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Significant Ammonia Recovery from Urea Plant Flared Gases

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Oman India Fertiliser Company (OMIFCO), Oman

SIGNIFICANT AMMONIA RECOVERY FROM UREA PLANT LP SECTION FLARED GASES

OMAN INDIA FERTILISER COMPANY (OMIFCO)

OMAN INDIA FERTILIZER COMPANY S.A.O.C. (OMIFCO) was set up as a joint venture project under the initiative of Government of Sultanate of Oman and Government of India.

OOC : Oman Oil Company S.A.O.C, Oman (50 % shareholder)

IFFCO : Indian Farmers Fertiliser Cooperative Ltd., India (25 % shareholder)

KRIBHCO : Krishak Bharati Cooperative Ltd., India (25 % shareholder)

OMIFCO was registered in the Sultanate of Oman as a closed joint stock company in the year 2000.

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Plant	Capacity	Licensor
Ammonia	2 x 1750 MTPD	Haldor Topsoe-Denmark
Urea	2 x 2530 MTPD	SAIPEM-Italy (Previously Snamprogetti)

PLANTS WERE COMMISSIONED DURING APRIL 2005

Annual Installed capacity:		Million MT
Ammonia	:	1.190
Urea	:	1.652

UREA PROCESS FEATURES AT OMIFCO

The Urea manufacturing process is based on the well established Ammonia stripping process designed by M/S SAIPEM of Italy.

The Urea manufacturing process is characterized by the following main process steps

a) Urea synthesis and NH3, CO2 recovery at high pressure.
b) Urea purification and NH3, CO2 recovery at medium & Low Pressures.
c) Urea concentration
d) Waste Water treatment.

UREA PROCESS FEATURES AT OMIFCO

Following advanced features are provided in the Urea plant design
To have lower energy consumption.

a) Ammonia feed Preheating with off-gases from the L.P decomposer and overhead gases from the process condensate treatment section.

b) Preheating of H.P carbonate recycle stream to H.P loop with hot process condensate from waste water section.

c) Heat supply to vacuum pre-concentrator by overhead off-gases from the M.P.de-composer.

d) Complete recovery of process condensate as Boiler feed water make up.

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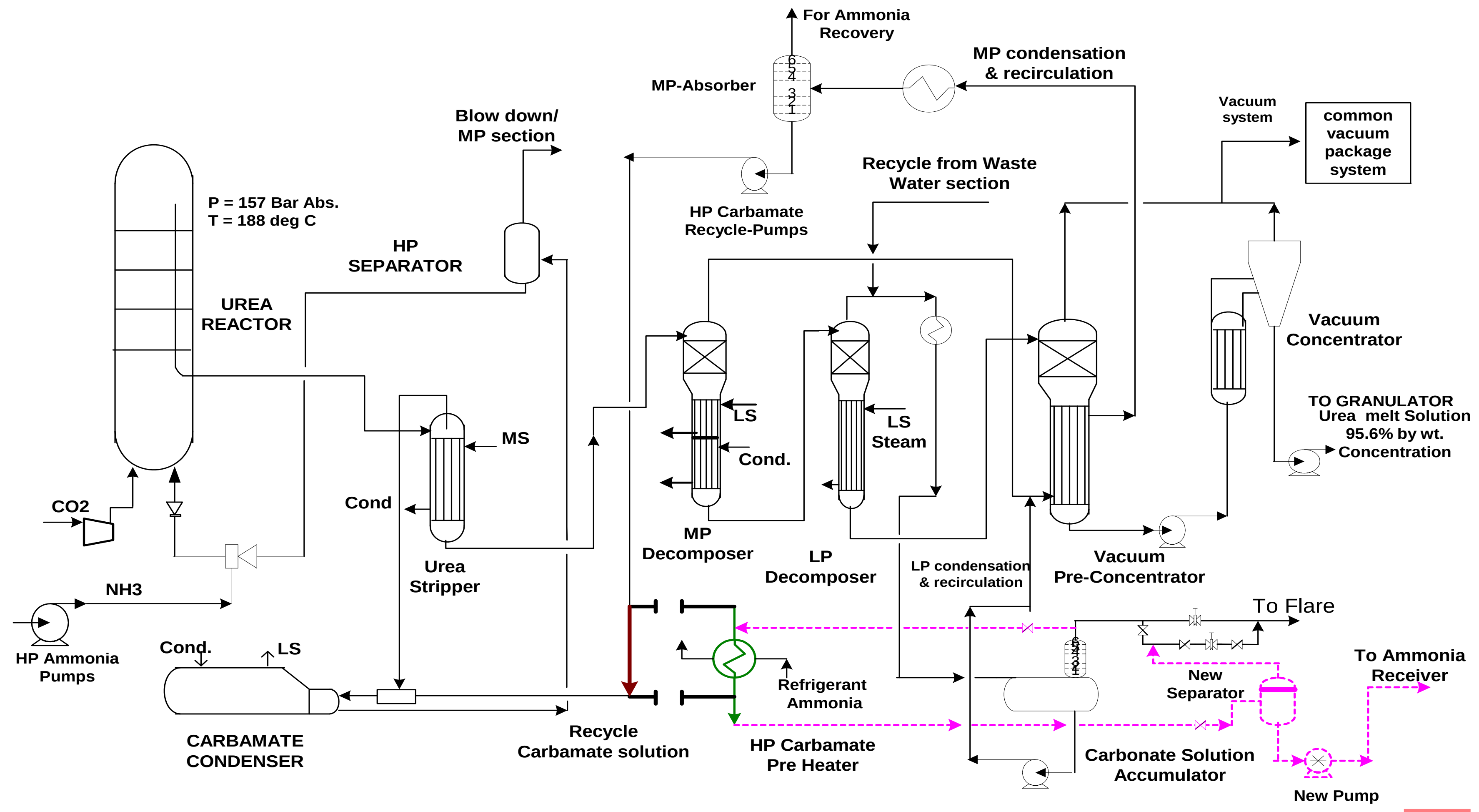

UREA PLANT PROCESS SCHEMATIC DRAWING

INITIAL PERFORMANCE:

In 2005 OMIFCO plants achieved all the process guarantees in:

- Plant capacity & Product Quality
- Environmental parameters
- Specific Ammonia consumption for Urea
- Specific Energy Consumption

- After overcoming initial teething problems gradually OMIFCO went on to improve the capacity utilization and on stream days from 2007 onwards.

- Plants consistently achieved capacity utilization at around 118 % to 120 % and the overall performance has been quite satisfactory with high on stream factor.

DESCRIPTION OF THE PROBLEM FACED:

- Higher Ammonia vapor losses (more than design) noticed from the LP section inert gases vent connected to the flare stack.
- Around 1400 to 1600 KGS/hr of Ammonia rich inert gases were being flared on continuous basis.
- Resulted in increased Ammonia Specific consumption for Urea. Also increased NOX emissions through the flare stack.

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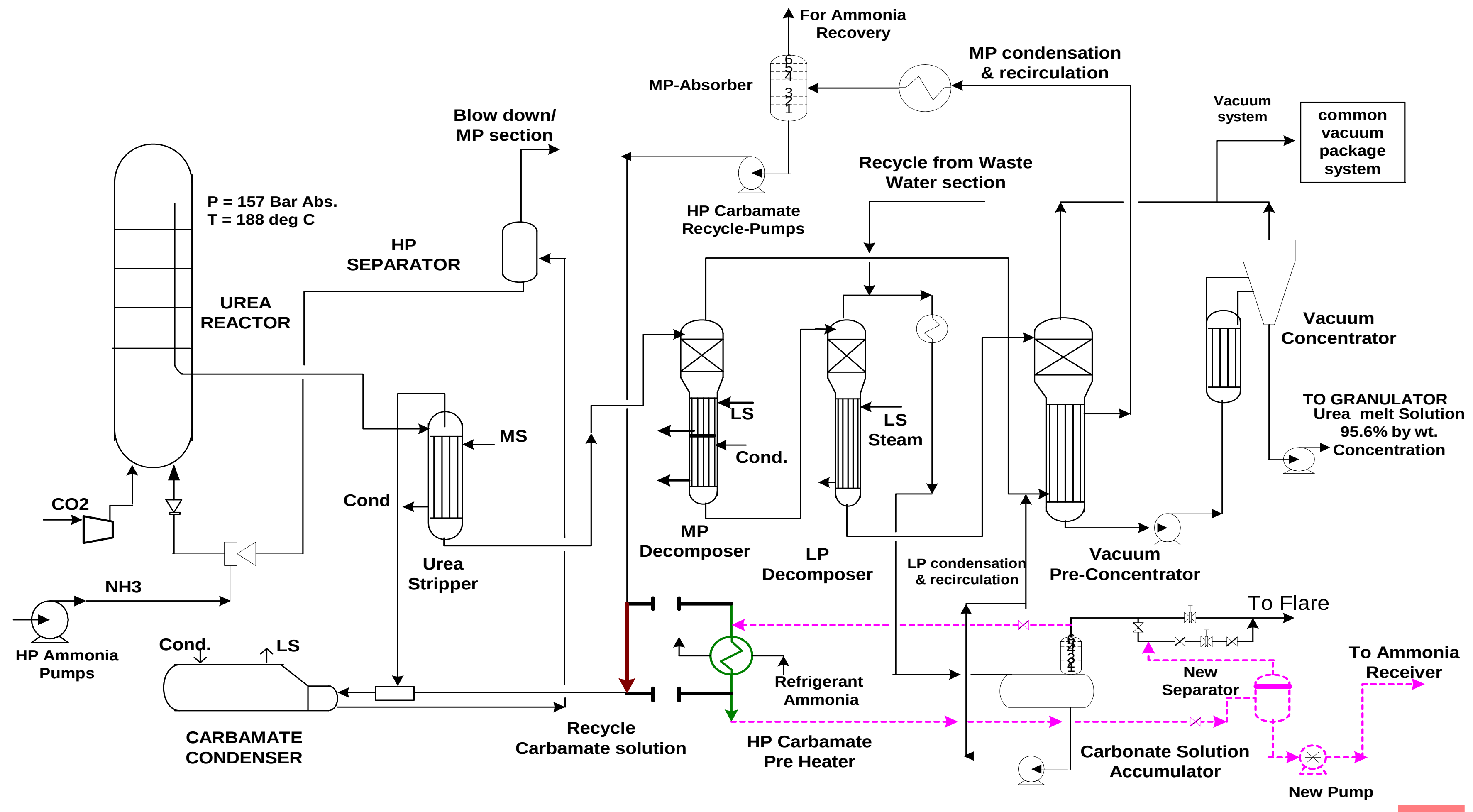

UREA PLANT PROCESS SCHEMATIC DRAWING

REASONS FOR HIGH AMMONIA LOSSES:

A) Urea Plants operation at higher loads:

Urea plants are operated at around 118% to 120% of the design capacity consistently.

B) Less Process Cooling Water:

Due to frequent leakages in the underground RTRP (Reinforced Thermal Resin Pipe) Cooling water headers the header pressure is kept on lower side than design and this resulted in less supply of cooling water flows to Urea plants.

REASONS FOR HIGH AMMONIA LOSSES:

C) No water addition to the scrubbing tower:

- Design envisaged 715 KGS/hr of LP condensate usage as scrubbing medium in the inert gases wash tower installed above the carbonate solution accumulator for scrubbing of ammonia from the inert gases stream before flaring.
- Addition of external water is not conducive for the Urea synthesis operations and reduces CO2 conversion.
- The plant load was getting restricted.
- For this reason OMIFCO had stopped LP condensate addition and taken advantage of higher load operation.

INITIAL OPTIMIZATION EFFORTS IMPLEMENTED

INITIAL OPTIMIZATION EFFORTS IMPLEMENTED:

1) Installation of split range operated control valves:

- As per the original plant design 6 Inch pressure control valve provided for maintaining the Carbonate accumulator overhead pressure.
- This control valve was primarily provided for quick release of vapors in case of any process upset condition.
- For maintaining a small flow of 1000 to 1500 NM3/hr of inert gases to flare stack this 6 Inch control valve was proving to be big in size and causing more losses of Ammonia.

INITIAL OPTIMIZATION EFFORTS IMPLEMENTED:

1) Installation of split range operated control valves:

- ❖ A split range controller was installed to operate the exiting high capacity valve and a newly installed small capacity 2 Inch control valve for close control of the Ammonia rich inert gases flow.
- ❖ This change helped to reduce the losses associated with the mismatch of the control valve size.
- ❖ But the Ammonia losses remained still on higher side and were a matter of concern.

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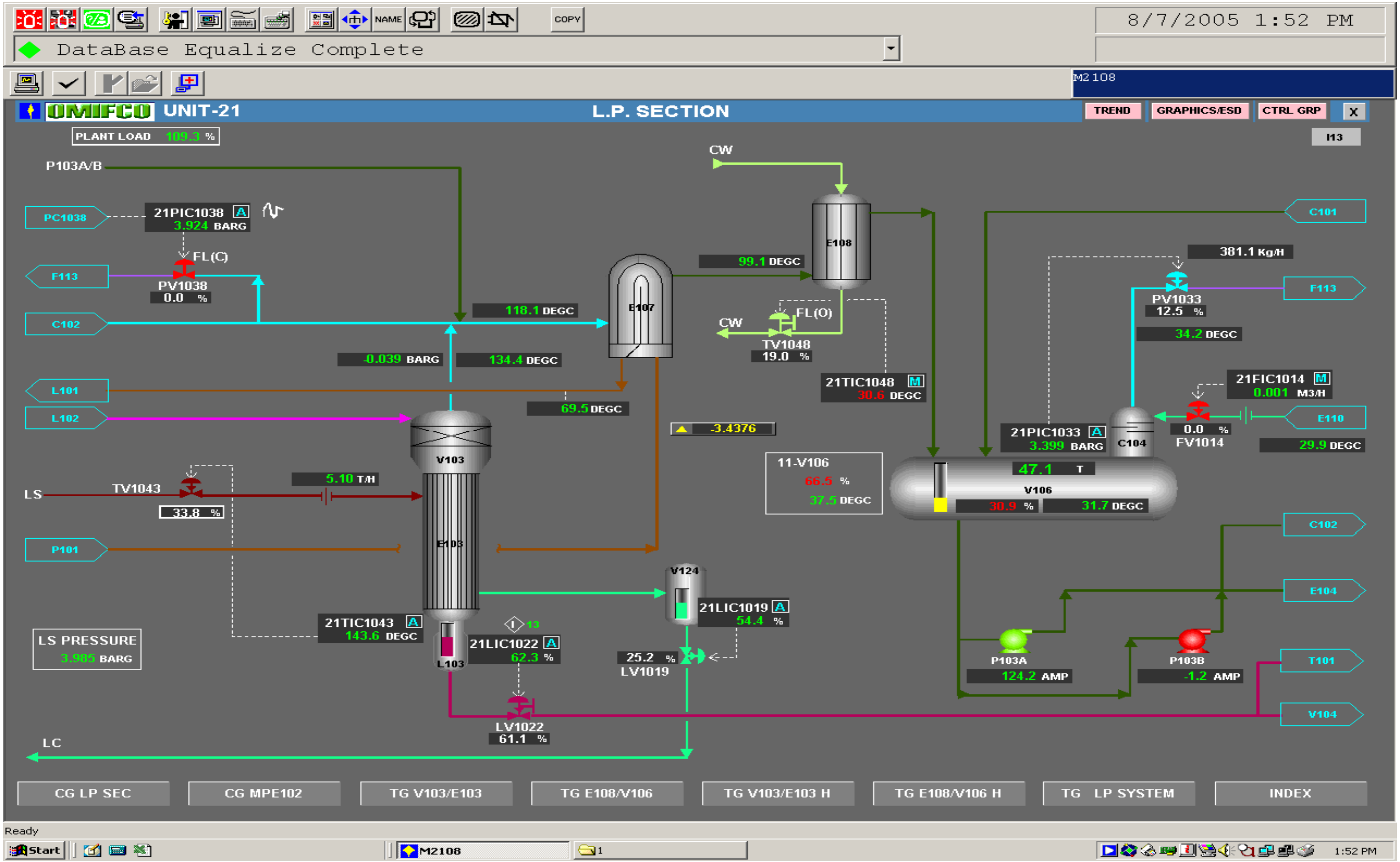

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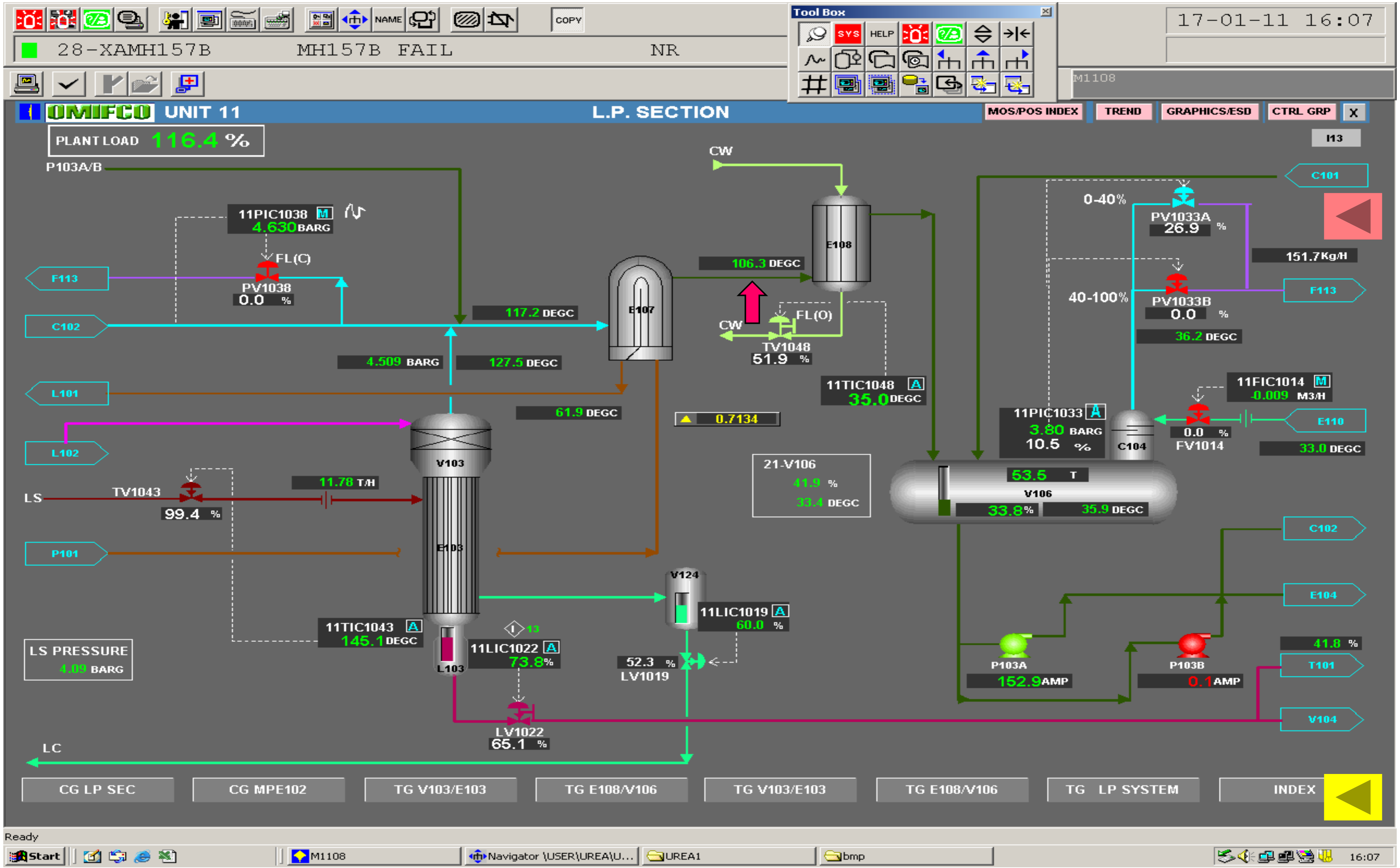

INITIAL OPTIMIZATION EFFORTS IMPLEMENTED:

2) **Addition of condensate at up stream of LP condenser:**

- Another optimization effort by adding the LW condensate at the upstream of LP condenser was implemented to see the impact.
- The vent losses reduced considerably (Vent valve opening reduced from 13.3% to 3.2%)
- But the average plant load reduced by 1% and the Steam consumption went up by 1 to 1.5 tons.
- The external water added to the system was impacting the Urea HP loop performance and thus load was getting reduced.

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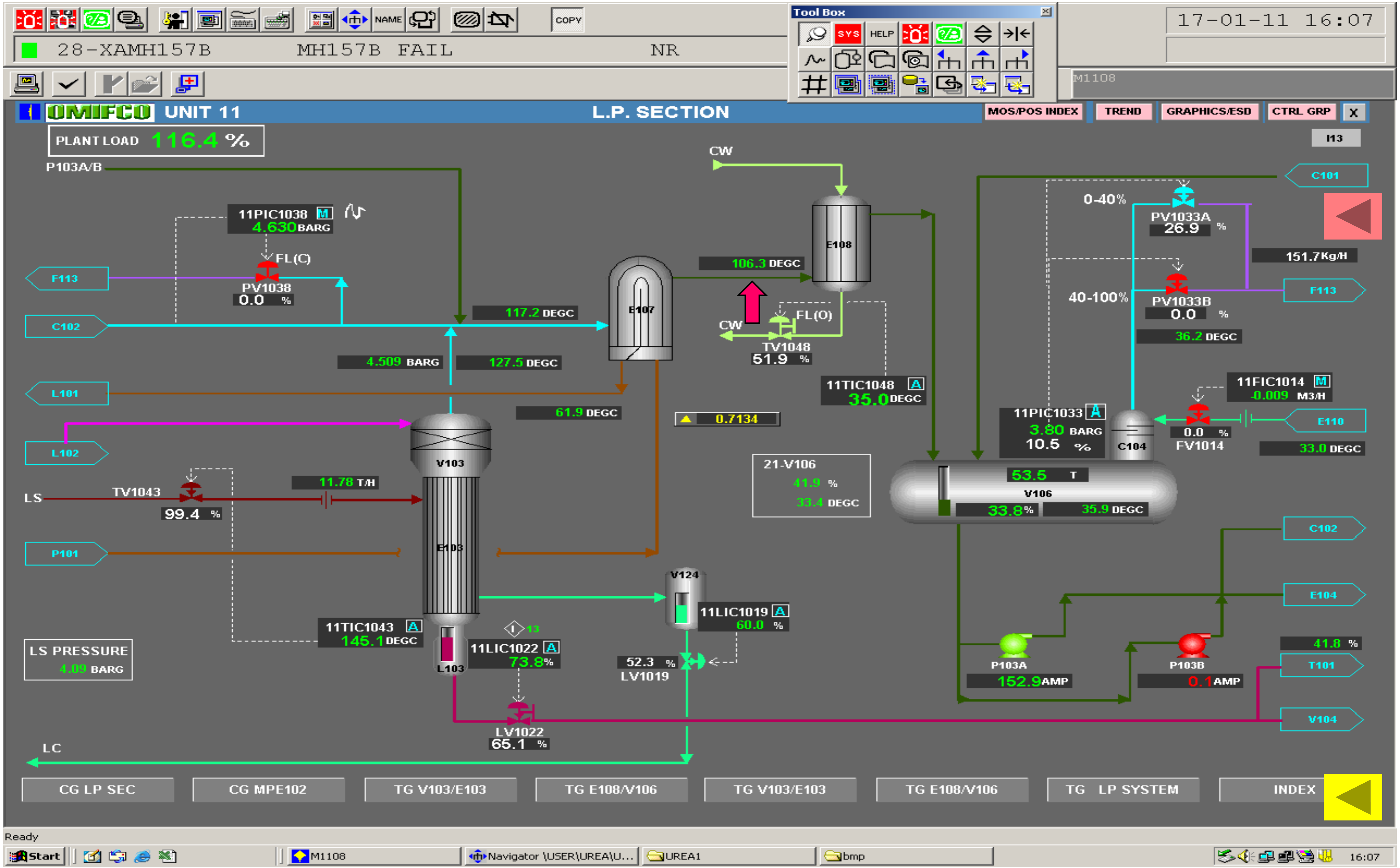

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES:

1) CHILLED WATER SYSTEM FOR MORE AMMONIA SCRUBBING:

- Chilled water (5 Deg.C) could be produced by installing Lithium Bromide based Vapor Absorption system, which consumes low pressure steam.
- Chilled water could replace the 45 Deg.C LW condensate facility provided for scrubbing the Ammonia from the LP vent inert gases.
- This option was examined as surplus LP steam was available in the OMIFCO complex. This chilled water scrubbing method would reduce the Ammonia losses significantly.
- But considering the disadvantage of external water entering into the Urea synthesis section this scheme was not pursued forward.

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES:

2) INSTALLATION OF SEPARATE AMMONIA SCRUBBER:

❖ A separate water scrubber was studied for recovering the Ammonia from the LP vent inert gases.

❖ The Ammoniacal solution from the scrubber would be sent to the Ammonia distillation column of the HRU for Ammonia recovery.

❖ Based on the current operated load the distillation column of HRU doesn't have sufficient margin to take additional feed and calls for extensive internal changes.

❖ And hence this option was not studied further.

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES:

3) INSTALLATION OF FALLING FILM TYPE HEAT EXCHANGER:

❖ In some Urea plants LP section vent vapors are scrubbed by cold condensate and then cooled through a falling film type vertical heat exchanger located at the top of the Carbonate Accumulator.

❖ This exchanger removes the heat of dissolution of Ammonia and lowers the Carbonate solution temperature in the accumulator and reduces the losses.

❖ This requires addition of new equipment and with associated changes this has significant cost. OMIFCO decided to evaluate this feature during planned Urea plant revamp.

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES:

4) DIVERTING THE LP VENT GASES TO THE SUCTION OF AMMONIA COMPRESSOR IN THE AMMONIA PLANT:

- ❖ The inert gases would be diverted to the suction of the Ammonia compressor located in the Ammonia plants through micro filtering arrangement.

- ❖ This was found feasible as the inert gases relieving control valve of Ammonia plant refrigeration system has margin to relieve more inert gases.

- ❖ But considering the risk of exposing Ammonia plant equipment to CO_2 and the carbonate formation possibilities during the Urea plant up set scenario, this option was not considered for implementation.

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES:

5) USING AMMONIA REFRIGERATION COMPRESSOR OF GRANULATION UNIT:

- New Ammonia chiller will be installed for recovering the Ammonia from the LP vent gases.
- This chiller shall be integrated with the Ammonia compressor of the Air chilling unit of the Urea Granulation section.
- The compressor minimum operated inter-stage pressure is at 4.0 Bar Abs (@ saturation temp. of -2.1 Deg. C only).

OPTIONS STUDIED FOR REDUCING THE AMMONIA LOSSES:

5) USING AMMONIA REFRIGERATION COMPRESSOR OF GRANULATION UNIT:

- Available stage pressure and saturation temperature restrict the new Ammonia chiller operation up to -2.1 Deg. C only.

- The available approach temp.(LMTD) for Ammonia condensing would be much less compared to a low pressure operated chiller. (@ 1.3 to 1.7 Bar Abs. pressure with a saturation temp. of about -23.0 Deg. C.)

- Due to this lower available LMTD other options for a low pressure Ammonia chiller were explored.

IMPLEMENTED SCHEME AS A FINAL SOLUTION

IMPLEMENTED SCHEME AS A FINAL SOLUTION:

- After examining various options Ammonia chiller usage was found to be more effective from efficiency and process safety point of view.
- Incidentally OMIFCO had two abandoned H. P. Carbonate Pre-heaters (DEU type Heat Exchangers) resting idle in Urea Plants.
- In both Urea plants H. P. Carbonate Pre-heater E-113 channel cover had leaked frequently during the initial two years of operation and had forced unexpected plant shutdowns.
- Subsequently they were taken out of service and kept in isolated condition. As LP steam had been surplus in Urea plants this decision was taken without any disadvantage to the site.

IMPLEMENTED SCHEME AS A FINAL SOLUTION:

- ❖ The available redundant E-113 also had transpired to work in the direction of the Ammonia chiller option.
- ❖ Simulation study indicated that it would meet the requirements of new process conditions and the surface area with requisite pressure drop profile.
- ❖ The provided material of construction for shell SS-304 and for tubes & channel SS-316 L were found to be suitable for the new conditions.
- ❖ Using this DEU type exchanger a scheme was developed for condensing the Ammonia vapors to facilitate their recovery from the inert gases stream.

IMPLEMENTED SCHEME AS A FINAL SOLUTION:

To facilitate the Ammonia recovery from the inert gases the following list of Equipment are Installed:

A) Two motor driven plunger pumps. (1+1).
B) One Ammonia Liquid Knock out Separator.
C) Three control valves.
D) Piping & Fittings as per requirement.
E) Redundant (E-113) heat exchangers (2nos) each of 158 M2 Surface.

IMPLEMENTED SCHEME AS A FINAL SOLUTION:

❖ The LP section vent gases of about 1400 to 1600 Kgs/hr flow (@ 3.9 Bar G & 36 Deg. C) are passed through the tube side of the Ammonia chiller.

❖ Refrigerant Ammonia drawn from the warm Ammonia header of the Urea plant is introduced on the shell side of the chiller.

❖ The condensed liquid Ammonia from the tube side is separated in a knock out separator and the balance non condensable gases are sent to the flare stack.

❖ From the knock out separator the liquid Ammonia is pumped (@19 Bar G & -8.7 Deg. C) to the Ammonia receiver of Urea plant located in the MP section.

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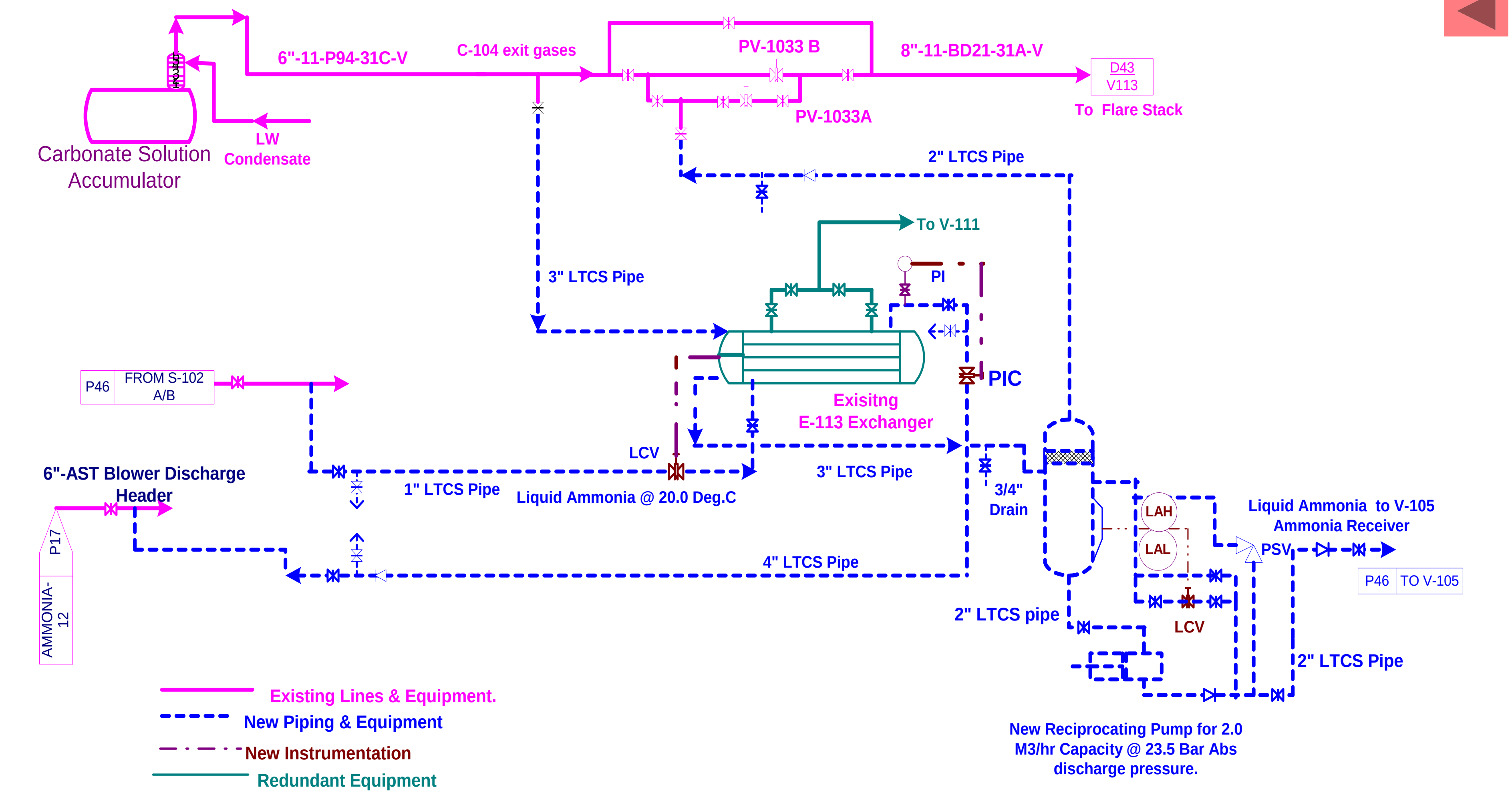

AMMONIA RECOVERY FROM LP VENT GASES IN UREA PLANT
CONCEPTUAL DIAGRAM

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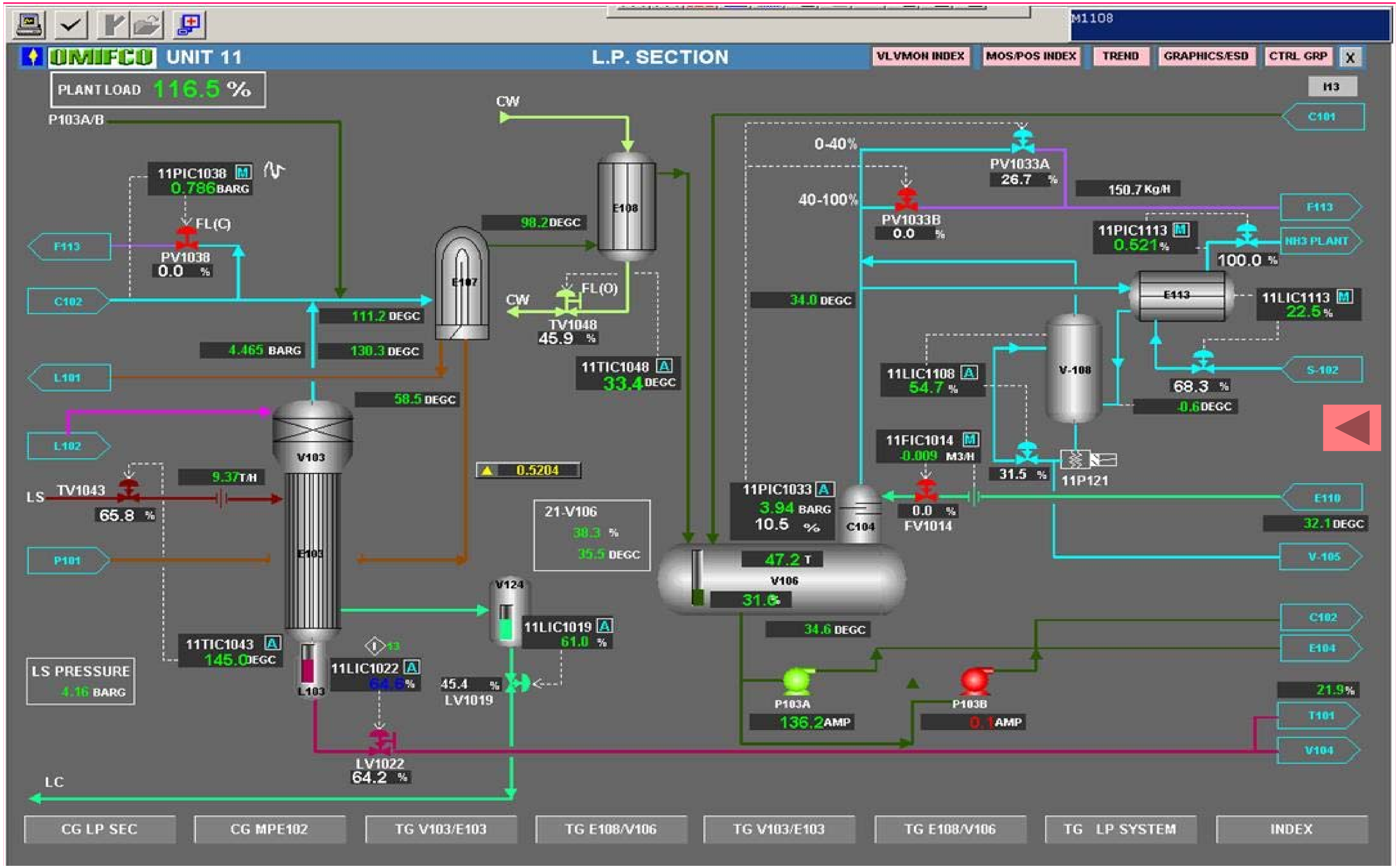

IMPLEMENTED SCHEME AS A FINAL SOLUTION:

- The refrigerant vapors generated from the Ammonia chiller (E-113) are sent to Ammonia plant's Ammonia Booster compressors common suction drum which operates at 0.03 Bar G Pressure.

- Ammonia vapors exit E-113 exchanger are connected to the existing 8 Inch size Ammonia Storage Blower discharge header at the common pipe rack nearer to the Urea plant Battery limits.

- This option helped to save around 300 meters of Process piping for two Urea plants

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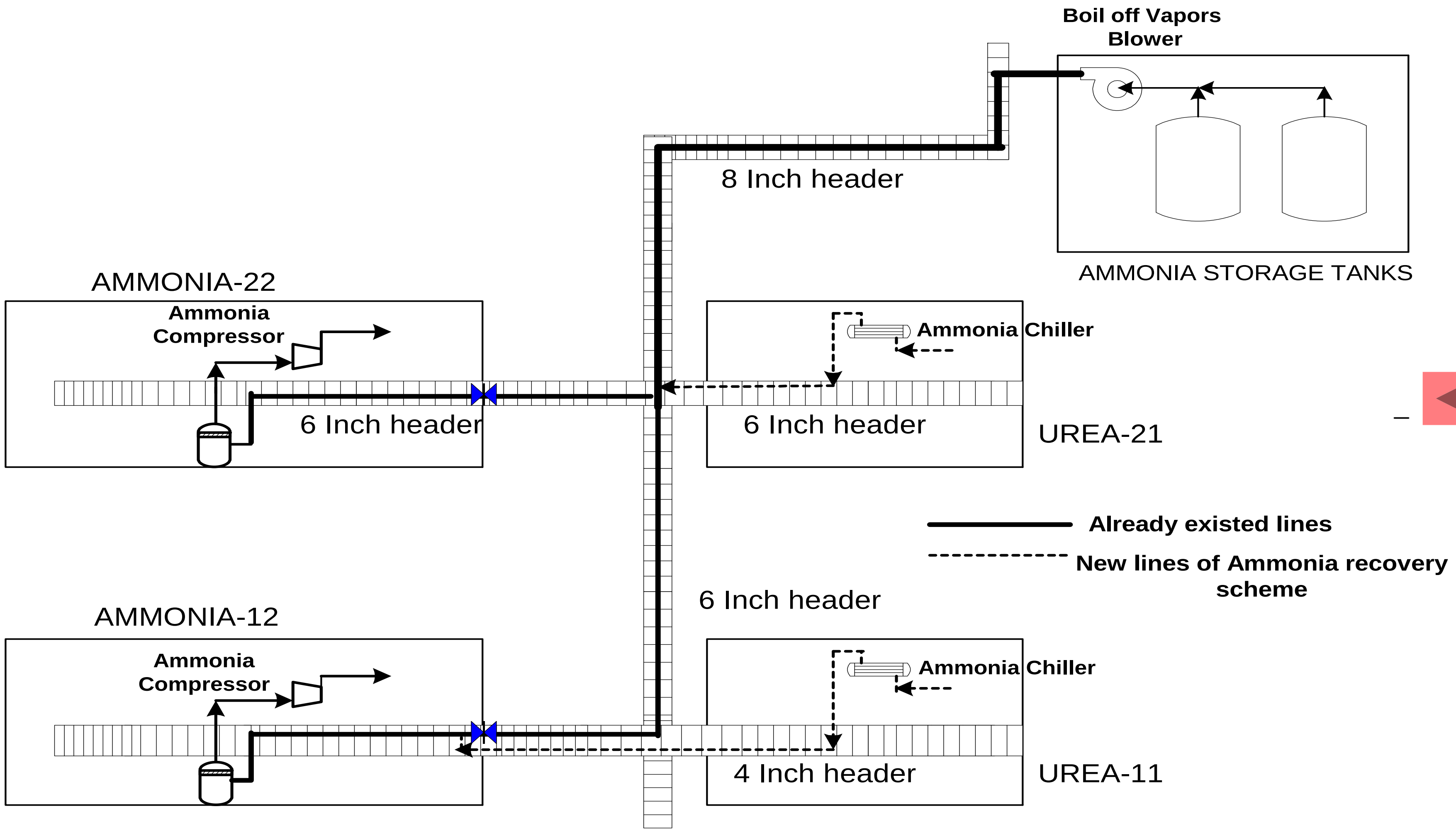

PLANT PIPING INTERCONNECTIONS AFTER THE AMMONIA RECOVERY SCHEME IMPLEMENTATION

IMPLEMENTED SCHEME AS A FINAL SOLUTION:

❖ This had been possible due to the available margins in the Ammonia Storage vapors transfer blower discharge pressure and the existing pressure drop profile in the interconnecting piping.

❖ The quantity of Ammonia condensed and recovered through the newly established Ammonia recovery system was verified by measuring the volume of Ammonia accumulated in the knock out separator.

❖ The volume measurement was done first by reducing the level to the minimum tractable level reading of K.O. separator and then the Ammonia transfer pump was stopped to let the level accumulate in the separator.

❖ Based on the time taken for the K. O. Separator volume build up the Ammonia recovered quantity has been established.

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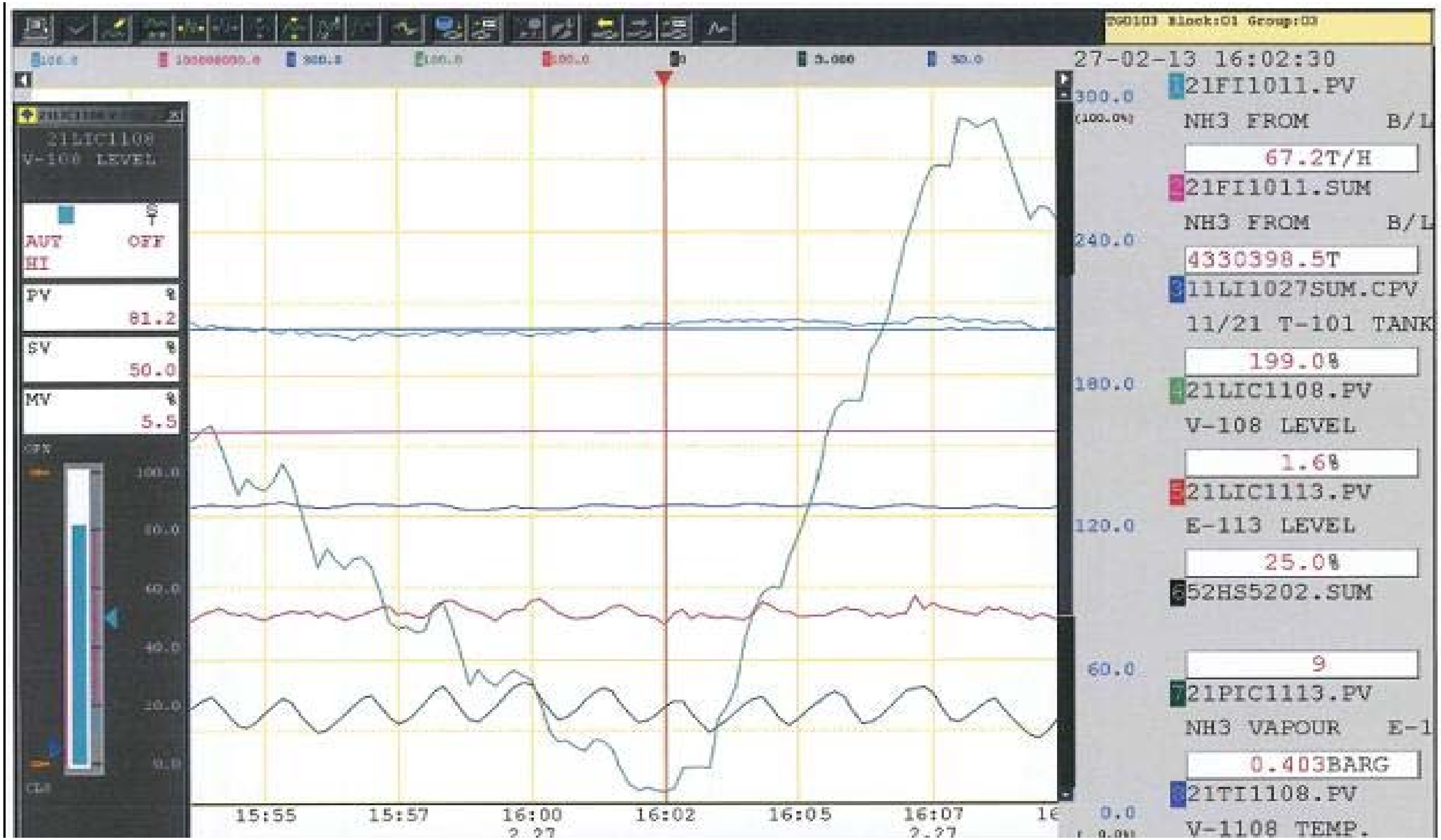
Time & Level readings at Ammonia pump stoppage. (@ Min. Level of Separator)



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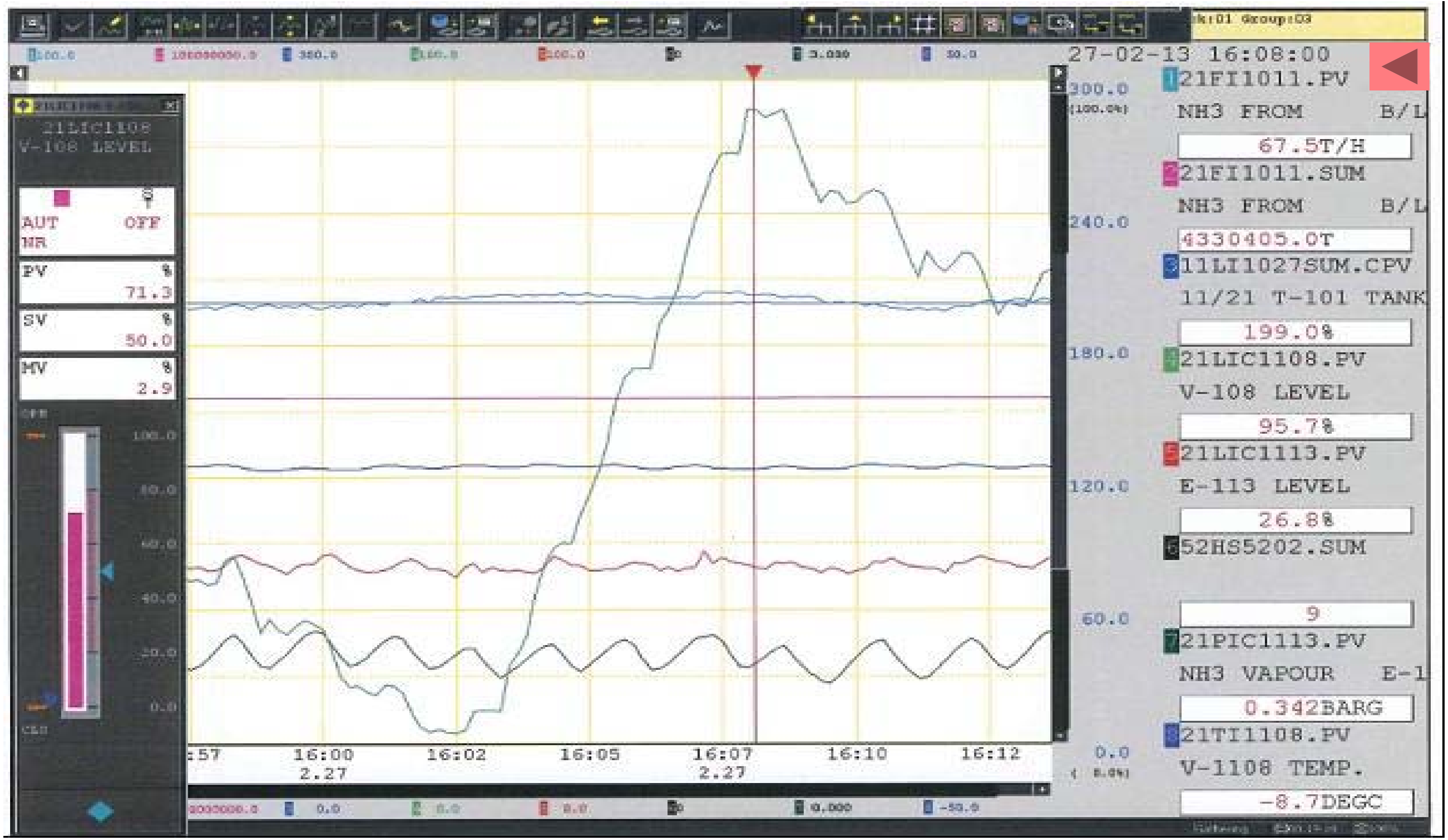
Time & Level readings at Ammonia pump Restart. (@ Max. Level of Separator)



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COST AND BENEFITS:

- Existing redundant HP Carbonate Pre-heaters (E-113) are used in a new role.
- Additional 0.32 million USD spent to establish associated facilities.
- 55 MTPD of Ammonia recovered from both the Urea plants. This increased Urea production by 96 MTPD.
- Ammonia flaring reduced & equivalent NOx generation reduced.
- Overall 4041 KGS/hr of NO generation reduced.
- Urea Sp. energy reduced by 0.065 Gcal/MT.

COST AND BENEFITS:

- ❖ Apart from the economic considerations, the Ammonia recovered indirectly saved the quantum of fuel that would have been spent on producing the equivalent Ammonia.
- ❖ The fuel saved had reduced equivalent of GHG emissions.
- ❖ Cold Ammonia added to Ammonia receiver has improved the performance of the HP Ammonia feed pumps.
- ❖ Pay Back of the scheme is achieved in less than a quarter year.

CONCLUSION:

- Even the best designed new generation plants with the latest process features do provide opportunities for further optimization for improving the performance.

- Depending on the site specific operated conditions the end user can explore more objectively and devise new criteria for harnessing the synergies of the state of art as built systems and equipment.

CONCLUSION:

- OMIFCO isolated the problematic HP carbonate pre-heaters based on the site specific conditions and solved the problem of frequent shutdowns and saved the water lost through the LP steam venting.

- The same redundant Carbonate pre-heaters have been reused in a new role to derive the benefits out of it and to solve another existing problem in an effective manner.

THANKS FOR YOUR KIND ATTENTION

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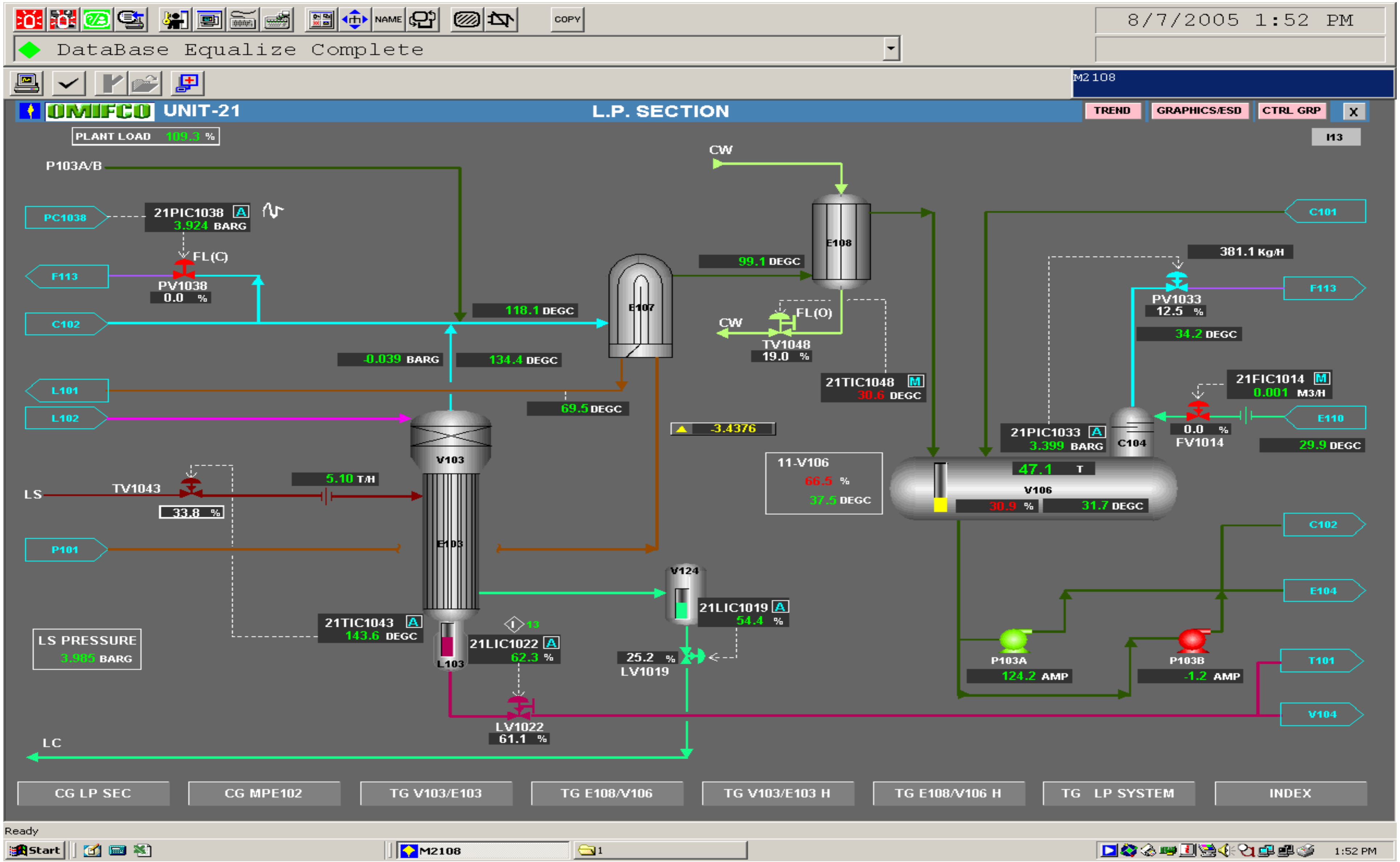

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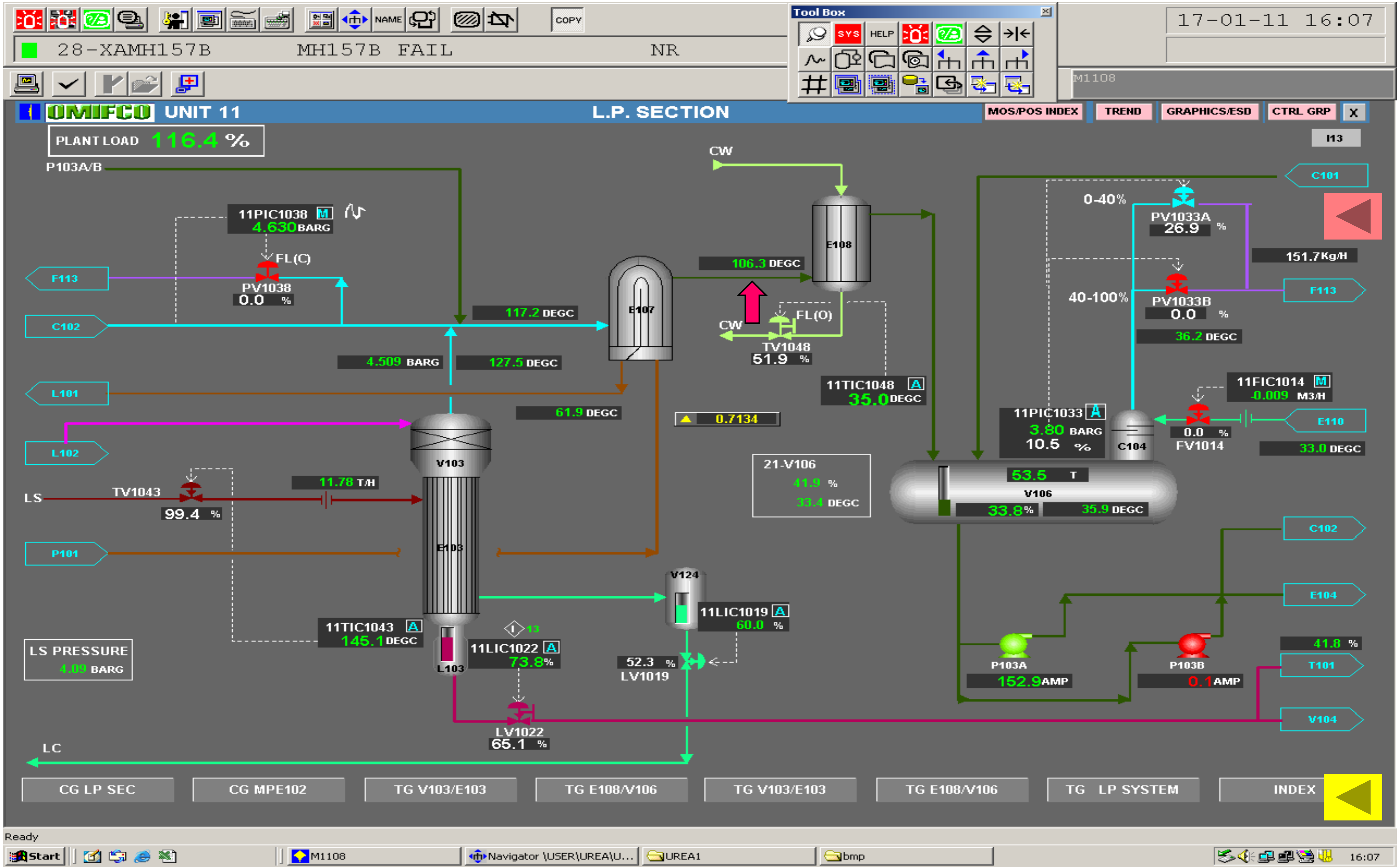

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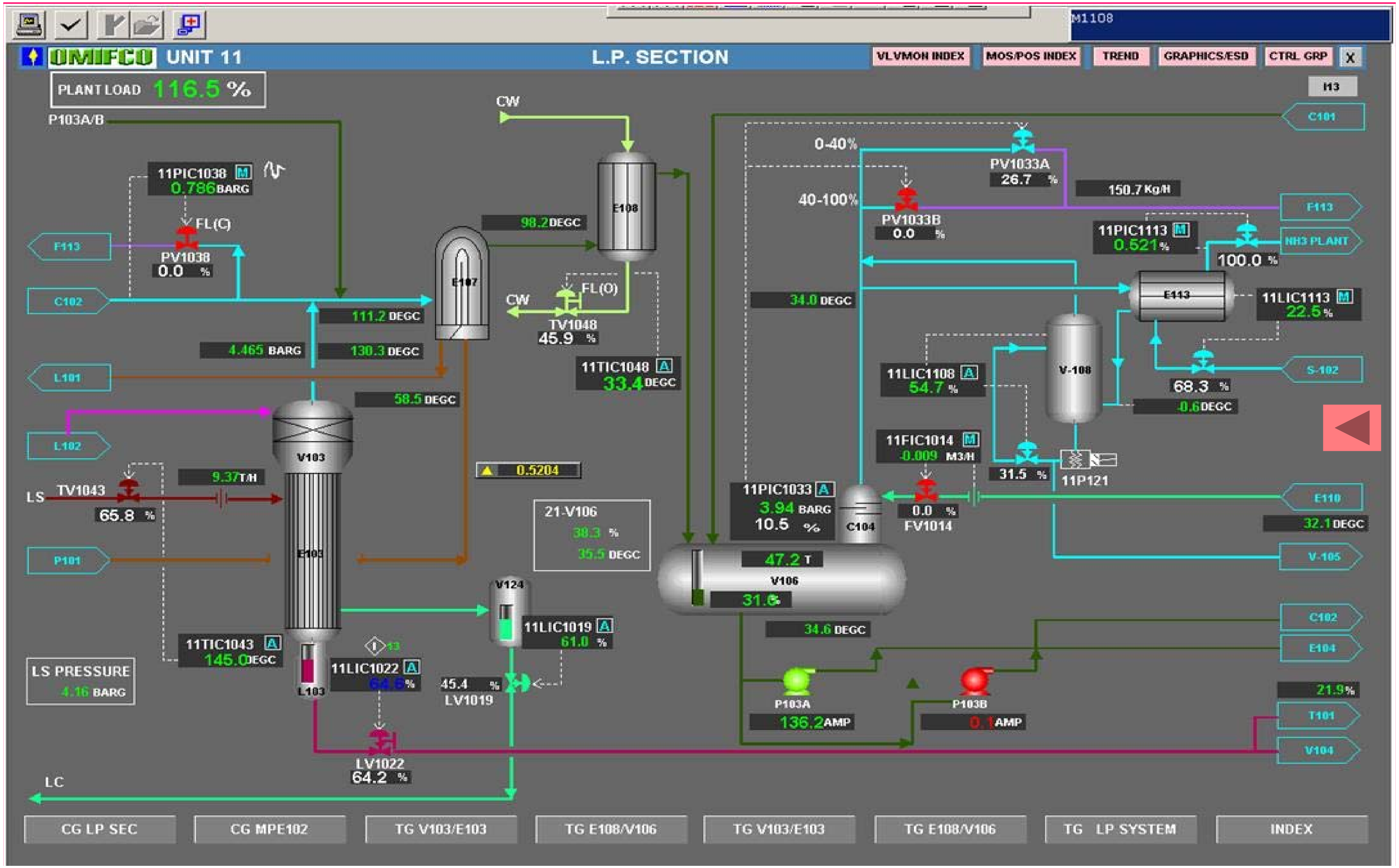

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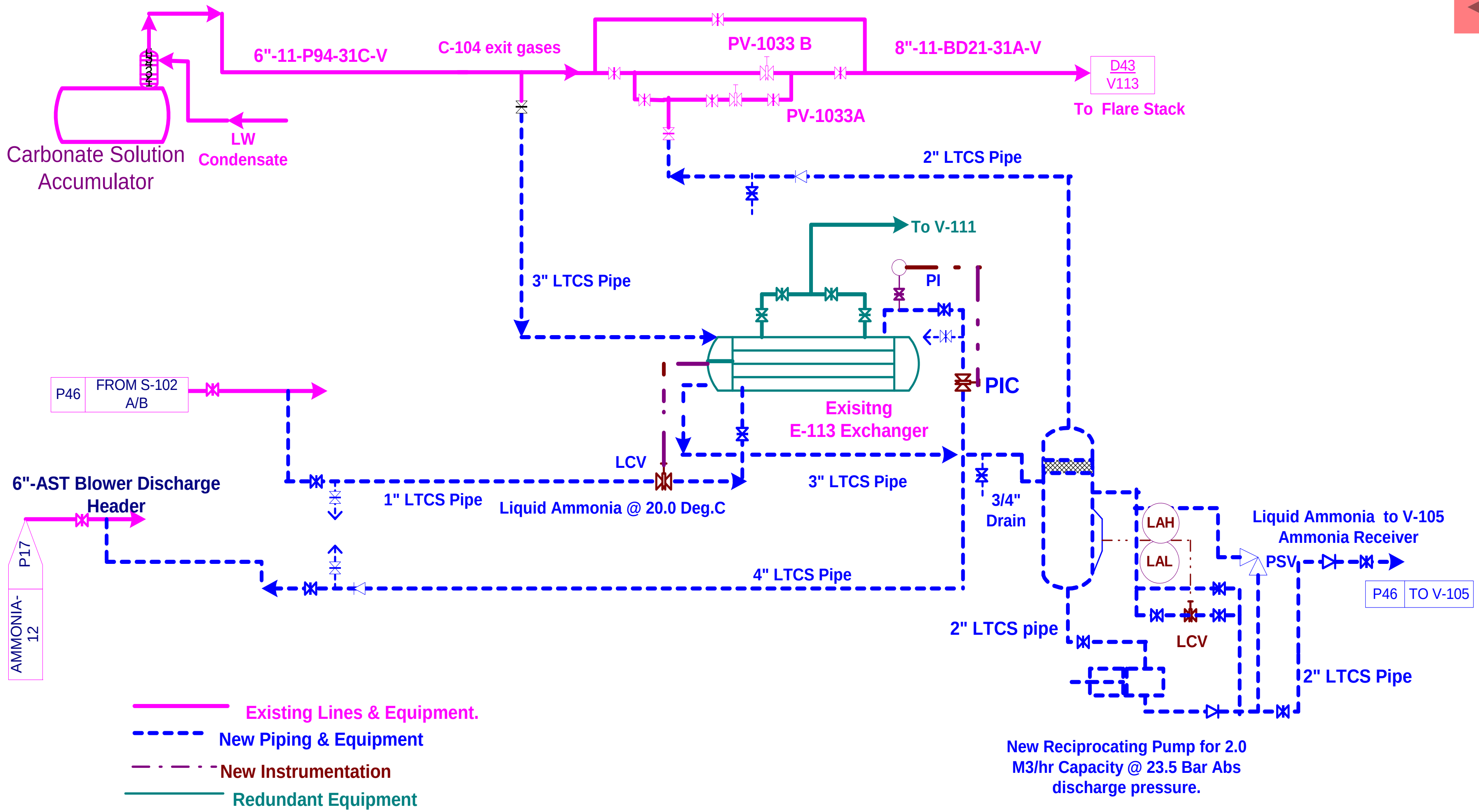

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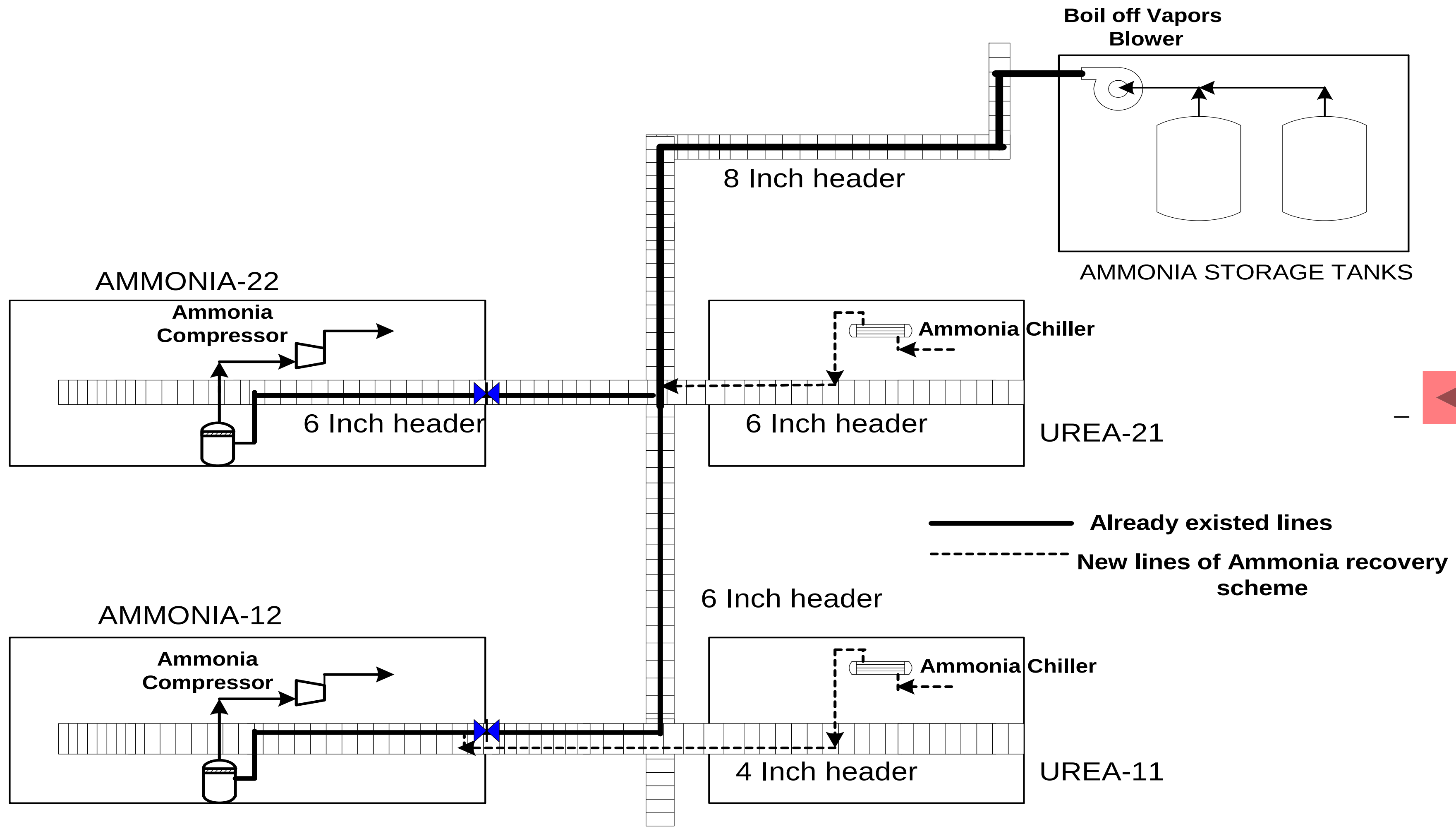

PLANT PIPING INTERCONNECTIONS AFTER THE AMMONIA RECOVERY SCHEME IMPLEMENTATION

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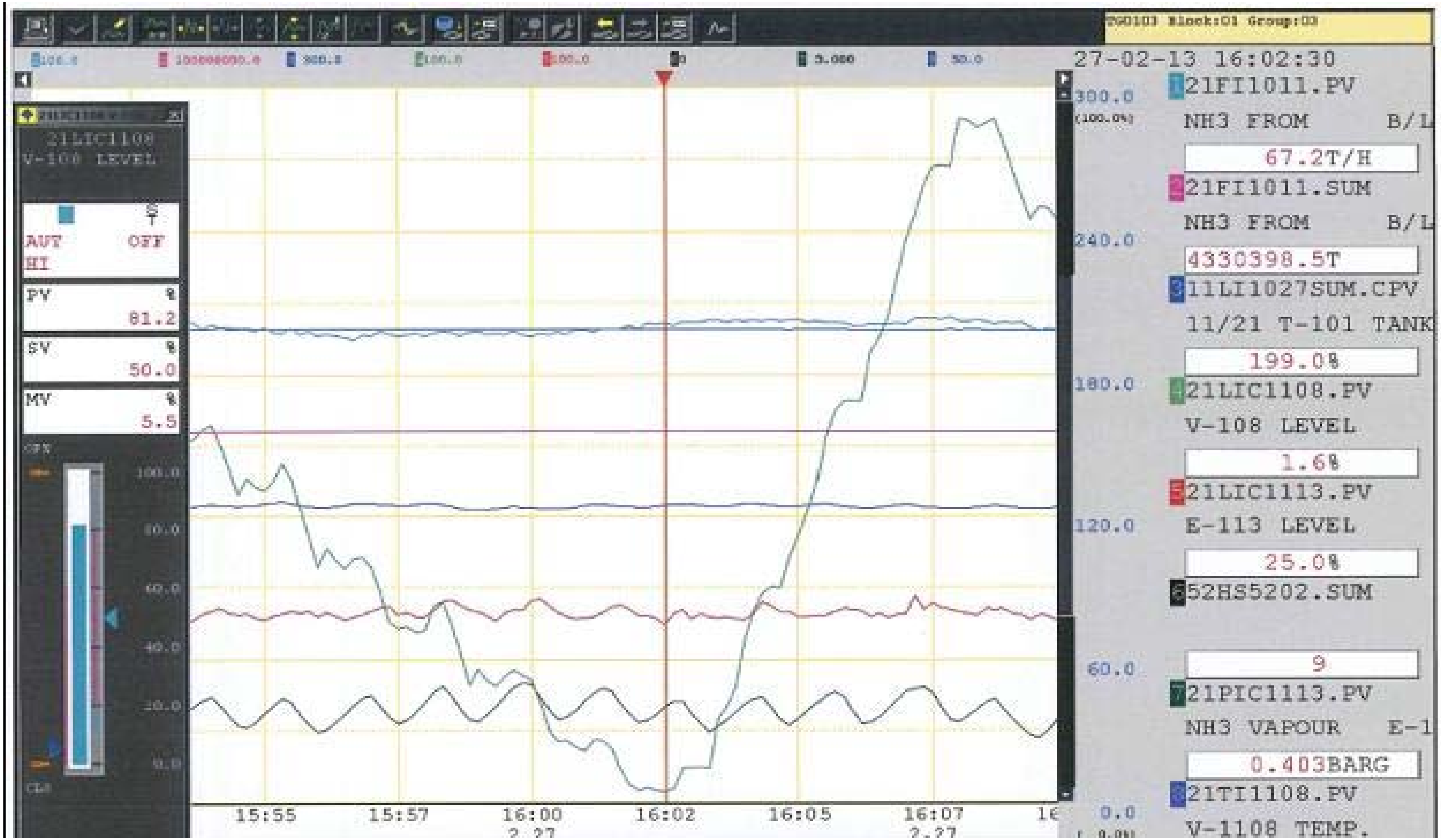
Time & Level readings at Ammonia pump stoppage. (@ Min. Level of Separator)



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Time & Level readings at Ammonia pump Restart. (@ Max. Level of Separator)