRIM HEATER LINE

Unit: Kg/cm^2

Particulars	Design	Before	After
Plant Load - MTPD Ammonia	600	600	618
Pressure drops across :			
- Primary reformer	3.0	1.4	1.4
- Secondary reformer & HP boilers	1.5	1.1	1.1
- Spray tower	Nil	1.4	1.3
- HTS	0.5	0.7	0.7
- MP boiler	-	0.3	0.5
- LTS	0.5	0.6	0.7
- Heat exchangers between LTS & absorber	1.0	1.9	2.2
- CO_2 absorber	0.3	0.2	0.2
- No.2 separator	0.9	0.6	0.6
- Methanator heat exchanger (Shell side)	0.5	1.4	0.4
- Methanator	0.3	0.5	0.5
- Methanator heat exchanger (Tube side) and final gas cooler	0.5	0.3	0.2
TOTAL :	9.0	10.4	9.8

NOTES :

1. 0.1 Kg/cm^2 gain in pressure drop corresponds to a gain in synthesis compressor capacity equivalent of 2.6 MTPD ammonia.
2. Minimum operated suction pressure of synthesis gas compressor is 18.0 Kg/cm^{2}G.

EXHIBIT- 9

VACCUM MEASUREMENT POINTS IN PRIMARY REFORMER

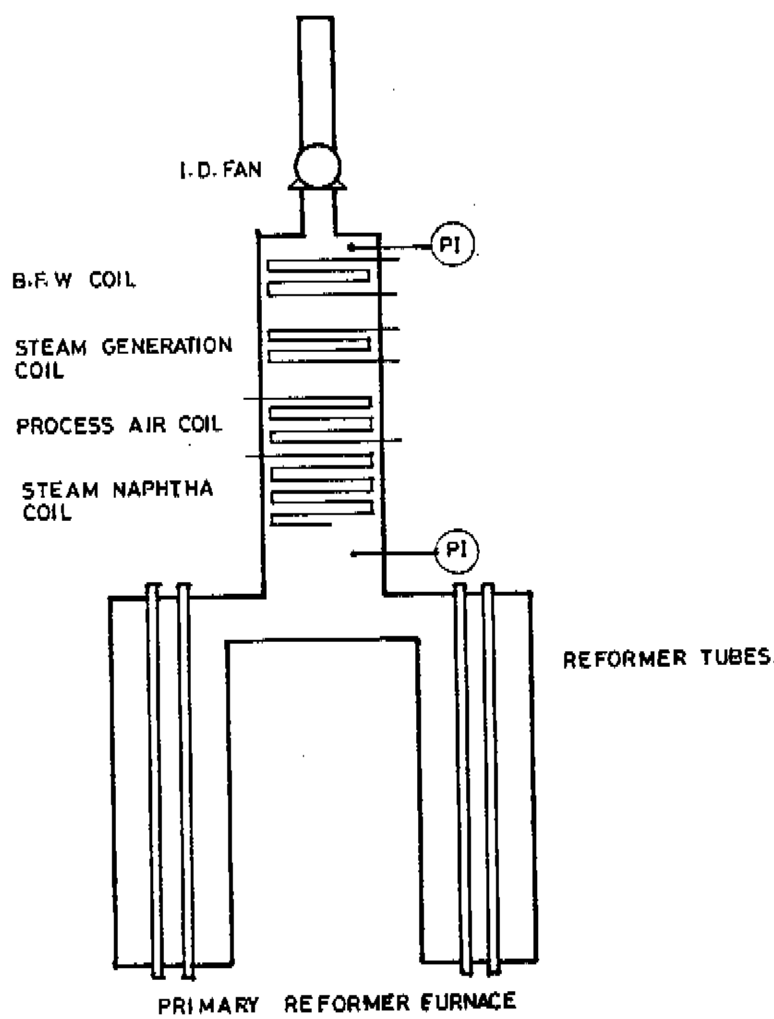


EXHIBIT - 10

REFORMER I.D. FAN COMPARATIVE DATA

Particulars		Unit	Details	
1. FAN				
- Fan supplier			Andrew-Yule India	Dengyosha Japan
- Capacity	- Design	NM^3/Hr	1,02,000	1,02,000
	- Actual	"	71,400	1,01,500
- Suction pressure	- Design	mm water	-103	-103
	- Actual	"	-43	-77
- Discharge pressure	- Design	"	0	0
	- Actual	"	0	0
- Suction temp.	- Design	^oC	220	220
	- Actual	^oC	200	230
- Damper opening	- Actual	%	Full	85
2. FURNACE				
- Furnace draft	- Design	mm water	-5 to -10	-5 to -1
	- Actual	"	-4	-13

EXHIBIT - 11

PRIMARY REFORMER-FLUE GAS ANALYSIS AT REFORMER I.D FAN INLET

Particulars	MTPD Ammonia	Flue Gas Mole %		
		O_2	CO_2	CO
I. Before ID fan replacement	518	1.0	10.5	0.01
	521	2.2	10.7	0.17
	523	2.0	10.8	NT
	524	2.6	11.6	NT
	540	1.4	11.0	0.7
II. After ID fan replacement in Sept'80	538	3.8	9.0	NT
	541	4.0	10.8	NT
	551	4.2	10.2	NT
	556	3.4	10.6	NT
	561	3.2	11.4	NT
	564	2.8	10.2	NT
	582	3.4	11.4	NT
	595	3.0	10.8	NT
	605	4.0	10.2	NT
	613	3.6	10.6	NT
	613	3.8	10.6	NT
	619	3.2	11.2	NT
	621	3.8	12.2	NT

NT : Not Traceable.

EXHIBIT - 12

TURBO AIR COMPRESSOR-CLEANING OF ISOTHERM COOLERS
TYPICAL COMPARATIVE DATA

Particulars		Unit	Design	Before Cleaning	After Cleaning
Vane opening		Deg.	48	40	45
Suction	- Pressure	mm Aq	-272	-506	-387
	- Temp.	^oC	45	34.5	36.0
Pressure drop across isotherm coolers					
	- I	mm Aq	126	993	237
	- II	"	114	455	178
	- III	"	101	NA	148
	- IV	"	70	NA	NA
Discharge	- Pressure	Kg/cm^2G	32.07	30.5	30.5
	- Temp.	^oC	137	146	152
Discharge flow		NM^3/hr	18410	16976	17952
ΔT across isotherm coolers					
	- I	^oC	67	7	32
	- II	"	62	18	40
	- III	"	56	40	NA
	- IV	"	50	NA	26

NA : Not Available.

EXHIBIT-13

AUGUMENTATION OF DESORPTION SYSTEM CAPACITY NEW CONDENSER

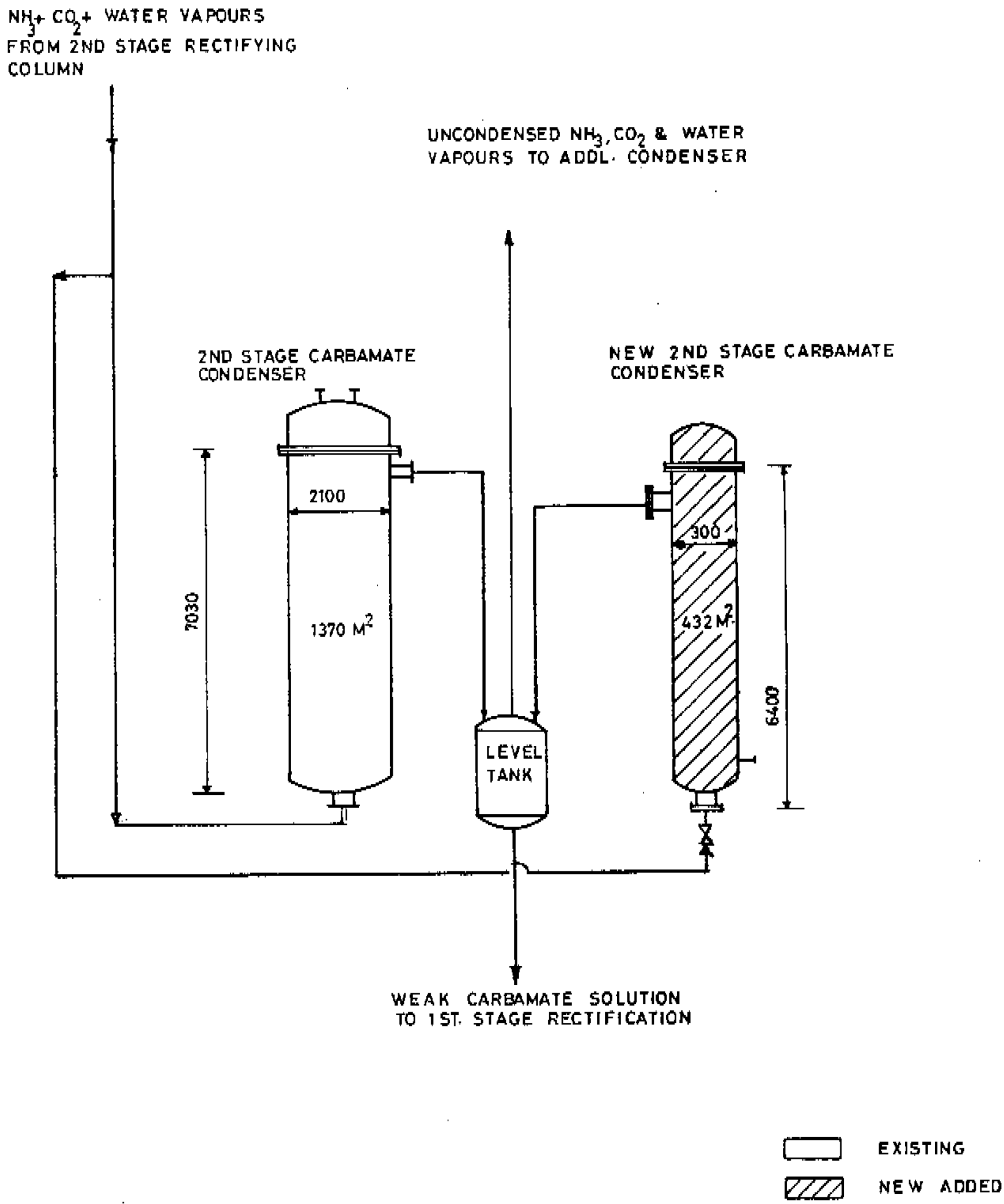


EXHIBIT-14

AUGUMENTATION OF DESORPTION SYSTEM CAPACITY DESORBER HT. INCREASE

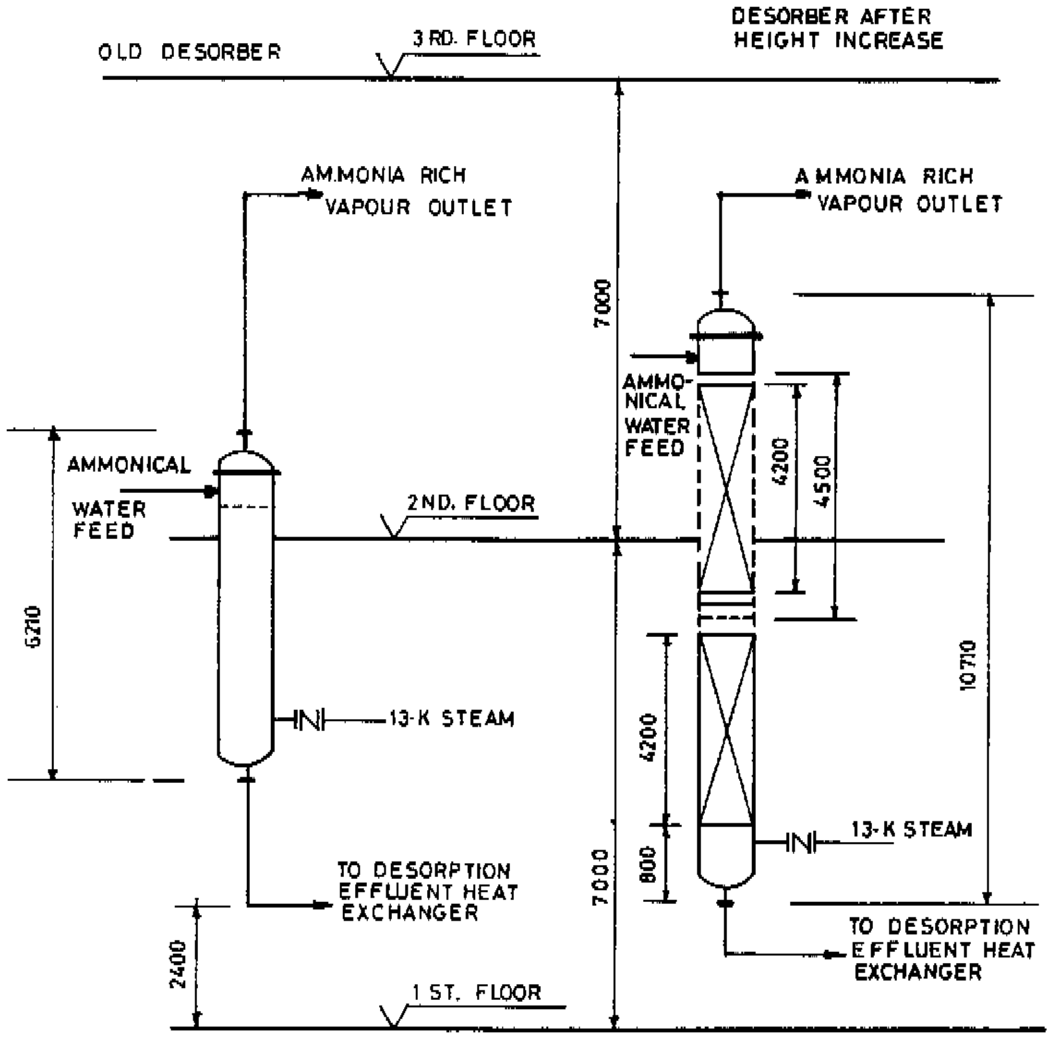


EXHIBIT-15

MIXER-ORIGINAL

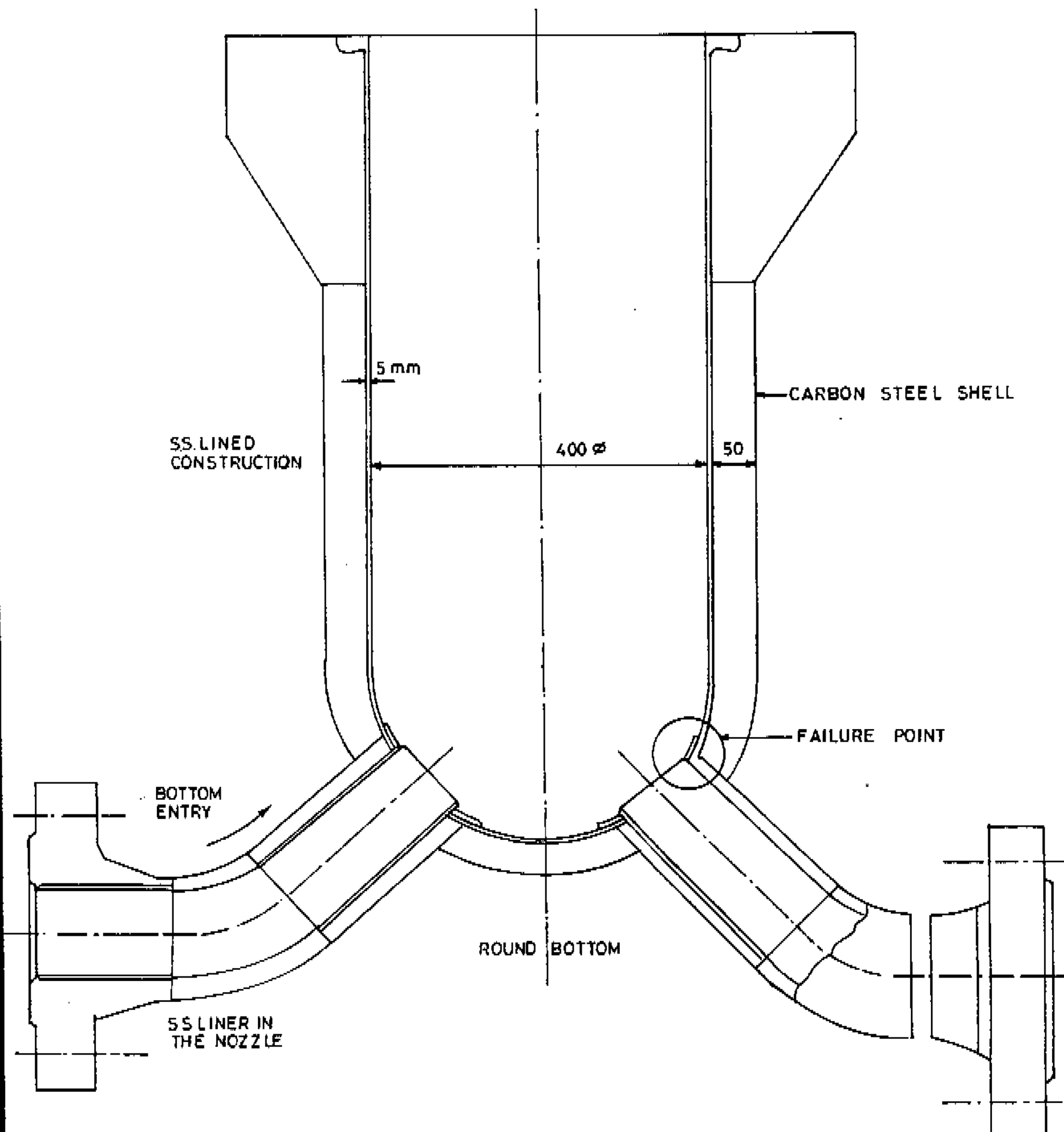


EXHIBIT-16

MIXER– NEW

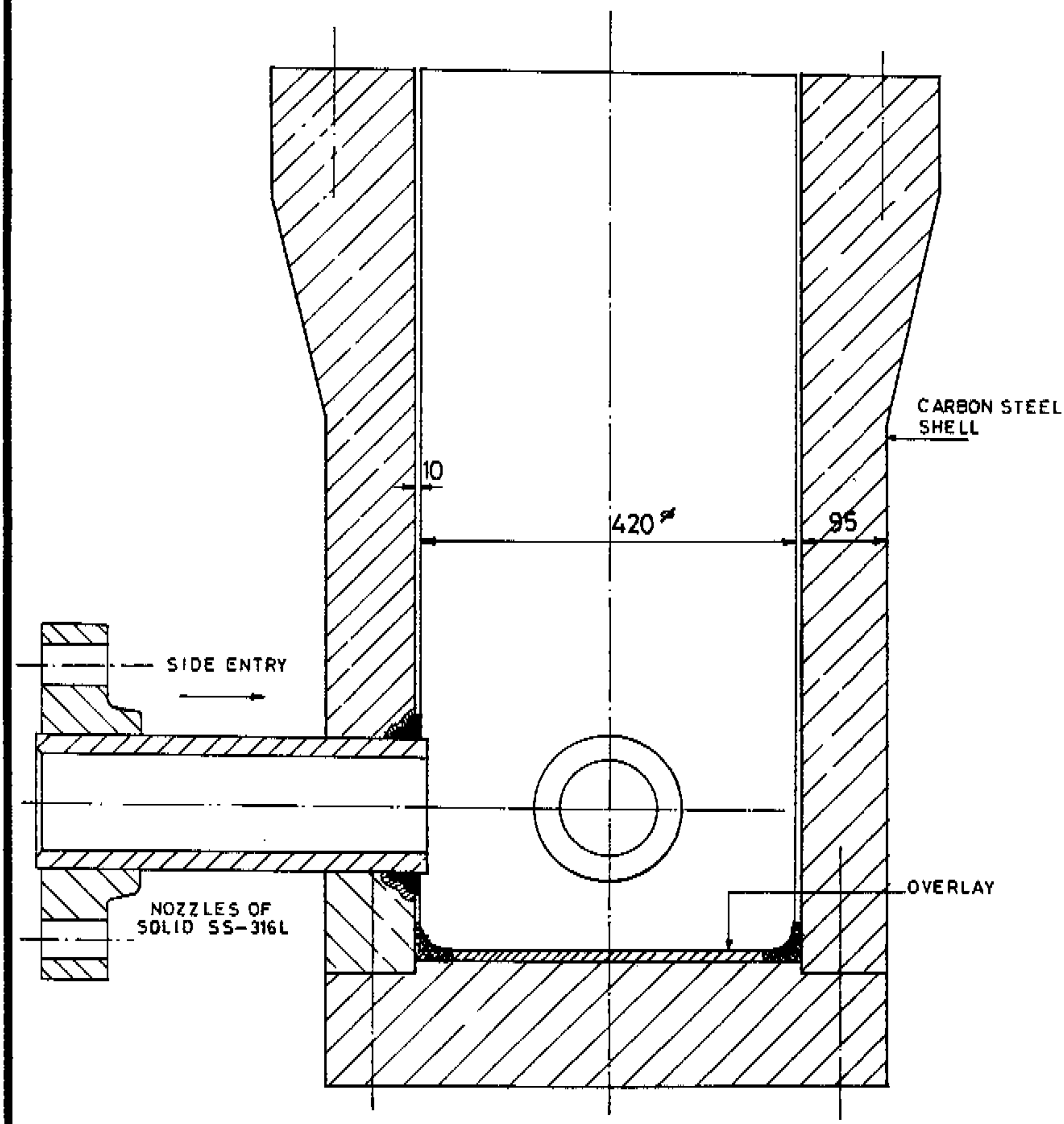
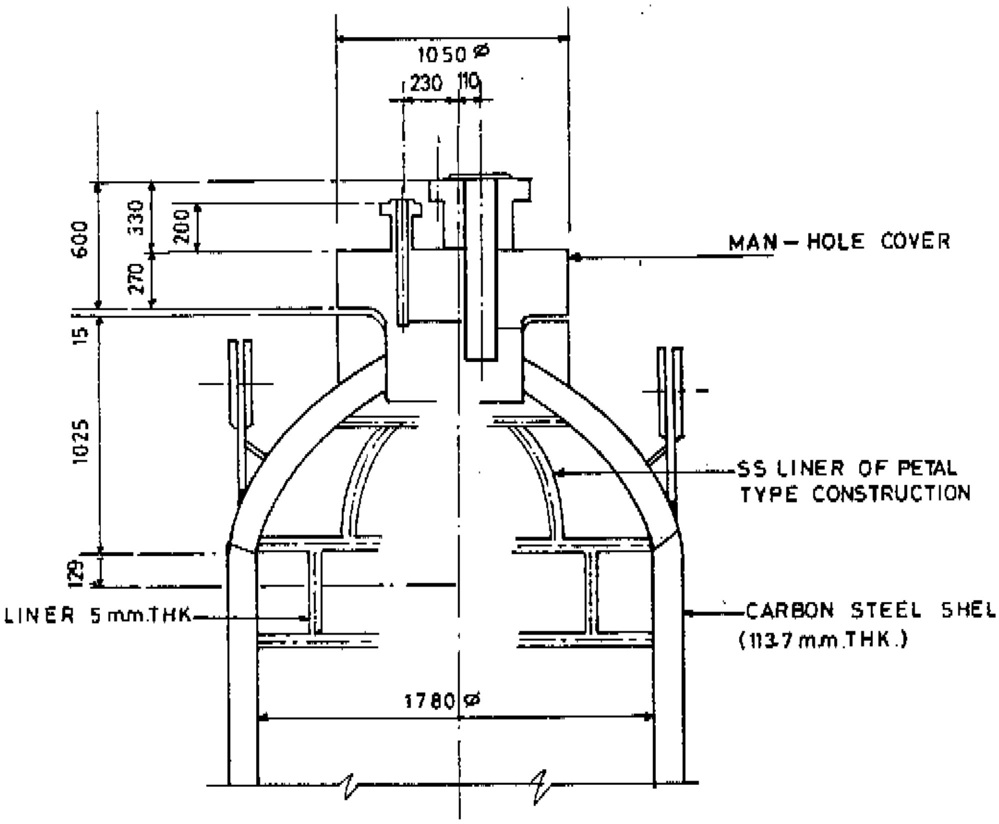


EXHIBIT-17

UREA REACTOR ORIGINAL



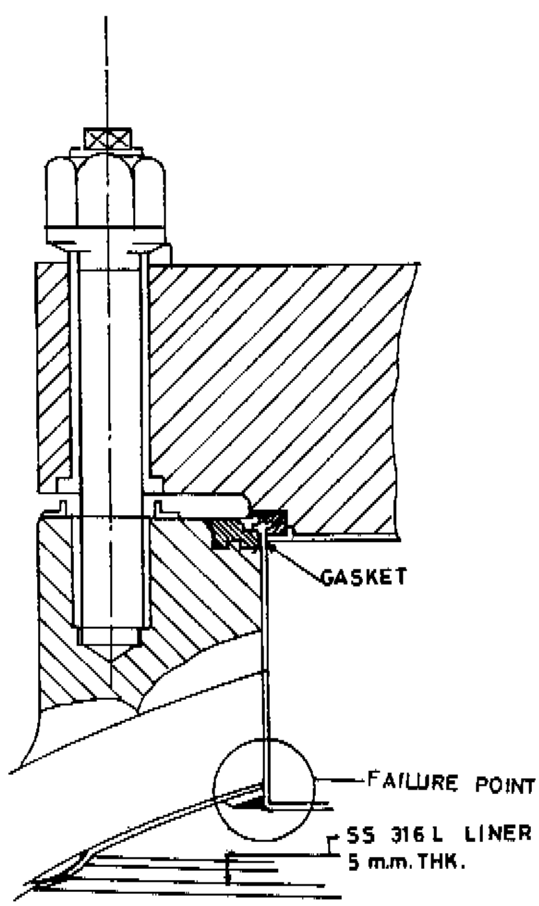


EXHIBIT-18

UREA REACTOR – NEW

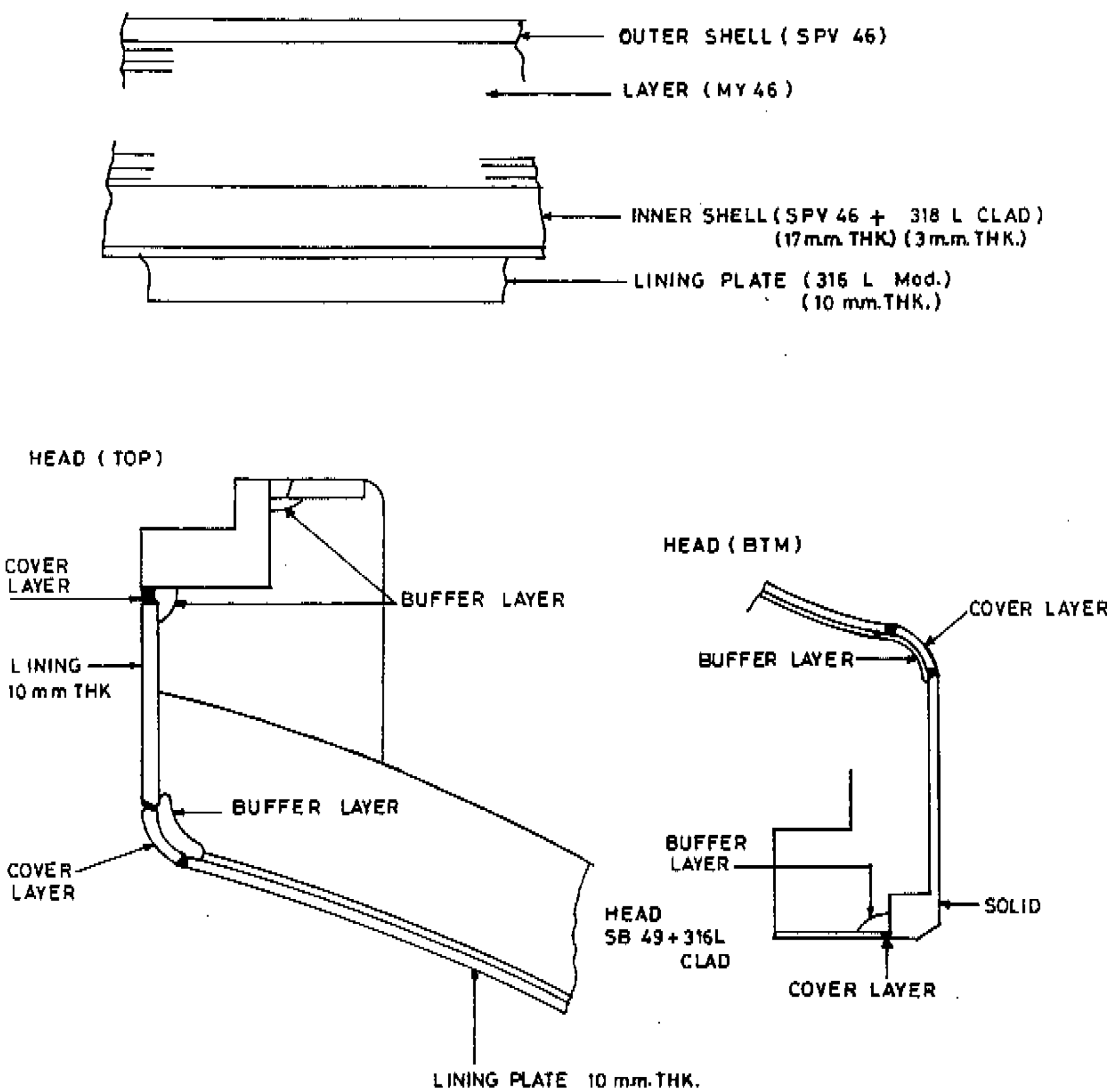


EXHIBIT - 19

UREA PRILLING TOWER I.D. FAN-COMPARATIVE DATA

Particulars	Unit	Old	New
FANS			
- Supplier		Dengyosha, Japan	✓
- No. of fans	No.	4	✓
- Characteristics of gas			
- Gas handled		Air with traces of NH_3+ urea dust	✓
- Operating temperature	^oC	70	85
- Operating parameters			
- Capacity/fan	NM^3/hr	90,000	1,47,000
- Pressure - Suction	mm Aq	-15	✓
- Discharge	"	0	✓
- Differential	"	15	✓
- Actual speed	RPM	580	730
Driver - Type		Motor	✓
- Output	KW	15	45
OPERATING DATA			
Temperature - Ambient	^oC	45	✓
- Prills	"	90-95	78-83
Prilling Load	MTPD	1000	✓

EXHIBIT - 20

CARBAMATE PUMPS - COMPARATIVE DATA

Particulars	Unit	Existing Reciprocating	New Installed Booster	New Installed Main
- Supplier		Worthington W.Germany	Sundstrand USA	Sundstrand USA
- Type		Plunger	Centrifugal	Centrifugal
- No. of pumps	No.	3 + 1	1	1
- Capacity	M^3/hr	28	75	75
- Speed		104 SPM	2960 RPM	16029 RPM
- Operating temp. - Design	^oC	110	✓	✓
- Design Pressure				
- Suction	Kg/cm^2 abs	21.5	20.0	32.6
- Discharge	"	205.5	32.6	217.6
- Differential	"	184.0	12.6	185.0
- Head developed	MLC	1670	115.0	1683.8
- Driver - Type		Motor	✓	✓
- Rating	KW	220	56	750
- RPM		2960	2960	2960