तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान

Institute of Oil and Gas Production Technology

पनवेल, नवी मुंबई

Panvel, Navi Mumbai

Project Report

on

पुंडी ईपीएस में गैस कम्प्रेशन, जीडीयू और डीपीडी की आवश्यकता के लिए अध्ययन

Study for Requirement of Gas Compression, GDU and DPD at Pundi EPS

दिसंबर – 2022

तेल एवं गैस उत्पादन प्रौद्योगिकी संस्थान
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विषय: पुंडी ईपीएस में गैस कम्प्रेशन, जीडीयू और डीपीडी की आवश्यकता के लिए अध्ययन

Subject: Study for Requirement of Gas Compression, GDU and DPD at Pundi EPS

" पुंडी ईपीएस में गैस कम्प्रेशन, जीडीयू और डीपीडी की आवश्यकता के लिए अध्ययन " रिपोर्ट की प्रति आपके अवलोकनार्थ संलग्न है।

Please find enclosed a copy of the report on "Study for Requirement of Gas Compression, GDU and DPD at Pundi EPS" for your kind perusal.

नितिन बी. जोशी
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Study for Requirement of Gas Compression, GDU and DPD at Pundi EPS

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Executive Summary

This pertains to the project titled "**Study for Requirement of Gas Compression, GDU and DPD at Pundi EPS**" taken up by IOGPT as an unscheduled project under AWP 2022-23.

Pundi EPS of Cauvery Asset is presently producing around 236 m^3/d of oil, 28 m^3/d of water and 32000 SCMD of gas. Due to absence of local consumers, Asset desires to evacuate the produced gas from Pundi EPS to Nannilam EPS for sales through 4" x 28 km pipeline and supply to GAIL Grid. The available pressure at Pundi EPS is around 1-3 kg/cm^2g and required pressure at Nannilam EPS is around 12-15 kg/cm^2g. Asset requested IOGPT to conceptualize the requirement of facility to supply gas as per PNGRB guidelines.

Simulation study has been carried out in PIPESIM and Aspen HYSYS process simulator. Study indicates that for transportation of peak gas rate, the required pressure at Pundi EPS will be around 23.5 kg/cm^2g. Hence the compression facility will be required. Further, simulation study in Aspen HYSYS indicates that GDU & DPD system are also required to avoid the condensation in the pipeline and to meet the desired PNGRB specifications.

The scheme for compression system, GDU and DPD system has been conceptualized. The study concludes the following:

- Reciprocating type gas compressors will be required to boost the pressure to around 25 kg/cm^2g.
- Two scheme for GDU & DPD have been conceptualized

  Scheme-A: Molecular sieve based GDU & Refrigerant based DPD

  Scheme-B: Refrigerant based GDU & DPD system with MEG injection to avoid hydrate formation

Ballpark cost estimates reveals that, CPEX and OPEX of Scheme-A are Rs. 7.72 crores and 1.08 crores per annum respectively and those of Scheme-B are Rs. 6.92 crores and 0.77 crores per annum respectively. Hence Scheme-B with reciprocating compressor system is recommended at Pundi EPS. However, Asset has already been using hired facilities for Narimanam, Tiruvarur, Adiakamangalam, Kamalapuram, Nannilam, Kuthalam, Kovilkalappal and Ramnad. Accordingly, Asset may take a decision on the basis of overall cost economics between owned and hired facilities and local factors.

Details of the study have been elaborated in the report.

Rajiv-Nischal

Rajiv Nischal
GGM-HOI IOGPT

Contents

1.0 Background

Cauvery Asset desires to evacuate the produced gas from Pundi EPS to Nannilam EPS for sales. Asset has informed that 4" x 28 km pipeline is laid from Pundi to Nannilam. The Available gas pressure at Pundi EPS is around 1-3 kg/cm^{2}g and the required pressure at Nannilam EPS is around 12-15 kg/cm^{2}g. Asset desires to install gas compressors at Pundi EPS in order to compress and evacuate the gas. This gas contains heavier hydrocarbons and is saturated with water. During transportation, condensation may take place in the pipeline which may cause damage to the pipeline. Hence, Asset desires to check the requirement of Gas Dehydration Unit (GDU) and Hydrocarbon Dew point Depression Unit (DPD) system at Pundi EPS.

Accordingly, requirement of gas compressors, gas dehydration and hydrocarbon dew point depressant at Pundi EPS has been envisaged in this study.

2.0 Scope of Work

- Simulation Study
- Scheme Conceptualisation

3.0 Basis of study

The inputs provided by the Asset are listed below:

3.1 Gas production profile of Pundi EPS

Table 3.1: Gas Production Profile		
Year	**Scenario-I: Total Gas, SCMD**	**Scenario-II: Total Gas, SCMD**
	BS-05+ Basement: BAU	BAU + 2 Released Loc. of Basement
2022-23	39987	39987
2023-24	36601	44354
2024-25	36761	53364
2025-26	42242	57365
2026-27	37578	50839
2027-28	30454	41714
2028-29	18831	28064
2029-30	10938	18938
2030-31	9078	15461
2031-32	7768	12809
2032-33	6592	10647
2033-34	5968	9421
2034-35	4800	7458

Asset has suggested to consider Scenario-I gas profile of for the study. For compressor system Asset has further suggested the following:

- Maximum quantity of gas to be compressed: 35,000 SCMD
- Minimum quantity of gas to be compressed: 16,000 SCMD

Also the Asset desires simulation results for the present production rate of 32000 SCMD.

The detailed production profile and mail received from the Asset are attached at Annexure-I.

3.2 Gas composition analysis of Pundi EPS

Table 3.2: Gas composition analysis	
Methane	53.380
Ethane	15.550
Propane	15.952
i-Butane	3.572
n-Butane	5.587
i-Pentane	1.424
n-Pentane	1.217
n-Hexane	1.080
n-Heptane	0.222
n-Octane	0.034
n-Nonane	0.0003
n-Decane	0.000
Carbon di-oxide	0.022
Nitrogen	1.957
Mol. Wt.	29.2
Cv (Net), Kcal/m^3	13842.24
Cv (Gross), Kcal/m^3	15147.219

The detailed gas composition is attached at Annexure-II.

3.3 Crude oil analysis is shown in Table 3.3.

Table 3.3: Crude oil analysis	
Volume %	Temperature, ^{0}C
IBP	48
10%	94
20%	115
30%	142
40%	163
50%	220
60%	282
70%	342
75%	360

3.4 Details of existing pipeline from Pundi to Nannilam: ID: 98.5 mm, Thickness: 7.9 mm, Length: 28 km

3.5 Separator operating pressure and temperature at Pundi: 2.5- 3 kg/cm^2g and 28-35 ^0C

3.6 Suction pressure and temperature of the compressor to be considered: 1-3 kg/cm^2g and 28-35 ^0C

3.7 Required arrival pressure at Nannilam end: 12-15 kg/cm^2g.

3.8 Air cooled exchangers are considered for inter-stage and discharge coolers in the compressor system. Temperature of air for air cooled exchangers: 45^0C.

3.9 Underground temperature (at 1 m depth): 25 ^0C

3.10 In simulation study, it is assumed that the gas is saturated with water at separator operating pressure and temperature.

3.11 The required water dew point and hydrocarbon dew point for gas sales is 0^0C at a pressure of 15 kg/cm^2g at the Nannilam EPS to adhere to PNGRB guidelines. However, keeping a margin in view of fluctuating operating conditions, the system has been designed for water dew point and hydrocarbon dew point of (-5) ^0C at a pressure of 15 kg/cm^2g.

3.12 In simulation study, a margin of 10% over the aerial distance has been considered in pipeline length to compensate for elevation and bends in the pipeline.

4.0 Process Description of Pundi EPS

Pundi EPS is having two processing trains and one test train. Well fluid is gathered in the HP header and routed to 1st stage separators of both the trains operating at a pressure of around 2.5 kg/cm^{2}g. The gas separated from 1st stage separator of both the trains is diverted to gas scrubber and further to sales. Presently it is flared due to non-availability of consumers. Liquid separated from 1st stage separator is routed to 2nd stage separators of respective trains which are operated at around 1.5 kg/cm^{2}g. Gas separated from 2nd stage separators is flared and separated liquid is stored in the storage tanks. One test train is also available at the Pundi EPS to test the wells. The schematic diagram is shown in Figure 4.1.

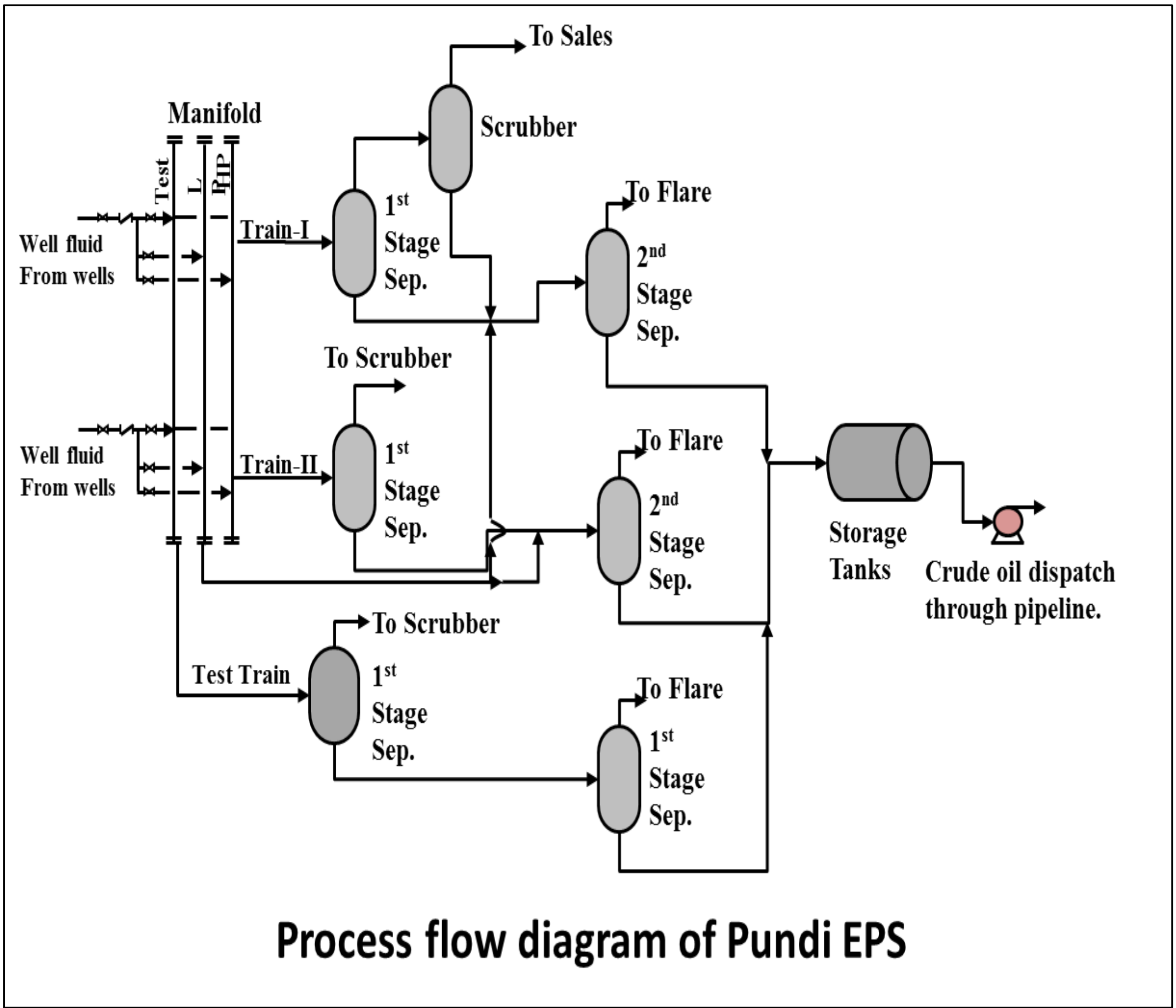

Figure 4.1: Schematic diagram of existing processing facility at Pundi EPS

5.0 Simulation Study and Scheme Conceptualisation

5.1 Simulation study for establishing back pressure at Pundi EPS

Simulation study was carried out in PIPESIM software to estimate the required pressure at Pundi-end for transportation of gas to Nannilam EPS through the existing 4" x 28 km pipeline. The results are tabulated in Table 5.1.

Table 5.1: Year-wise estimated back-pressure at Pundi

Year	Gas throughput, SCMD	Receiving Pressure at Nannilam EPS end, Kg/cm^{2}g	Back pressure at Pundi end, Kg/cm^{2}g
2022-23	39987	15	22.7
2023-24	36601		21.7
2024-25	36761		21.8
2025-26	**42242**		**23.4**
2026-27	37578		22.0
2027-28	30454		20.0
2028-29	18831		17.1
2029-30	10938		15.9
2030-31	9078		15.7
2031-32	7768		15.6
2032-33	6592		15.5
2033-34	5968		15.5
2034-35	4800		15.4

From Table 5.1 above, it is seen that the required pressure at the outlet battery limit of Pundi EPS will be around 25 kg/cm^{2}g for transporting the maximum available quantity of gas. However, Asset suggested that the maximum and minimum quantity of gas to be compressed will be around 35000 SCMD and 16000 SCMD respectively. Accordingly, the compressor system is considered with fallowing specifications:

- Compressors: 3 (2 operating + 1 stand-by): Reciprocating type with air-cooled inter-stage and discharge coolers.
- Capacity: 0.20 LSCMD each
- Suction Pressure: 1-2 kg/cm^{2}g
- Discharge Pressure: 25 kg/cm^{2}g (Pressure drop of 1-1.5 kg/cm^{2}g has been considered in GDU-DPD unit)

The compressors may be electrical motor driven or gas engine driven. Asset may like to select the type of compressor drive based on the field conditions.

5.2 Simulation study for establishing water and hydrocarbon dew point

Further simulation study has been carried out in Aspen HYSYS process simulator to check the water and hydrocarbon dew points of gas and to estimate the dropout liquid.

The simulation study reveals that both the water dew point and hydrocarbon dew point will be around 54^{0}C. The water content in the dispatched gas will be approximately 304 lb/MMSCF @ 24 kg/cm^{2}g & 54 ^{0}C, which is higher than the pipeline specification of 7 lb/MMSCF. The dropout liquid in the pipeline is shown in Table 5.2.

Table 5.2: Liquid condensed in pipeline

Year	Gas throughput, SCMD	Liquid condensed, m^3/d
2022-23	39987	11.60
2023-24	36601	11.11
2024-25	36761	11.07
2025-26	**42242**	11.85
2026-27	37578	11.27
2027-28	30454	10.08
2028-29	18831	6.57
2029-30	10938	3.98
2030-31	9078	3.36
2031-32	7768	2.91
2032-33	6592	2.51
2033-34	5968	2.30
2034-35	4800	1.90

Hence, dehydration system is required at Pundi to meet the pipeline specification of 7 lb of water per MMSCF of gas and also water dew point of less than zero deg C at operating pressure at discharge point of Nannilam EPS. Also, in order to avoid the hydrocarbon condensation in pipeline, DPD system is required.

5.3 Selection of GDU & DPD system

5.3.1 Gas dehydration system:

During natural gas processing, gas dehydration is more often accomplished by glycol based dehydration or by molecular sieve based solid desiccant adsorbing systems.

5.3.1.1 TEG-based gas dehydration system:

In this process, gas is first passed through a scrubber to remove the carried over liquid, if any. The gas then enters the absorption column, i.e., contactor, where it comes in contact with the lean glycol which flows counter-currently. The gas after dehydration in the contactor exits from top of the contactor and exchanges heat with the lean glycol entering the contactor. After that the gas is routed to TEG scrubber for removal of carried over TEG if any. Rich glycol, after absorbing moisture from gas in the contactor, is sent to the flash drum to remove the dissolved hydrocarbons, if any. Afterwards it will be passed through a series of filters and then routed to heat exchangers, where the hot lean glycol from the regeneration column will transfer heat to the rich glycol. The preheated rich glycol will be routed to the regenerated column, where the absorbed moisture in the glycol will be vaporised through reboiler. The liberated water vapour is released from the top of the regeneration column. The stripping gas will be utilised to strip out the moisture from the glycol to increase the purity of the glycol. As mentioned above, the hot lean glycol from the regeneration column exchanges heat with the incoming rich glycol and is pumped back into the contactor.

The schematic diagram of TEG based GDU system is shown in Figure 5.1.

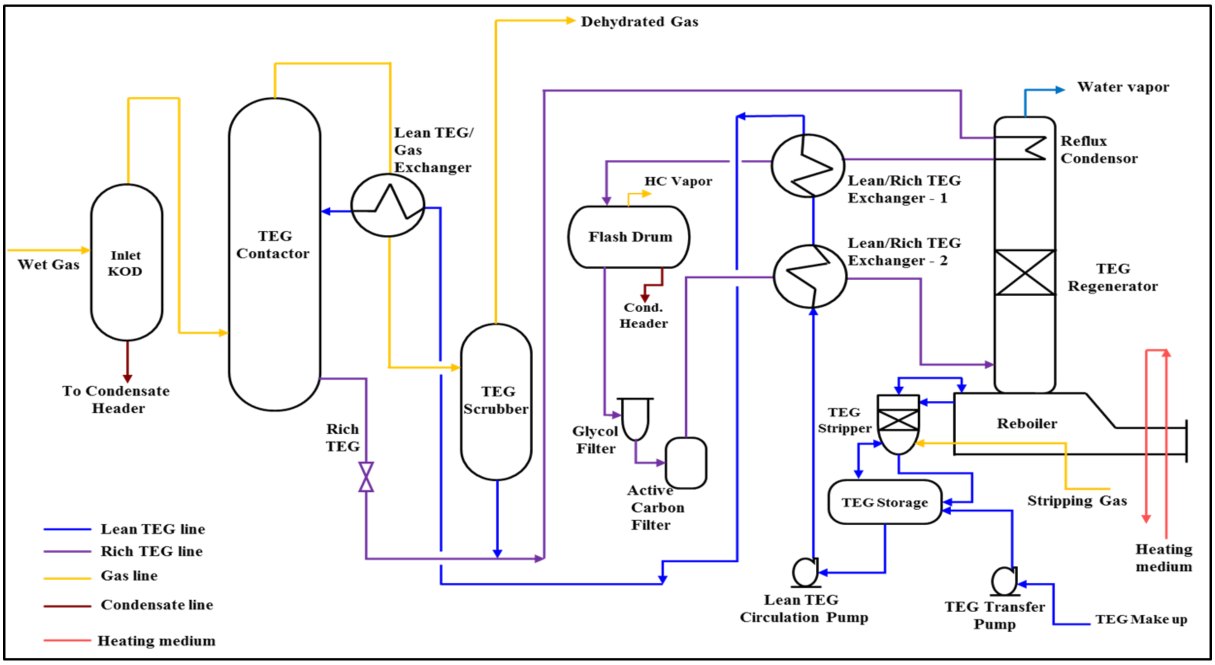

Figure 5.1: Schematic of TEG based Gas Dehydration system

Simulation study reveals that water dew point of around zero degree Celcius at 25 kg/cm^{2}g can be achieved in TEG based dehydration system. However, as mentioned at 3.11 in the section “Basis of Study”, the water dew point temperature is required to be dropped to (-) 5 ^{0}C, which is not possible in TEG based GDU hence, it is not considered further.

5.3.1.2 Molecular sieve based gas dehydration unit:

Molecular sieve based gas dehydration system is adsorption process, which is a surface phenomenon and does not involve any chemical reaction.

The system consists of two solid desiccant towers, which are used for adsorption and regeneration alternately. When one tower is in adsorption process, the other one will be in regeneration; and vice versa. The wet gas after passing through the scrubber enters the adsorber column and comes into contact with the dessiccant bed. Water vapour is adsorbed by solid desiccants and the dry gas leaves the tower from the bottom. Flow of wet gas into the adsorber column is continued till the bed reaches its saturation limit. Just before the bed saturation occurs, the adsorbing tower is switched over for regeneration and the other tower is put into use for adsorption.

A portion of dry gas leaving the adsorption tower is heated in a furnace or an electric heater to regenerate the saturated solid desiccant bed. The hot gas is passed through the tower in regeneration cycle resulting in vaporisation of water from the bed. The hot regenerated bed must be cooled before it can be switched over for drying the wet gas. Accordingly, after completion of the heating process; inlet gas is fed into hot regenerated bed until the bed is cooled. The water laden gas leaving the regeneration tower is cooled and free water is removed through a KOD. The gas after regeneration is recycled back into the adsorption tower.

A schematic of molecular sieve drying process is shown in Figure 5.2. In the figure, Dryer-I is in adsorption process, while Dryer-II is in regeneration process.

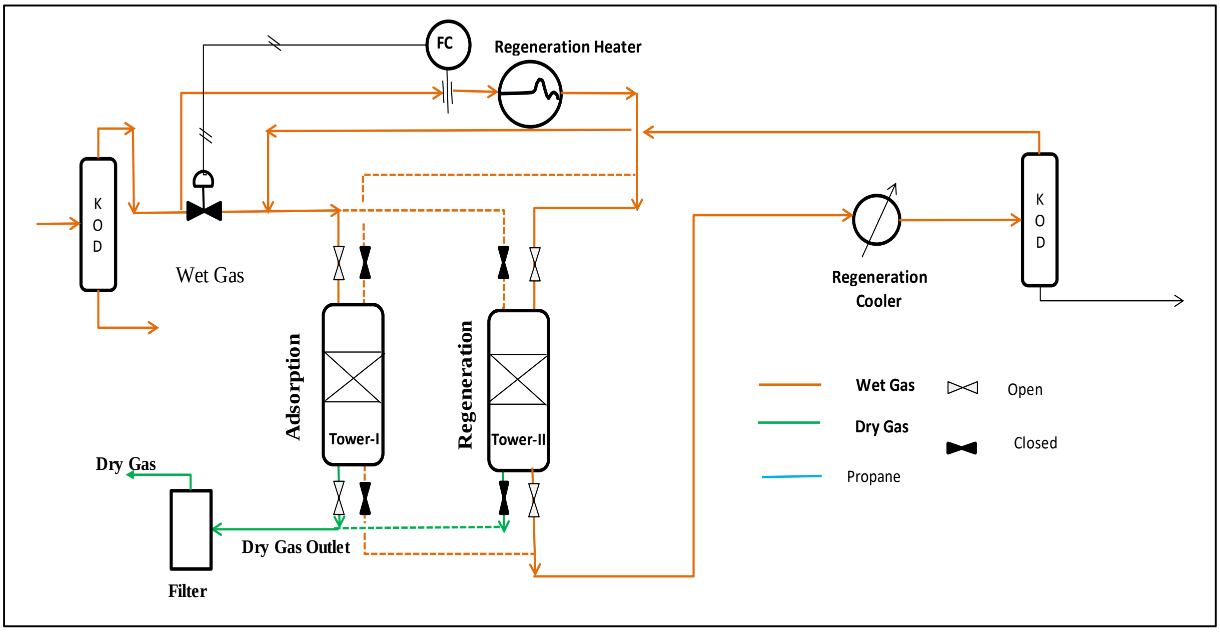

Figure 5.2: Schematic of molecular sieve based Gas Dehydration system

Molecular sieve based dehydration system is suitable for dehydration of gas to the required dew point of ~ (-5) degree Celsius in the downstream DPD unit without hydrate formation. Hence, this system is considered for gas dehydration.

Broad list of equipment for Molecular Sieve based GDU:

A list of major equipment required for the molecular sieve based GDU is shown in Table 5.3.

Table 5.3: List of equipment for Molecular sieve based GDU

SN	Components / Parameters	Nos.
1	Inlet gas KOD	1
2	Molecular sieve dryer bed	2
3	Regeneration gas Furnace	1
4	Regeneration gas cooler	1
5	Regeneration gas KOD	1
6	Filters	1+1

5.3.2 Dew point Depression Unit:

After removal of moisture, gas will be routed through hydrocarbon dew point depression unit to achieve zero hydrocarbon dew point. Following are technically proven and commercially available processes for hydrocarbon dew point depression:

- Joule –Thomson expansion & compression system
- Refrigerant based dew point control systems

5.3.2.1 Joule Thomson expansion & compression system

A schematic diagram of Joule –Thomson expansion & compression system based DPD unit is shown below in Figure 5.3.

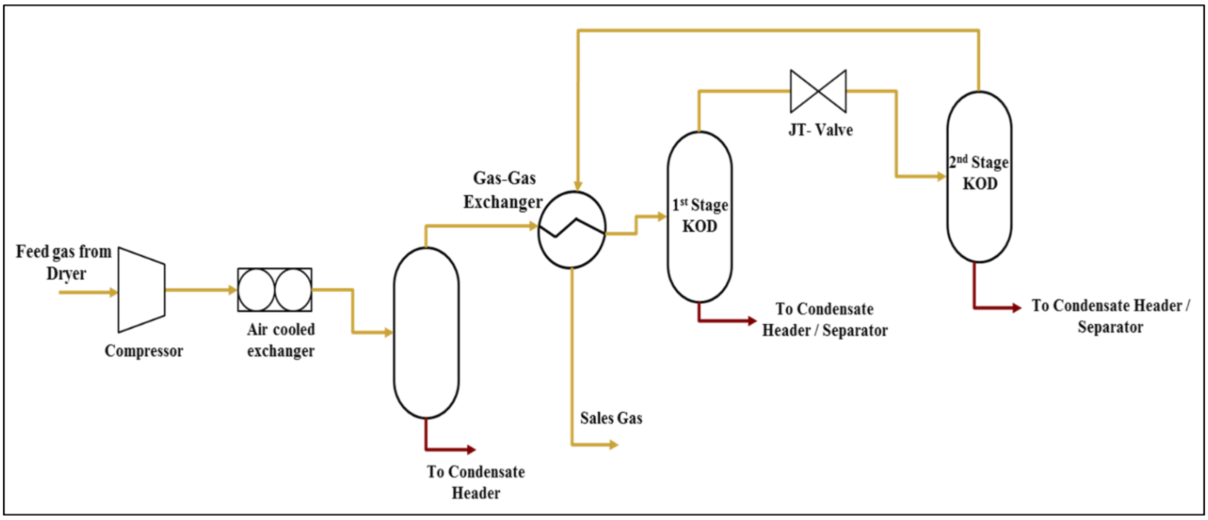

Figure 5.3: Schematic of Joule –Thomson expansion & Compression based DPD

In JT- expansion compression process, the dehydrated feed gas is compressed and precooled in a gas-gas exchanger. The precooled gas will be passed through 1st stage KOD in which dropout condensate, if any, will be removed. Further, the gas will be expanded from higher pressure to lower pressure to achieve sub-zero temperature and will be routed to 2nd stage KOD. The dropout condensate, if any, will be removed in 2nd stage KOD. The chilled and dew pointed gas will be routed to gas-gas exchanger to precool the incoming gas as briefed earlier.

Available gas pressure after compression and dehydration at Pundi EPS will be around 25 kg/cm^{2}g. It needs to be boosted to higher pressure of around 90 kg/cm^{2}g before expansion up to 5 kg/cm^{2}g in JT valve to achieve sub-zero temperature and to further compress to 25 kg/cm^{2}g. Due to high requirement of energy for compression, this process is cost intensive and not considered further for dew point depression.

5.3.2.2 Refrigerant based DPD Unit:

Dew point depression can be carried out by the use of compact liquid refrigerant techniques such as R-134A which requires less space as compared to conventional propane refrigeration packages. Moreover, R-134A is a non-flammable refrigerant. Considering difficulties in transportation and storage of propane in Cauvery Asset, R-134A based DPD system is preferred over propane based DPD system. The schematic of R-134A based DPD is shown in the Figure 5.4.

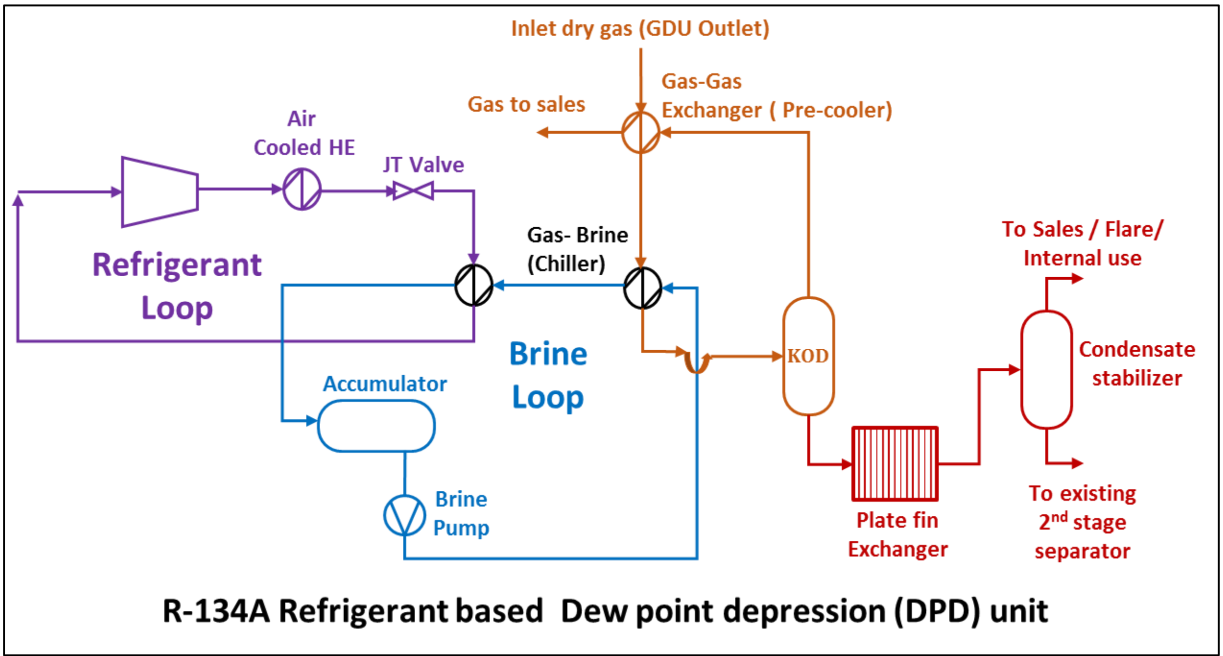

Figure 5.4: Schematic of refrigerant based dew point depression unit

The scheme consists of three segments.

1. Refrigeration Loop
2. Brine Loop
3. Gas Loop

Refrigerant shall be compressed to around 15 bar, followed by cooling through air cooled heat exchanger and then expanded to around 1.5 bar by a JT valve. After expanding, the refrigerant will attain a temperature of around -15^{0}C, which is used to cool the brine solution to -11^{0}C. The chilled brine solution shall be circulated in the Chiller to achieve hydrocarbon dew point of the incoming precooled gas to around -5^{0}C. The chilled hydrocarbon gas will be routed to a KOD. The chilled gas from the KOD will be routed to pre-cooler for cooling the incoming feed gas before being routed to sales. The dropped out condensate from KOD will be heated by ambient air to positive temperatures in plate fin exchanger (PHE). Heated condensate from the PHE will be routed to the condensate stabilizer operating at 2.5 kg/cm^{2}g. The flashed gases will be routed to internal use / sales / flare. The liquid separated from the condensate stabilizer vessel will be routed to the existing 2nd stage separator operating at 1.5 kg/cm^{2}g.

Broad list of equipment for R-134A Refrigerant based DPD Unit:

A list of major equipment required in refrigerant based DPD unit is shown in Table 5.4.

Table 5.4: List of equipment for Refrigerant based DPD unit

SN	Components / Parameters	Nos.
1	Gas-Gas exchanger (Pre-cooler)	1
2	Brine -Gas Exchanger (Chiller)	1+1
3	Refrigerant Compressor with air cooler, Refrigerant - Brine Exchanger & JT Valve	1+1
4	Brine Accumulator	1
5	Brine pumps	1+1
6	KOD (for separation of drop out condensate)	1
7	Plate fin exchanger for heating condensate	1
8	Condensate stabilization vessel	1

5.3.3 Single refrigerant based system with injection of hydrate inhibitor to achieve water and hydrocarbon dew point

Further, simulation study has been carried out in Aspen HYSYS to establish the feasibility of reducing both moisture dew point and hydrocarbon dew point to zero degree Celsius as per PNGRB guideline in a single refrigerant based system with injection of Mono-Ethylene Glycol (MEG) as a hydrate inhibitor. The study indicates that the desired water and hydrocarbon dew points can be achieved in the single unit. Accordingly, a scheme has been envisaged, which is shown in Figure 5.5.

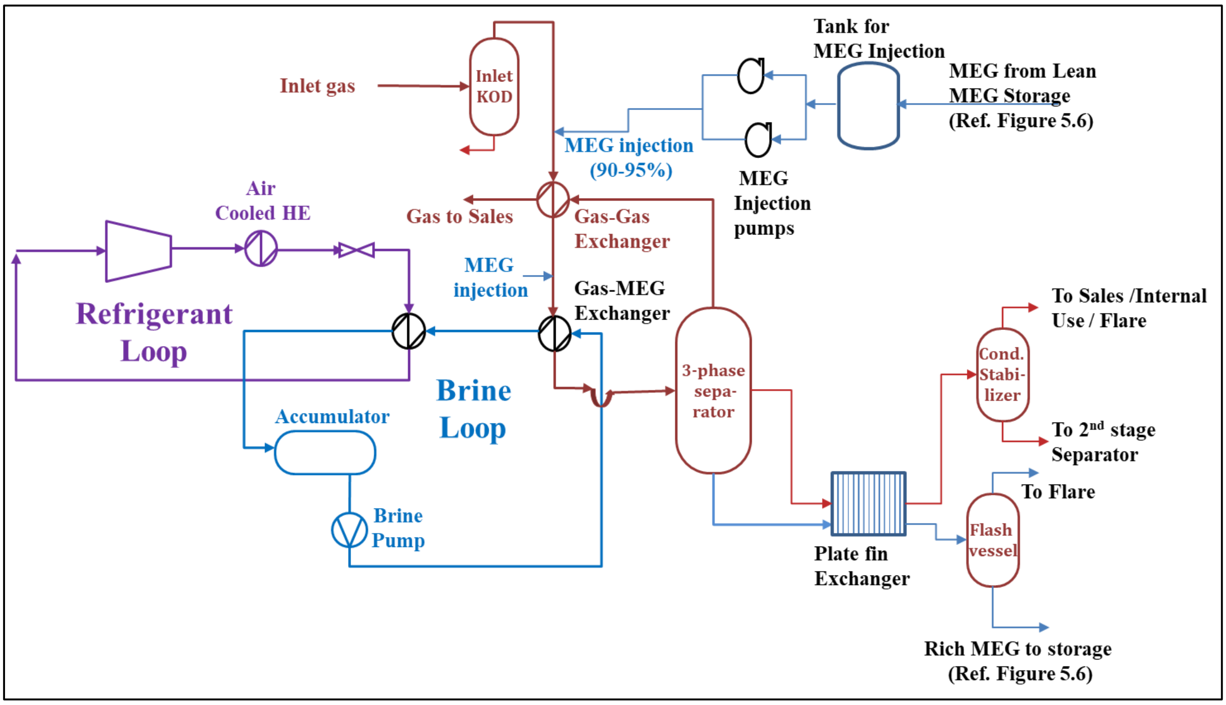

Figure 5.5: Schematic of refrigerant based GDU & DPD system

The scheme consists of the following segments:

1. Refrigeration Loop
2. Brine Loop
3. Gas Loop
4. Injection of lean MEG
5. Regeneration of MEG

Refrigerant shall be compressed to around 15 bar, followed by cooling through air cooled heat exchanger and then expanded to around 1.5 bar by a JT valve. After expanding, the refrigerant will attain a temperature of around -15^{0}C, which is used to cool the brine (MEG + Water) solution to -11^{0}C.

The chilled brine solution shall be circulated in the chiller to cool the incoming precooled wet gas to sub-zero temperatures.

The inlet wet gas will be received in the KOD to remove entrained liquid, if any. The gas from KOD will be pre-cooled in the pre-cooler by using the chilled dew pointed gas. The precooled gas will be routed to chiller in which it will be cooled to around -5 ^{0}C by using the chilled brine solution.

As the gas is saturated with moisture, there will be chances of hydrate formation. To avoid hydrate formation, lean MEG (90% wt. MEG) from the Lean MEG storage tank will be injected in to the gas stream at inlet of chiller and also provision shall be given at inlet of pre-cooler. The chilled gas from the chiller along-with the injected MEG and dropout condensate will be routed to the 3-phase vertical separator.

The chilled gas from the 3-phase separator will be routed to pre-cooler for cooling the incoming feed gas as mentioned earlier before being routed to sales. The condensate & rich MEG separated from the separator will be heated to atmospheric temperature in a plate fin exchanger (PHE). Rich MEG after heating in PHE will be flashed in the flash vessel. Flash gases will be routed to flare system and rich MEG will be routed to the rich MEG storage tanks. The heated condensate will be routed to the condensate stabilizer operating at 2.5 kg/cm^{2}g. The separated gas from condensate stabilizer will be used for internal consumption / sales / flare and condensate will be routed to the existing 2nd stage separator.

Regeneration of MEG:

The schematic of regeneration of MEG is shown in Figure 5.6.

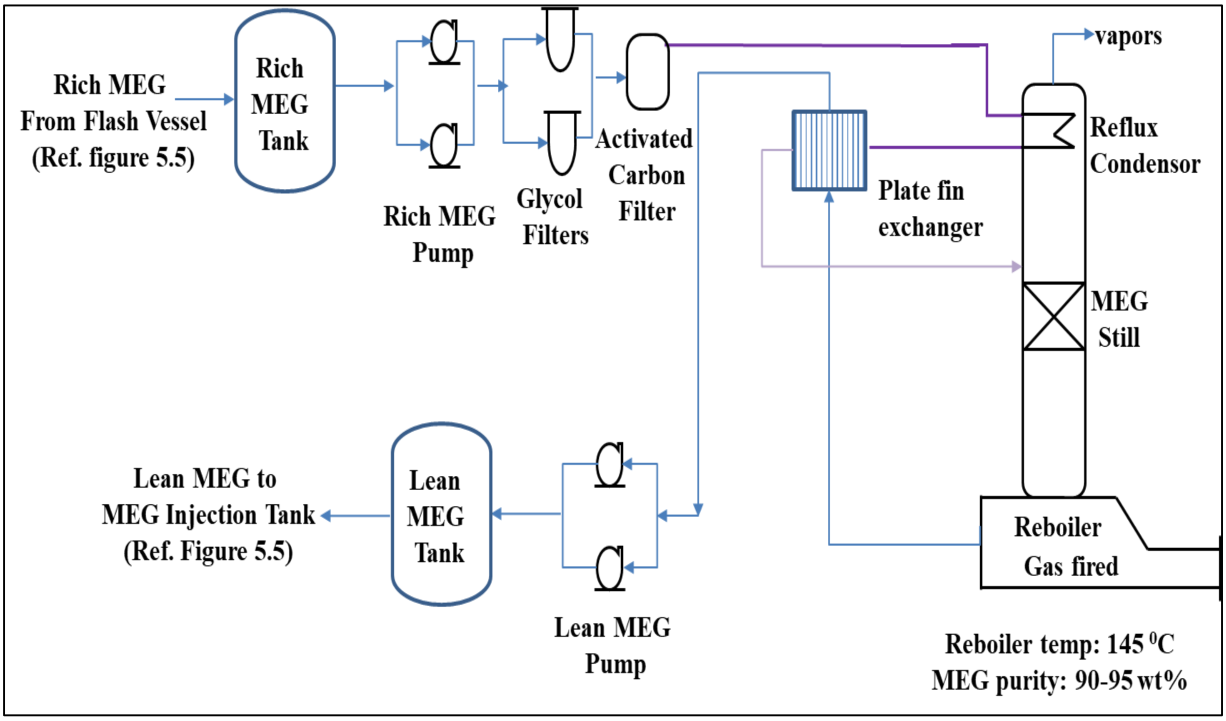

Figure 5.6: Schematic of MEG regeneration system

The rich MEG will be pumped from the rich MEG storage tanks and will be passed through series of filters and then routed to regeneration column condenser. After gaining heat in the condenser of regeneration column, rich MEG will be pre-heated in the lean-rich MEG exchanger. Preheated rich MEG will be routed to the regeneration column, where the absorbed moisture will be vaporised through reboiler system. The liberated water vapour is released from the top of the regeneration column. Hot lean MEG from the regeneration column exchanges heat with the incoming rich glycol as mentioned earlier and is pumped back into the lean MEG storage tanks.

For smaller injection rate of lean MEG, less amount of rich MEG will be generated which will be stored in rich MEG storage tank. Hence, generally MEG regeneration is carried out in batch process.

Broad list of equipment for Refrigerant based GDU & DPD Unit with MEG injection:

A list of major equipment for refrigerant based common unit for dehydration and dew point depression is shown in Table 5.5.

Table 5.5: List of equipment for Refrigerant based GDU & DPD unit with MEG injection

SN	Components / Parameters	Nos.
1	Inlet gas KOD	1
2	Gas-Gas exchanger (Pre-cooler)	1
3	Gas-MEG (Brine) Exchanger (Chiller)	1+1
4	3-Phase separator	1
5	Plat Fin Exchanger (Exchanger for rich MEG and condensate)	1
6	Condensate stabilizer	1
7	Flash Vessel	1
8	Brine Accumulator	1
9	Brine pumps	1+1
10	Refrigerant Compressor with Air cooler, Refrigerant - Brine Exchanger and JT Valve	1+1
11	Tank for MEG injection	1
12	MEG injection Pump	1+1

Broad list of equipment for MEG regeneration system:

A list of major equipment for MEG regeneration is shown in Table 5.6.

Table 5.6: Equipment list for MEG Regeneration system

SN	Equipment	No
1	Lean-rich glycol exchanger (Plate Fin Exchanger)	1
2	MEG Regeneration column	1
3	Reboiler	1
4	Reflux condenser	1
5	Lean MEG Pumps	1+1
6	Rich MEG Pump	1+1
7	Glycol Filters	1+1
8	Activated carbon filter	1
9	Lean MEG Storage tanks	1
10	Rich MEG storage tanks	1

Based on the above, following two schemes have been considered for GDU & DPD.

Scheme A): Molecular sieve based GDU & Refrigerant based DPD

Scheme B): Refrigerant based GDU & DPD system with MEG injection and MEG regeneration system

In both the schemes, condensate generated in DPD unit is heated and flashed in the condensate stabilizer. The flash gas from the condensate stabilizer after meeting requirement of local consumers, will be used as internal consumption like fuel for compressors, power generation, etc. From simulation, quantity of flash gas from the condensate stabilizer and net gas to Nannilam EPS have been estimated considering zero dew point @ 24 kg/cm^{2}g at Pundi EPS for peak rates as per the profile (42242 SCMD), present production rate (32000 SCMD), maximum gas to be compressed (35000 SCMD) and minimum gas to be compressed (16000 SCMD) and are shown in Table 5.7. The condensate generated in KODs of compressors and in the condensate stabilizer will be routed to the existing second stage separators. The estimated quantity of net condensate gained in oil after the second stage separators is also shown in the table for the different gas rates.

Table 5.7: Gas and condensate rate

Sr. No.	Gas to compressor suction, SCMD	Flash gas from condensate stabilizer	Net gas from DPD unit to Nannilam EPS, SCMD (zero dew pointing at 24 kg/cm^{2}g at Pundi)	Net condensate from condensate stabilizer and compressor KODs, received in oil from second stage separators, m^3/d
1	42242	11257	29476	5.4
2	32000	8513	22352	4.2
3	35000	9332	24429	4.5
4	16000	4265	11169	2.2

The stream summary for the present gas quantity of 32,000 SCMD is shown in table 5.8 below:

Table 5.8: Stream Summary

	Compressor inlet	Compressor outlet	DPD Outlet	Flash Gas	Condensate from flash vessel
Vapour / Phase Fraction	1.0	1.0	1.0	1	0
Temperature [C]	35.0	53.6	35.1	24.4	24.4
Pressure [kg/cm2_g]	3.0	25.0	23.1	2.4	2.4
Molar Flow [m3/d_(gas)]	32000	31466	22352	8513	601
Mass Flow [kg/h]	1649.8	1593.5	863.7	658.0	71.8
Components	Mole %				
Methane	0.534	0.542	0.710	0.1369	0.0027
Ethane	0.156	0.157	0.154	0.1747	0.0192
Propane	0.160	0.159	0.086	0.3529	0.1380
i-Butane	0.036	0.035	0.010	0.0968	0.0945
n-Butane	0.056	0.054	0.011	0.1551	0.2132
i-Pentane	0.014	0.013	0.001	0.0364	0.1244
n-Pentane	0.012	0.011	0.001	0.0291	0.1322
n-Hexane	0.011	0.008	0.000	0.0151	0.2172
n-Heptane	0.002	0.001	0.000	0.0012	0.0519
n-Octane	0.000	0.000	0.000	0.0000	0.0063

n-Nonane	0.000	0.000	0.000	0.0000	0.0003
n-Decane	0.000	0.000	0.000	0.0000	0.0000
CO2	0.000	0.000	0.000	0.0001	0.0000
Nitrogen	0.020	0.020	0.027	0.0016	0.0000
Molecular weight	29.2	28.7	21.9	43.8	67.8
Cv (Net), Kcal/m^3	13842	13601	10409	20872	32763
Cv (Gross), Kcal/m^3	15147	14888	11464	22692	35452
RVP, Psia					52.42

Further simulation study also reveals that in order to achieve the required dew point of zero degree Celsius at 15 kg/cm^{2}g at Nannilam EPS, produced gas needs to be dew pointed up to 5^{0}C at 24 kg/cm^{2}g at the Pundi EPS.

The schematic of the final facilities is shown in the Figure 5.7.

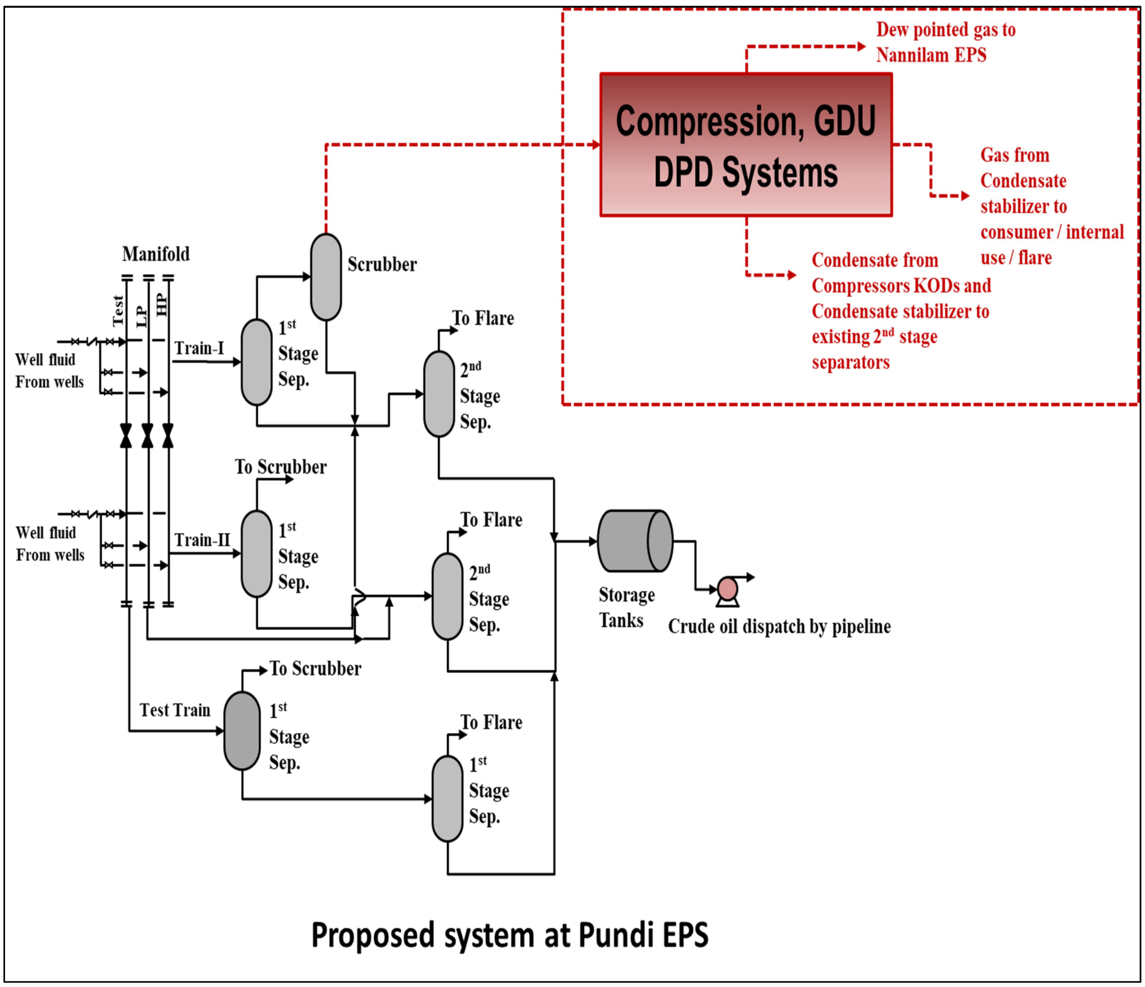

Figure 5.7: Proposed system at Pundi EPS

6.0 Capacities of Units and List of Equipment

Simulation models of LP gas compressor, gas dehydration unit and dew point depression unit have been prepared in Aspen HYSYS process simulator based on the input data provided by the Asset.

The details of the LP gas compressor system and GDU DPD schemes (Scheme-A and Scheme-B described in previous section) along with their capacities, suction and discharge pressure & temperature & power requirement are shown in Table 6.1.

Table 6.1: Required LP gas Compressor details

Installation	Peak LP gas, LSCMD	Nos.	LP Gas Compressor Package (Reciprocating type , Air-cooled cooler and associated inlet, inter-stage & Outlet KODs)	Power requirement, kW (only for working compressors)
Pundi EPS	0.42	3 (2 op. +1 s/b)	Capacity: 0.20 LSCMD each Suction P/T: 1-3 kg/cm^{2}g/ 35^{0}C Discharge P/T: 25 kg/cm^{2}g / 54^{0}C	300

Details of both the schemes for GDU & DPD are given below.

Scheme A): Molecular sieve based GDU & Refrigerant based DPD

Capacities of GDU (Section 5.3.1.2) and DPD system (Section 5.3.2.2) for the scheme are shown in Table 6.2.

Table 6.2: Details of the units at Pundi EPS (Scheme-A)

Molecular sieve based GDU system (Capacity: 0.4 LSCMD)				
SN	Components	Capacity	Duty/ Power/ Size	Operating pressure, kg/cm^{2}g & Temperature, ^{0}C
1	Inlet gas KOD	0.4 LSCMD	0.6 m x 2.2 m	25 kg/cm^{2}g / 54^{0}C
2	Molecular sieve dryer bed (2 nos.)	0.4 LSCMD each	1.1 m x 3.3 m	25 kg/cm^{2}g / 54^{0}C
3	Regeneration gas Furnace	-	1.2x0.046 MMkcal/hr	25 kg/cm^{2}g / 54^{0}C- 250^{0}C
4	Regeneration gas cooler	-	1.2x0.046 MMkcal/hr	25 kg/cm^{2}g / 54^0 C-250^{0}C
5	Regeneration gas KOD	250 SCMH	0.5 m x 1.8 m	25 kg/cm^{2}g / 54^{0}C
6	Filters (1+1)	0.4 LSCMD each	-	25 kg/cm^{2}g / 54^{0}C
Liquid refrigerant based DPD unit (Capacity: 0.4 LSCMD)				
SN	Components	Capacity	Duty/ Power/ Size	Operating pressure, kg/cm^{2}g & Temperature, ^{0}C
1	Gas-Gas exchanger	-	1.2 x 0.03 MMkcal/hr.	-
2	Brine -Gas Exchanger (2 nos.)	-	1.2x 0.09 MMkcal/hr each	-
3	KOD (For separation of dropout condensate)		0.5 m x 1.8 m	
4	Refrigerant - Brine Exchanger (2 nos.)	-	1.2x 0.09 MMkcal/hr each	-

Table 6.2: Details of the units at Pundi EPS (Scheme-A)				
Molecular sieve based GDU system (Capacity: 0.4 LSCMD)				
SN	Components	Capacity	Duty/ Power/ Size	Operating pressure, kg/cm^2g & Temperature, ^0C
5	Refrigerant Compressor with air cooler (1+1)	3100 kg/hr	100 KW	Suction: 0.3 kg/cm^2g / -10^0C Discharge: 15 kg/cm^2g / 55^0C
6	Brine pumps (1+1)	22000 kg/hr ($20.8\ m^3/hr$)	4.0 kw	Suction: atm./ -11^0C Discharge: 5 kg/cm^2g /-11^0C
7	Brine Accumulator	3 m^3	-	Atm. /-11^0C
8	Plate fin heat exchanger for heating condensate @ 24 kg/cm2g	-	1.2x 0.02 MMKcal/hr	-5 ^0C to 25 ^0C
9	Plate fin heat exchanger for heating condensate @ 3 kg/cm2g	-	1.2x 0.05 MMKcal/hr	-15 ^0C to 25 ^0C
10	Condensate stabilization vessel	-	0.5 m x 1.8 m	2.5 kg/cm^2g / 25^0C

Scheme B): Refrigerant based GDU & DPD system with MEG injection to avoid hydrate formation

Capacity of combined GDU and DPD system along with MEG regeneration system as described in Section 5.3.3 for the scheme are shown in Table 6.3.

Table 6.3 Details of the units at Pundi EPS (Scheme-B)				
Liquid refrigerant based GDU & DPD unit with MEG Injection (Capacity: 0.4 LSCMD)				
SN	Components	Capacity	Duty/ Power/ Size	Operating pressure, kg/cm^2g & Temperature, ^0C
1	Inlet gas KOD	0.4 LSCMD	0.6 m x 2.2 m	22-31 kg/cm^2g / 35^0C-45^0C
2	Gas-Gas exchanger (Pre-cooler)	-	1.2x0.03 MMKcal/hr	-
3	Brine -Gas Exchanger (Chiller) (2 nos.)		1.2x0.09 MMKcal/hr each	-
4	3-Phase separator	0.4 LSCMD	0.5 m x 2.3 m	22-31 kg/cm^2g / -5^0C
5	Condensate stabilizer		0.5 m x 1.8 m	2.5 kg/cm^2g / 25^0C
6	Flash drum		0.5 m x 1.8 m	2.5 kg/cm^2g / 25^0C-45^0C
7	Exchanger for rich MEG and condensate	-	1.2x 0.07 MMKcla/hr	-5^0C to 25^0C
8	Brine pumps (1+1)	22000 kg/hr ($20.8\ m^3/hr$)	4.0 kW	Suction: atm / -11^0C Discharge: 5 kg/cm^2g / -11^0C
9	Brine Accumulator	3 m^3		Atm. / -11^0C
10	Refrigerant – Brine Exchanger (1+1)	-	1.2x 0.09 MMKcal/hr each	-
11	Refrigerant Compressor with air cooler (1+1)	3100 kg/hr	100 kw	Suction: 0.3 kg/cm2g / -10^0C Discharge: 15 kg/cm^2g / 55^0C
12	MEG injection Pump (1+1)	0.30 m^3/d each	0.02 kW	Suction: atm./ 25^0C-45^0C Discharge: 15 kg/cm^2g / 25^0C-45^0C
13	Tank for MEG injection	1.0 m^3		Atm. / 25^0C-45^0C

MEG regeneration system:				
SN	Components	Capacity	Duty/ Power/ Size	Operating pressure, kg/cm^{2}g & Temperature, ^{0}C
1	Rich MEG transfer Pump (to regeneration column (1+1)	1 m^3/hr	0.2 kW	Suction: atm./ 25^{0}C-45^{0}C Discharge: 5 kg/cm^{2}g / 25^{0}C-45^{0}C
2	Lean-rich glycol exchanger (Plate Fin Exchanger)	-	1.2x0.032 MMkcal/hr	-
3	MEG Regeneration column	1 m^3/hr		-
4	Reboiler (Gas fired)	-	1.2x0.27 MMKclal/hr	0.2 kg/cm^{2}g / 145^{0}C
5	Reflux condenser	-	1.2x0.05 MMKclal/hr	0.1 kg/cm^{2}g/ 98^{0}C
6	Rich MEG Storage tanks	5 m^3		Atm. / 25^{0}C-45^{0}C
7	Lean MEG transfer pumps (1+1)	1 m^3/hr	0.2 kW	Atm. – 5 kg/cm^{2}g / 25^{0}C-45^{0}C
8	Lean MEG storage tanks	5 m^3		Atm. / 25^{0}C-45^{0}C
9	Glycol Filters (1+1)	1 m^3/hr	-	5 kg/cm^{2}g / 25^{0}C-45^{0}C
10	Activated carbon filter	1 m^3/hr	-	5 kg/cm^{2}g / 25^{0}C-45^{0}C

Note: The required Lean MEG quantity in Scheme-B at Pundi EPS is around 0.3 m^3/d. The rich MEG containing condensed water in the DPD unit will be around 0.5 m^3/d. Considering operational flexibility and batch process, MEG regeneration unit of capacity 1 m^3/hr has been considered at Pundi EPS.

7.0 Ballpark Cost Estimates

Ballpark cost estimates of the Scheme-A (Molecular Sieve based dehydration system & Refrigerant based DPD unit) and Scheme-B (Refrigerant based GDU & DPD system with MEG injection & MEG regeneration system) have been carried out based on the available in-house cost data. The manpower cost is not considered for estimation of OPEX. This cost will be required to be updated by Asset based on the real time cost data base of Engineering Services before taking approval for field implementation. Comparison of ball park capital cost and operating cost estimates is shown in Table 7.1

Table 7.1: Cost comparison of Scheme-A & Scheme-B

Scheme-A	Molecular Sieve based GDU (Capacity: 0.4 LSCMD of gas)	CAPEX, Crores	4.87
		OPEX, Crores/ Annum	0.55
	Refrigerant based DPD unit (Capacity: 0.4 LSCMD of gas)	CAPEX, Crores	2.85
		OPEX, Crores/ Annum	0.53
	Total of Scheme-A	CAPEX, Crores	**7.72**
		OPEX, Crores/ Annum	**1.08**
Scheme-B	Refrigerant based GDU & DPD system with MEG injection (Capacity: 0.4 LSCMD of gas)	CAPEX, Crores	3.03
		OPEX, Crores/ Annum	0.54
	MEG regeneration system (Capacity: 1 m^3/hr of rich MEG)	CAPEX, Crores	3.89
		OPEX, Crores/ Annum	0.23
	Total of Scheme-B	CAPEX, Crores	**6.92**
		OPEX, Crores/ Annum	**0.77**

Ballpark cost estimates based on owning of the facilities reveals that the Scheme-B required less CAPEX and OPEX.

However, Asset has already been using hired facilities for compressors, GDU & DPD at Narimanam, Tiruvarur, Adiakamangalam, Kamalapuram, Nannilam, Kuthalam, Kovilkalappal and Ramnad. Accordingly, Asset may take a decision on the basis of overall cost economics between owned and hired facilities and local factors.

8.0 Summary

Pundi EPS of Cauvery Asset is presently producing around 236 m^3/d of oil, 28 m^3/d of water and 32000 SCMD of gas. Due to absence of local consumers, Asset desires to evacuate the produced gas from Pundi EPS to Nannilam EPS for sales through 4" x 28 km pipeline and supply to GAIL Grid. The available pressure at Pundi EPS is around 1-3 kg/cm^2g and required pressure at Nannilam EPS is around 12-15 kg/cm^2g. Asset requested IOGPT to conceptualize the requirement of facility to supply gas as per PNGRB guidelines.

Simulation study has been carried out in PIPESIM and Aspen HYSYS process simulator. Study indicates that for transportation of peak gas rate, the required pressure at Pundi EPS will be around 23.5 kg/cm^2g. Hence the compression facility will be required. Further, simulation study in Aspen HYSYS indicates that GDU & DPD system are also required to avoid the condensation in the pipeline and to meet the desired PNGRB specifications.

The scheme for compression system, GDU and DPD system has been conceptualized. The study concludes the following:

- Reciprocating type gas compressors will be required to boost the pressure to around 25 kg/cm^2g.
- Two scheme for GDU & DPD have been conceptualized

  Scheme-A: Molecular sieve based GDU & Refrigerant based DPD

  Scheme-B: Refrigerant based GDU & DPD system with MEG injection to avoid hydrate formation

Ballpark cost estimates reveals that, CPEX and OPEX of Scheme-A are Rs. 7.72 crores and 1.08 crores per annum respectively and those of Scheme-B are Rs. 6.92 crores and 0.77 crores per annum respectively. Hence, Scheme-B with reciprocating compressor system is recommended at Pundi EPS. However, Asset has already been using hired facilities for compressors, GDU & DPD at many other installations. Accordingly, Asset may take a decision on the basis of overall cost economics between owned and hired facilities and local factors.

9.0 Annexures

Annexure-I

Gas Production Profile:

	BS-05	Basement	otal Pundi Field: Scenario-	Basement	Total Pundi Field: Scenario-2
	BAU	BAU	BS-05 + Basement : BAU	BAU+ 2 Released Loc.	AU+2 Released Loc. Of Basement
Year	Gas, m3/d	Gas, m3/d	Gas, m3/d	Gas, m3/d	Gas, m3/d
2022-23	17412	22575	39987	22575.3	39986.9
2023-24	15806	20795	36601	28547.9	44354.1
2024-25	18542	18219	36761	34821.9	53363.5
2025-26	26707	15534	42242	30657.5	57364.9
2026-27	24592	12986	37578	26246.6	50838.6
2027-28	19714	10740	30454	22000.0	41714.4
2028-29	10119	8712	18831	17945.2	28064.3
2029-30	3869	7068	10938	15068.5	18937.6
2030-31	3406	5671	9078	12054.8	15461.2
2031-32	3220	4548	7768	9589.0	12808.8
2032-33	2976	3616	6592	7671.2	10647.3
2033-34	3119	2849	5968	6301.4	9420.5
2034-35	2526	2274	4800	4931.5	7457.8

Boundary Conditions & Assumption:

1. For Basement, one tank based model was prepared as the wells are observed to follow a single pressure trend. Considering the material balance approach at field scale, the gas profile is generated by considering the likely average GOR vs pressure trend with envisaged oil production. The projected oil production is based on decline rate of 21% p.a. and new well potential (25 m3/d/well).

2. Two new locations available in Basement namely, PUDI & PUDJ are considered for production w.e.f. September-2023 & December-2023 based on drilling timeline provided by Cauvery Asset.

3. The projected profiles are at sand face and flow assurance study may be required to estimate actual realisation at surface.

4. Profile doesn't consider operational and shut-down losses.

Re: Draft Report_Study for requirement of Gas Compressor, GDU and DPD at Pundi EPS
A PRABHAKARAN to: Narendra Vikram Katre 11/02/2022 04:19 PM
Cc: NB JOSHI, VK6 SINGH
From: A PRABHAKARAN/ONGCL
To: Narendra Vikram Katre/ONGCL@ONGCL
Cc: NB JOSHI/ONGCL@ONGCL, VK6 SINGH/ONGCL@ONGCL
1 Attachment

R-Draft Report_Study for Requirement of Gas Compressor GDU and DPD at Pundi EPS_19.10.2022.docx

Dear Sh Katre,
Attached Reviewed Draft Report with few minor changes, Will be helpful to us if the following information are addressed in the report,
1) We are planning to get RFQ as below:
Quantity of Gas to be compressed (Present Production): 32,000 SCMD,
Max Qty of Gas to be compressed : 35,000 SCMD
Min Qty of Gas to be compressed : 16,0000 SCMD
Request to give simulation result for the above quantity,
a) Qty of Gas Flashed at condensate stabilizer:
b) Qty of Condensate generated
c) with stream composition including Net Cv and Gross Cv.

2) If possible may please include Cost benefit Analysis of Owning Compressor + GDU Vs Hiring Compressor + GDU, this will give us support for getting concurrence of the proposal.

3) In Scheme-B the rate of Gas and Condensate considering zero dewpoint @ 30 Kg/cm2 is tabulated: Like to know the reason for taking 30 Kg/cm2 .

4) Table 4.9 may include results for Gas Qty: 35000, 32000 and 16000 SCMD.

5) Fig 4.9 Please change the crude oil is dispatched through Pipeline instead of oil tanker.

6) New Cv and Gross Cv in the stream summary may be included.

Regards,

A Prabhakaran,
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Annexure-II

Gas Composition:

ऑयल एण्ड नेचुरल गैस कॉरपोरेशन लिमिटेड
Oil and Natural Gas Corporation Limited

सतह रसायन– सतह टीम
कावेरी परिसम्पत्ति
नेरवी ऑफिस कॉम्प्लेक्स, नेरवी – 609 604
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No. CA/ST/CHEM/PUNDI GAS Analysis Report	Date: 28.08.2022
From	GM (Chem), I/c Surface Chemistry, ST, Cauvery Asset, Karaikal
To	SAM-V, ST, Cauvery Asset, Karaikal

Field	PU
Source	
SamplingDate	24.08.2022
AnalysisDate	27.08.2022
Pr Kg/cm²	2.8
Temp °C	39
Gas Composition (% Vol)	
C1	53.380
C2	15.550
C3	15.952
i-C4	3.572
n-C4	5.587
i-C5	1.424
n-C5	1.217
C6	1.080
C7	0.222
C8	0.034
C9	0.003
C10	0.000
CO2	0.022
N2	1.957
H2S	0.000
C3+C4	25.110
Z	0.9924
SP.GR.	1.0174
CV(Net)	13842.251
CV(Gross)	15147.219
AV. Mwt	29.2

(Basant Kumar Menariya)
Senior Chemist

तेल एवं गैस उत्पादन प्रौद्यौगिकी संस्थान

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