



**REPORT
FOR
CAPACITY ASSESSMENT OF KG BASIN NGPL NETWORK
OF
M/S GAIL (INDIA) LIMITED**

**[IN LINE WITH PNGRB (DETERMINING CAPACITY OF PETROLEUM,
PETROLEUM PRODUCTS AND NATURAL GAS PIPELINE) REGULATIONS, 2010]**

This Report is prepared for M/s PNGRB and it is for use by M/s PNGRB or their assigned Representatives/ Organisations only. The matter contained in the Report is confidential.

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Abbreviations

| | | |
|-------|---|--|
| PNGRB | : | Petroleum and Natural Gas Regulatory Board |
| EIL | : | Engineers India Limited |
| GTA | : | Gas Transport Agreement |
| LOA | : | Letter of Award |



1.0 EXECUTIVE SUMMARY

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Petroleum and Natural Gas Regulatory Board (PNGRB) [hereby may also be referred as “Client” for the subject service] was constituted under The Petroleum and Natural Gas Regulatory Board Act, 2006 (NO. 19 OF 2006) notified via Gazette Notification dated 31st March, 2006.

By exercising its power under provision 2 (d) of the said regulation, PNGRB provided LOA PNGRB/Tech/10-CapNGPL/(8)/2015(P-2791) Dated 29.03.2023 (Refer **ANNEXURE-VIII**) for carrying out the capacity assessment of existing GAIL’s KG Basin NGPL network of M/s GAIL (India) Limited [hereinafter referred as an “Entity” also] for the given period of operation i.e. Year 2015-16 to 2023-24 by Engineers India Limited (EIL) [a Govt. of India Undertaking] as a third party for providing the technical assistance.

Role of EIL shall be to review the capacity assessment submitted by the operator & as determined by Entity in line with capacity determination criteria defined in the PNGRB (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010 [hereinafter referred as a “PNGRB Regulation” or “Regulation” also] (Refer **ANNEXURE-I**) and based on data/ inputs provided by Entity/ PNGRB.

This report presents the observations arrived at by the EIL for the data/ inputs furnished by Entity/ PNGRB w.r.t. provisions of applicable Petroleum and Natural Gas Regulatory Board (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010. Accordingly, following results are summarized based on capacity assessment for each year as carried out by EIL:

PNGRB regulation i.e. Petroleum and Natural Gas Regulatory Board (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010 defines the step wise methodology for the determination of Pipeline capacity. Hence, year wise methodology adopted by Entity has been reviewed by EIL against defined step wise methodology given in the regulation of capacity determination as clause no. 5.(5).

Entity data/ inputs has been verified by EIL w.r.t stepwise methodology given in Clause no. 5.(5) and supported data/ inputs submitted by Entity/ PNGRB. Tabulated below are the comparative capacity assessment figures (rounded-off figures) at an interval of one year as carried out by entity & EIL:

| Assessment years | Pipeline Capacity as determined by Entity (in MMSCMD) | Pipeline Capacity as assessed by EIL (in MMSCMD) | Remark |
|------------------|---|--|--|
| | Entity | EIL | |
| | Software used - Pipeline Studio (TGNET) | Software used - Pipeline Studio (TGNET) | |
| 2015-16 | 5.70 | 11.41 | Size of Pipeline section of Tatipaka -Chinchinad P/L was 18" in assessment year 2015-16 which has been changed to 24" in the next assessment year. |
| 2016-17 | 9.58 | 12.10 | |
| 2017-18 | 8.15 | 17.37 | Sources increased by 8 no's and deliveries reduced by 7 no's |
| 2018-19 | 8.77 | 19.37 | Odalarevu source added |
| 2019-20 | 8.09 | 19.37 | |
| 2020-21 | 8.41 | 19.37 | |
| 2021-22 | 8.41 | 19.37 | |
| 2022-23 | 7.44 | 19.37 | |
| 2023-24 | 6.97 | 19.37 | |

Notes :

- As the pipeline capacity was arrived as per PNGRB regulation [based on MAOP considerations], hence variation in determined capacity for various assessment years is due to change in sources and /or deliveries and / or network length and / or network configuration etc.
- For assessment year 2018-19, Odalarevu source Impact for KG Basin pipeline network is in range of 2 MMSCMD
- It was observed that Bantumilli source was not shown in KG Basin pipeline network for the above assessed capacity assessment years.
- Size of Pipeline section of Tatipaka -Chinchinad P/L was 18" [Length 19.7 KM Approx.] in assessment year 2015-16 which has been changed to 24" in the next assessment year. The Impact on the capacity is in range of 1 MMSCMD
- Tatipaka -Oduru – KJ point section [Length 75.7 KM Approx.] was changed from 18" [original size] to 24" [replaced size] in the Assessment year 2017-18. The Impact on the capacity is in range of 0.27 MMSCMD



2.0 INTRODUCTION

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The Petroleum and Natural Gas Regulatory Board (PNGRB) [hereby may also be referred as Client for the subject service] was constituted under The Petroleum and Natural Gas Regulatory Board Act, 2006 (NO. 19 OF 2006) notified via Gazette Notification dated 31st March, 2006.

The Act provides for the establishment of Petroleum and Natural Gas Regulatory Board to protect the interests of consumers and entities engaged in specified activities relating to petroleum, petroleum products and natural gas and to promote competitive markets and for matters connected therewith or incidental thereto.

In exercise of the powers conferred by section 61 of the Petroleum and Natural Gas Regulatory Act, 2006 (19 of 2006), the Petroleum and Natural Gas Regulatory Board has made the Regulation for determining the capacity of Petroleum, Petroleum products and Natural gas pipeline in year 2010. As per Petroleum and Natural Gas Regulatory Board (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010, the capacity assessment is carried out by EIL.

PNGRB has entrusted EIL vide Letter of Award (LOA) No.: PNGRB/Tech/10-CapNGPL/(8)/2015(P-2791) Dated 29.03.2023 for carrying out capacity determination which is [hereinafter referred as an "Entity"] for the given period of operation as mentioned above. Scope of work for EIL was to assess the capacity for the given period of operation as mentioned above in line with capacity determination criteria defined in the PNGRB (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010 as per the process given in clause 5.0.

EIL along with PNGRB have interacted with the Entity on the received procedure followed in capacity determination carried out by the Entity.

For capacity assessment purpose, Entity has considered operating condition and free flow. Further, Entity informed that while carrying out capacity determination exercise they have considered Clause no. 5.(5) of PNGRB Capacity Regulations and additional considerations

etc. It was requested to entity that capacity determination shall be carried out based on step wise methodology given under Clause no. 5.(5) of PNGRB Capacity Regulations only.

Hence, entities were requested to kindly submit capacity figures & supporting TGNET files based on step wise methodology given under Clause no. 5.(5) of PNGRB Capacity Regulations only for assessment purpose.

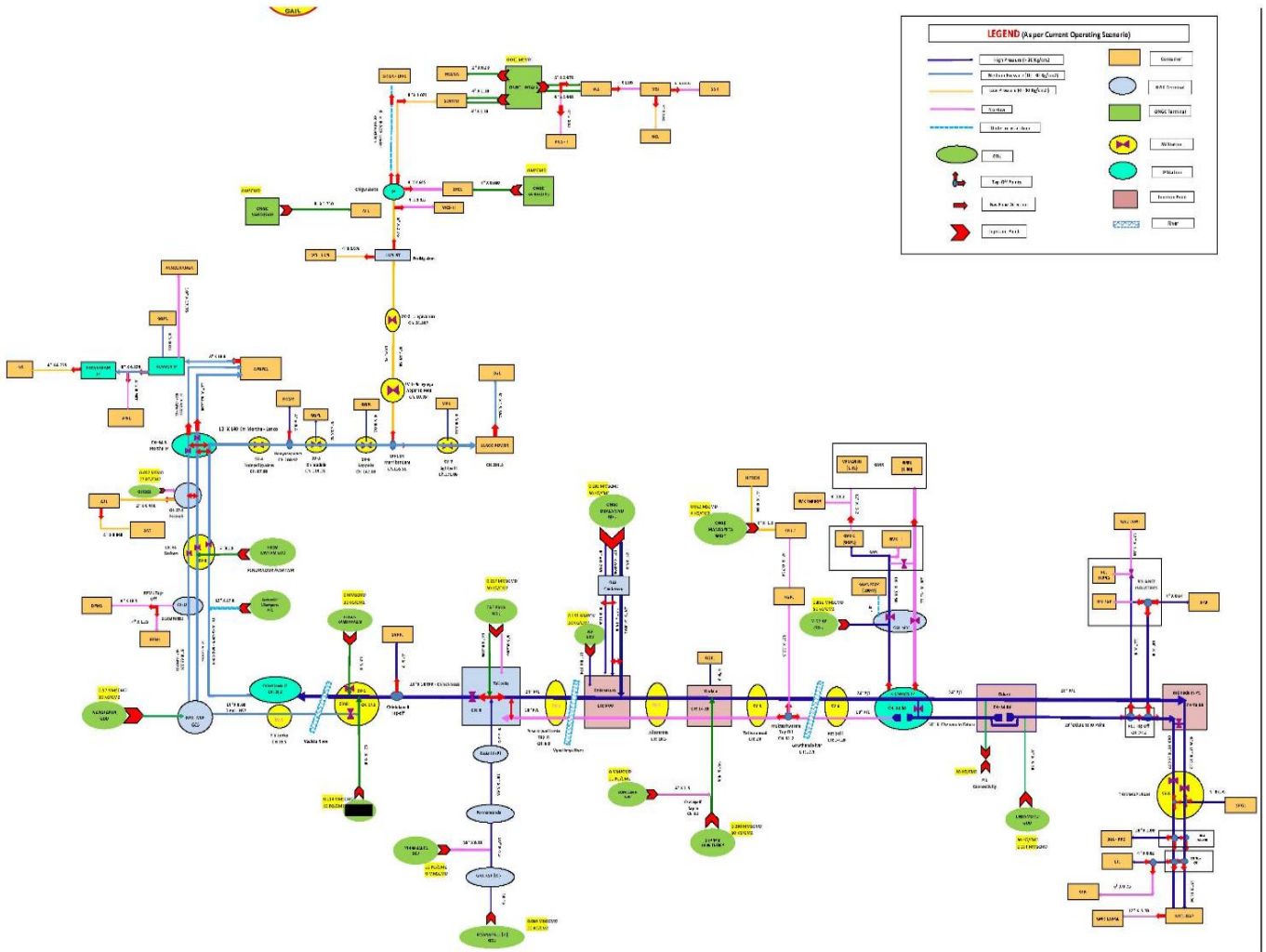
In absence of above, EIL carried out the assessment of the same based on the procedure detailed in the PNGRB Regulation for determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline, 2010. For capacity assessment purpose, EIL has assumed gas at the entry point is unlimited & the selected software was run till any customer connected to the system reaches limiting condition as defined in regulation. The capacity at this juncture was considered as the maximum system capacity achievable in the pipeline system.

The observations and understanding of applicable Regulation have been presented to PNGRB. PNGRB has reviewed the approach which has been detailed out in following sections of the report.



3.0 EXISTING PIPELINE NETWORK DESCRIPTION

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| Financial Year | Length considered in Simulation (km) for capacity assessment |
|----------------|--|
| 2015-16 | 830.47 |
| 2016-17 | 901.28 |
| 2017-18 | 818.87 |

| | |
|---------|--------|
| 2018-19 | 796.87 |
| 2019-20 | 796.87 |
| 2020-21 | 796.87 |
| 2021-22 | 796.87 |
| 2022-23 | 796.97 |
| 2023-24 | 796.97 |

Source List:

| 15-16 | 16-17 | 17-18 |
|------------------------|---------------------|---------------------|
| Narsapur MP | NARSAPUR MP | NARSAPUR MP |
| mori+GS49 | mori | mori |
| cairn | KESANAPALLI | KESANAPALLI |
| Endamaru | cairn | cairn |
| PASALPUDI | RGTEL | Endamaru |
| TATIPAKA | Endamaru | Note-1 |
| MANDAPETTA | Note-1 | PASALPUDI |
| Odalarevu-G1+G15 | PASALPUDI | TATIPAKA MP |
| Lingala Kaikaluru | TATIPAKA MP | MANDAPETTA W + HP |
| RSGDP | MANDAPETTA | KEI-RSOS |
| RAVVA1 | KEI-RSOS | Odalarevu-G1 |
| GMAA | Odalarevu-G1 | Lingala Kaikaluru |
| Kammapelam | Total length-901.28 | RSGDP |
| SCPL Kavitam | | RAVVA1 |
| Nandigama | | GMAA |
| BG Shirke | | Kammapelam |
| RGTEL | | SCPL Kavitam |
| ONGC Ponnamanda | | Nandigama |
| ONGC_Adavipalem | | BG Shirke |
| KESANAPALLI | | RGTEL |
| KEI-RSOS | | Total length-818.87 |
| PENUMADAM | | |
| NARSAPUR LP | | |
| Total length-830.47 KM | | |

Note-1 : As per Entity, Odalarevu Tie-in connectivity was completed in 2018.

| 18-19 | 19-20 | 20-21 |
|---------------------|---------------------|---------------------|
| NARSAPUR MP | NARSAPUR MP | NARSAPUR MP |
| mori | mori | mori |
| KESANAPALLI | kESANAPALLI | KESANAPALLI |
| cairn | cairn | cairn |
| Endamaru | Endamaru | Endamaru |
| Odalarevu | Odalarevu | Odalarevu |
| PASALPUDI | PASALPUDI | PASALPUDI |
| TATIPAKA MP | TATIPAKA MP | TATIPAKA MP |
| MANDAPETTA W + HP | MANDAPETTA W + HP | MANDAPETTA W + HP |
| KEI-RSOS | KEI-RSOS | KEI-RSOS |
| Odalarevu-G1 | Odalarevu-G1 | Odalarevu-G1 |
| Lingala Kaikaluru | Lingala Kaikaluru | Lingala Kaikaluru |
| RSGDP | RSGDP | RSGDP |
| RAVVA1 | RAVVA1 | RAVVA1 |
| GMAA | GMAA | GMAA |
| Kammapelam | Kammapelam | Kammapelam |
| SCPL Kavitam | SCPL Kavitam | SCPL Kavitam |
| Nandigama | Nandigama | Nandigama |
| BG Shirke | | |
| RGTIL | | |
| Total length-796.87 | Total length-796.87 | Total length-796.87 |

| 21-22 | 22-23 | 23-24 |
|-------------------|-------------------|-------------------|
| NARSAPUR MP | NARSAPUR MP | NARSAPUR MP |
| mori | mori | mori |
| KESANAPALLI | kESANAPALLI | KESANAPALLI |
| cairn | cairn | cairn |
| Endamaru | Endamaru | Endamaru |
| Odalarevu | Odalarevu | Odalarevu |
| PASALPUDI | PASALPUDI | PASALPUDI |
| TATIPAKA MP | TATIPAKA MP | TATIPAKA MP |
| MANDAPETTA W + HP | MANDAPETTA W + HP | MANDAPETTA W + HP |
| KEI-RSOS | KEI-RSOS | KEI-RSOS |
| Odalarevu-G1 | Odalarevu-G1-G15 | Odalarevu-G1-G15 |
| Lingala Kaikaluru | Lingala Kaikaluru | Lingala Kaikaluru |
| RSGDP | RSGDP | RSGDP |
| RAVVA1 | RAVVA1 | RAVVA1 |
| GMAA | GMAA | GMAA |

| | | |
|---------------------|---------------------|---------------------|
| Kammapelam | Kammapelam | Kammapelam |
| SCPL Kavitam | SCPL Kavitam | SCPL Kavitam |
| Nandigama | Nandigama | Nandigama |
| | RGTIL | RGTIL |
| | | |
| Total length-796.87 | Total length-796.97 | Total length-796.97 |

Deliveries :

| Deliveries,15-16 | Deliveries,16-17 | Deliveries,17-18 |
|----------------------|------------------|----------------------|
| TO-TTPK-LANCO | TO-TTPK-LANCO | TO-TTPK-LANCO |
| BGL-VIJWDA | BGL-VIJWDA | BGL-VIJWDA |
| SCPL-TDPLGDM | SCPL-TDPLGDM | SCPL-TDPLGDM |
| Lingalacustomers | Lingalacustomers | Lingalacustomers |
| APGPCL | APGPCL | APGPCL |
| TGL | TGL | TGL |
| DPML | DPML | DPML |
| SAT | RPML | SAT |
| ASL | SAT | ASL |
| GVK II | VPPL | GVK II |
| RAK | APGDC | RAK |
| SPGL | PESPL | SPGL |
| BGL Kkd | ASL | BGL Kkd |
| CIL | KGPL | CIL |
| NFCL | SEIL | NFCL |
| SVPPL | GREL | SVPPL |
| BGL Hyd | GVK II | BGL Hyd |
| MEIL | GMR VPGL | MEIL |
| | RVK | |
| For Ramagundam | REL | For Ramagundam |
| For TGPL | RAK | For TGPL |
| GGPL East Godavari | Gautami | GGPL East Godavari |
| GGPL West Godavari | SPGL | GGPL West Godavari |
| For HPCL GSPCL | BGL Kkd | For HPCL GSPCL |
| RIL | CIL | For HSIL |
| EASTERN POWER- GVK I | Silk Road | EASTERN POWER- GVK I |
| KEI RSOS - EXIT | NFCL | KEI RSOS - EXIT |
| SEIL | GMR Berge | SEIL |
| GMR-VEMAGIRI | SVPPL | |
| Vijaya porcelain | BGL Hyd | |

| | | |
|-----------------|--------------|--|
| Maharaja Paper | APEPDCL/GVKI | |
| Padmasree | reverse RIL | |
| Konaseema | MEIL | |
| GMR Energy | KEI | |
| GVK-GAUTAMI | | |
| GVK Ind | | |
| SILKROAD | | |
| RVK | | |
| GMR Rajahmundry | | |
| | | |

| Deliveries,18-19 | Deliveries,19-20 | Deliveries,20-21 |
|----------------------|----------------------|--------------------|
| TO-TTPK-LANCO | TO-TTPK-LANCO | TO-TTPK-LANCO |
| BGL-VIJWDA | BGL-VIJWDA | BGL-VIJWDA |
| SCPL-TDPLGDM | SCPL-TDPLGDM | SCPL-TDPLGDM |
| Lingalacustomers | Lingalacustomers | Lingalacustomers |
| APGPCL | APGPCL | APGPCL |
| TGL | TGL | TGL |
| DPML | DPML | DPML |
| SAT | SAT | SAT |
| ASL | ASL | ASL |
| GVK II | GVK II | GVK II |
| RAK | RAK | RAK |
| SPGL | SPGL | SPGL |
| BGL Kkd | BGL Kkd | BGL Kkd |
| CIL | CIL | CIL |
| NFCL | NFCL | NFCL |
| SVPPL | SVPPL | SVPPL |
| BGL Hyd | BGL Hyd | BGL Hyd |
| MEIL | MEIL | MEIL |
| | | |
| For Ramagundam | For Ramagundam | For Ramagundam |
| For TGPL | For TGPL | For TGPL |
| GGPL East Godavari | GGPL East Godavari | GGPL East Godavari |
| GGPL West Godavari | GGPL West Godavari | GGPL West Godavari |
| For HPCL GSPCL | For HPCL GSPCL | For HPCL GSPCL |
| For HSIL | For HSIL | |
| | | |
| EASTERN POWER- GVK I | EASTERN POWER- GVK I | |
| KEI RSOS - EXIT | KEI RSOS - EXIT | |

| Deliveries,21-22 | Deliveries,22-23 | Deliveries,23-24 |
|--------------------|--------------------|----------------------------|
| TO-TTPK-LANCO | TO-TTPK-LANCO | TO-TTPK-LANCO |
| BGL-VIJWDA | BGL-VIJWDA | BGL-VIJWDA |
| SCPL-TDPLGDM | SCPL-TDPLGDM | SCPL-TDPLGDM |
| Lingalacustomers | Lingalacustomers | Lingalacustomers |
| APGPCL | APGPCL | APGPCL |
| TGL | TGL | TGL |
| DPML | DPML | DPML |
| SAT | SAT | SAT |
| ASL | ASL | ASL |
| GVK II | GVK II | GVK II |
| RAK | RAK | RAK |
| SPGL | SPGL | SPGL |
| BGL Kkd | BGL Kkd | BGL Kkd |
| CIL | CIL | CIL |
| NFCL | NFCL | NFCL |
| SVPPL | SVPPL | SVPPL |
| BGL Hyd | BGL Hyd | BGL Hyd |
| MEIL | MEIL | MEIL |
| | | |
| For Ramagundam | For Ramagundam | For Ramagundam |
| For TGPL | For TGPL | For TGPL |
| GGPL East Godavari | GGPL East Godavari | GGPL East Godavari |
| GGPL West Godavari | GGPL West Godavari | GGPL West Godavari |
| For HPCL GSPCL | For HPCL GSPCL | For HPCL GSPCL |
| | For MEIL | For MEIL |
| | | For IOCL |
| | | For MNGL |
| | | Oduru exit point customers |

Refer flow diagram given in annexures for pipeline schematic, supply & delivery points flow & process parameters etc. for respective capacity assessment years.



4.0 DATA/ INPUTS SUBMITTED BY ENTITY

4.0 DATA/ INPUTS SUBMITTED BY ENTITY

Entity has submitted requisite data along with the capacity to PNGRB in line with the assessment Regulations, as applicable:

- a. Pipeline Network simulation snapshot indicating pipeline sections, entry and exits points, compressor station etc.
- b. Simulation Input data for each pipe section such as length (km), inside diameter (mm), wall thickness (mm), pipe wall roughness (micron), ground elevation profile, subsoil temperature, pipeline efficiency etc.
- c. Simulation Input data including all gas sources, gas entry temperature & pressure, quality & composition of natural gas, minimum and maximum gas flow etc.
- d. Equipment data.
- e. Consumer and supply contracts with contractual pressure, flow, temperature, gas quality etc. at source and delivery nodes.
- f. Latest model files for simulation as created & used by entity i.e. Input & output files of simulations/ calculations of pipeline facilities.
- g. Design/ operational inputs/ information/ data which entity considered to be applicable for carrying out the capacity assessment of pipeline facilities.
- h. During meeting, Entity has submitted the following inputs to PNGRB as per regulation for capacity assessment of the pipeline:

- Presentation by Entity During meeting (Refer **ANNEXURE-VII**)
- Capacity Assessment Applications
- As-Built Data
- Input/ Output Data considered for Simulation
- Gas Contracts Extract
- Simulation Models
- Entry/ Exit Point Pressure

Further, In line with Sr. No. 12 & 13 of Schedule-A of PNGRB regulation, EIL requested Entity to submit "Maximum achievable capacity of the pipeline under steady state condition as determined under section 5 of these regulations" and "Section wise maximum achievable capacity of the pipeline as determined under section 5 of these regulations" respectively.

Further, as per Clause No. 5.(2), Entity was requested to submit the detailed calculations of the capacity. Accordingly, it was desired that Entity will submit the year wise & step wise calculations and results based on 10 steps methodology followed by them as given under Clause no. 5.(5) of PNRB regulation. Moreover, wherever any particular option/ scenario/ parameter has been selected & considered by Entity for capacity determination purpose, the reason for the selection may also be provided for assessment purpose.

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5.0 METHODOLOGY

5.0 METHODOLOGY

PNGRB Act provide for the establishment of Petroleum and Natural Gas Regulatory Board to protect the interests of consumers and entities engaged in specified activities relating to petroleum, petroleum products and natural gas and to promote competitive markets and for matters connected therewith or incidental thereto.

By exercising its power under provision 2 (d) of the said regulation, PNGRB has planned to carry out the capacity determination for the given period of operation by an Agency/ Consultant.

For the above purpose, PNGRB appointed EIL (i.e. an agency or consultant or experts) to carry out the capacity assessment in line with PNGRB (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010.

The following methodology was adopted for meeting the above objective:

- a. Kick off meeting of the job was conducted at PNGRB office
- b. Required data/ inputs of existing pipeline network were obtained through Kick-off meeting, site visits, e-mails, telephonic discussions with PNGRB etc.
- c. Entity was requested to submit the requisite data along with the capacity to PNGRB in line with the Regulations. PNGRB was requested to provide the same to EIL. The submissions inter alia include the following as a minimum:
 - Schematic diagram of the Pipeline Network indicating pipeline sections, entry and exits points, check valve etc. Consumer and supply contracts (for each requested period for assessment)
 - Simulations in terms of pressure, flow, temperature at all source and delivery nodes using Panhandle flow equation.
 - Input data for each pipe section data such as length (km), inside diameter (mm), wall thickness (mm), pipe wall roughness (micron), knot spacing, gas equation used, ground elevation profile, temperature, pipeline efficiency, drag factor etc.
 - Input data including gas sources, gas entry temperature, quality & composition of gas, minimum & maximum gas pressure, minimum and maximum gas flow etc.
 - Performance data, Datasheets, P&IDs etc.

- Designed & Current operational data.
 - Description of current Pipeline operation w.r.t. designed pipeline facilities.
 - Model files for pipeline simulation as created & used by entity i.e. Input & output files of simulations/ calculations of pipeline facilities in line with applicable PNGRB regulation.
 - Any other inputs/ information/ data, as applicable, for carrying out the capacity assessment of pipeline facilities.
- d. The data received from Entity was reviewed by EIL to check its completeness for capacity assessment purpose. Shortfall in the submission/ clarifications was estimated & informed to Entity/ PNGRB.
- e. Entity sent presentation to EIL & PNGRB on overview of pipeline facilities, capacity assessment applications on the capacity determination & limiting condition for capacity determination
- f. Model files for pipeline simulation created & used by entity for capacity determination of subject assessment years were reviewed in detail by EIL along with verification of relevant input / output parameters and considered flow equations.
- g. EIL reviewed the native files w.r.t the approach considered by entity for capacity assessment purpose
- h. During the meeting, EIL provided comprehensive list of additional data / clarifications required from Entity.
- i. Entity provided following response w.r.t step wise compliance based on 10 steps methodology followed as given under Clause no. 5.(5) of PNGRB Capacity Regulations. Entity reply as follow-
- The entire pipeline system was configured in the selected software package operating offline (Emerson's TNet 4.2). The steady state condition of the pipeline hydraulics with contractual flow parameters (pressure, temperature and flow) at entry and exit points were simulated in the selected software package.
 - At the originating point and at intermediate points in the direction of flow, the pressure is set as a fixed parameter corresponding to the maximum allowable operating pressure (MAOP) or available compression facilities (except for depleting sources) and the maximum pressure at all exit points with contractual flow was computed.
 - Thereafter, assuming gas at the entry point (single source of gas) is unlimited and volume maximized at critical customer location/ farthest point location, the selected software is run till

- -any customer connected to the system reaches limiting condition of pressure required at the respective exit point AND/OR
- The velocity of natural gas reaches limiting value.
- The capacity at this juncture would be the maximum system capacity achievable in the pipeline system and the customer at the exit point where pressure becomes limiting becomes the critical customer.
- The simulation is carried out fixing the major source at pressure as per above step and other sources are configured in TG Net software considering evacuation volume from these other sources. The capacity of the network then is as determined following limiting conditions mentioned in previous step.
- The section wise capacity is the volume throughput through the section as per the software simulation under capacity conditions determined in above steps.
- Scheduling of sources at entry points and delivery at exit points is being done to optimize the pipeline system capacity as described under serial no.4 above.
- Exit point pressures are mentioned in Schedule A and Entity has simulated steady state (using approved flow equations Pan A /B on TNet) ensuring all Exit points meeting contractual minimum pressure and flow requirements.
- Entity has estimated the same from simulation model of entire network
- Entity has submitted the maximum achievable system capacity and average section wise capacity of the natural gas pipeline so determined, under the steady state simulation with the details of variable or constant parameters, to the Board in the specified format at Schedule A along with system flow diagram for the pipeline system including compressor stations, metering and regulating stations as applicable

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6.0 RESULTS & ANALYSIS

6.0 RESULTS & ANALYSIS

6.1 Constant Parameters used under Steady State conditions for Determining Capacity of Pipeline are as below:

1. Pipeline Outside diameter: As per data submitted by entity in capacity applications
2. Weighted average wall thickness: As per data submitted by entity in capacity applications
3. Length of the pipeline: As per data submitted by entity in capacity applications
4. Roughness for trunk line: As per data submitted by entity in capacity applications
5. Friction factor equation: Panhandle – A Modified for < 24", Panhandle – B Modified for > 24"
6. Standard Temperature & Pressure: 1.01325 Barg & 15 Deg C
7. Allowable Max velocity in the pipeline: 20 m/s
8. Average Sub- Soil temperature: 25 - 30 Deg C
9. In case of contractual pressure at any entry & exit point is within a band, the arithmetic mean rounded up to first decimal shall be considered.
10. MAOP : 72 kg/cm²g [As per inputs provided by Entity, Refer Annexure- VII]

6.2 Step wise methodology given for Capacity determination in Clause No. 5.(5) of PNGRB regulation

Capacity determination shall be carried out by Entity w.r.t. step wise methodology given for Capacity determination in Clause No. 5.(5) of PNGRB regulation.

Subsequently, all data/inputs & capacity determination carried out by Entity have been reviewed by EIL w.r.t. step wise methodology given for Capacity determination in Clause No. 5.(5) of PNGRB regulation.

In view of the same, EIL observations as below may be referred against year wise action taken by Entity for each step of methodology for capacity determination of Natural Gas Pipeline:

- (i) The entire pipeline system shall be configured in the selected software package operating offline. The steady state condition of the pipeline hydraulics with contractual flow parameters (pressure, temperature and flow) at entry and exit points shall be simulated in the selected software package.***

Entity Action:

Entity has configured the entire pipeline system operating offline on year wise basis in the selected software package.

EIL observation:

EIL during meeting observed that Entity has configured the entire pipeline system operating offline on year wise basis in the selected software package i.e. TGNET

- (ii) At the originating point and at intermediate points in the direction of flow, set the pressure as a fixed parameter corresponding to the maximum allowable operating pressure (MAOP) or available compression facilities and compute the maximum pressure at all exit points with contractual flow.***

Entity Action:

At the originating point, pressure was set in terms of operating conditions.

EIL observation:

As per regulation, at the originating point and at intermediate points in the direction of flow, the pressure should be set as a fixed parameter corresponding to the MAOP in one case and corresponding to the available compression facilities in another case.

(iii) Thereafter, assuming gas at the entry point (single source of gas) is unlimited, the selected software will be run till any customer connected to the system reaches limiting condition of pressure required at the respective exit point or maximum flow capacity is reached at entry or intermediate compressor stations (if installed in the system) or the velocity of natural gas reaches limiting value as defined in these regulations. The capacity at this juncture would be the maximum system capacity achievable in the pipeline system and the customer at the exit point where pressure becomes limiting shall be the critical customer.

Entity Action:

Entity has run the selected software with limiting operating conditions. The capacity at this juncture has been defined as maximum system capacity achievable in the pipeline system.

EIL observation:

As per regulation, for capacity assessment purpose, gas at the entry point has been assumed as unlimited with MAOP conditions & then the selected software was run till any customer connected to the system reaches limiting condition as defined in regulation.

(iv) Now simulate the flow from any other source considering the entry should take place at the pressure marginally higher than the available at that section. The exercise carried above shall be repeated to get threshold pressure limit at any location to calculate the flow exiting from each point in the entire pipeline system and the sum total of these flows shall be the pipeline capacity as determine by the approved flow equation and selected software. This would be the system capacity for multi-source pipeline system.

Entity Action:

This pipeline is a multiple entry point (several source of gas) pipeline network. Entity has run the selected software till the limiting operating conditions.

EIL observation:

Considering unlimited gas availability from entry points at MAOP, flow at exit points was increased until limiting conditions are achieved as defined in regulation.

- (v) The section wise capacity of the pipeline system shall be computed between an entry point and exit points. In case of multi entry, the section wise capacity may also be determined taking into account flow from each of the input points. Thus the first section is from first entry point to first exit point and second section shall be from first entry point to second exit point and another section and so on. This exercise shall be repeated for each of the entry point. However, in a real time working, the effect of each source will have to be workout on the pipeline capacity and the flow parameters at intermediate points shall not be allowed to reduce the system or section capacity. The procedure mentioned above shall be applicable for determining the capacity of specific section of the pipeline.**

Entity Action:

Section wise maximum achievable capacity of the pipeline as determined under limiting operating conditions has been submitted.

EIL observation:

Section wise capacity has been simulated as per methodology described under sub clause 5.(5).a (v) of capacity regulation.

- (vi) In a real time model of pipeline system, the flow at specific entry point shall be the actual available flow from that source. The gas supply from various sources at entry points and delivery at exit points shall be scheduled to optimize the pipeline system capacity.**

Entity Action :

Scheduling of sources at entry points and delivery at exit points with operating conditions is being done to optimize the pipeline system capacity as described under 5.(5).a(vi) of capacity regulations.

EIL observation:

Scheduling of sources at entry points and delivery at exit points has been done to optimize the pipeline system capacity as described under 5.(5).a(vi) of capacity regulations.

(vii) The obligatory or contractual requirement of pressure at any exit point shall determine the possible capacity within a particular section serving that exit points. Provided further that maintainability of a particular steady state hydraulics condition at any exit point shall be mutually determined between capacity determining authority and the transporter within the flexibility available in the system. The section wise capacity thus calculated with single or multiple entry and exit points shall be run with the approved flow equation and selected software package offline in the steady state operation of the system to arrive at capacities of various sections.

Entity Action:

With operating conditions, Entity has simulated all Exit points for meeting contractual minimum pressure requirements.

EIL observation:

Considering unlimited gas availability from entry point at the prevailing MAOP conditions, flow at exit points is increased until limiting conditions are achieved as defined in regulation.

(viii) This exercise shall be continued for computing section wise capacity of the pipeline system including the spur lines. In case of spur lines the tap off point shall be designated as the source point or entry point for spur line and computable (to be fed to the flow computing formula) or contractual hydraulics shall be allowable pressure at that point after accounting for the pressure drop from the tap off point to the consumer point of the spur line or branch line.

Entity Action :

While doing section wise capacity determination, Entity has estimated the same from simulation model of entire network with operating conditions.

EIL observation:

Section wise capacity was estimated from the simulation model of P/L network with MAOP conditions.

(ix) For determining, de-rated MAOP of an existing pipeline, results based on the Instrumented pig survey shall be considered to calculate de-rating factor. In absence of results of the intelligent pig survey (IPS) in any pipeline, hydro testing shall be carried out to establish MAOP of that pipeline as per provisions in the relevant regulations on Technical Standard and Specifications including Safety Standards. Provided that in absence of hydro testing the entity may put up proposal for de-rating based on random thickness survey of the pipeline. Board reserves the right to check such survey data.

Entity Action:

Entity had informed that there is derating in certain sections of the Pipeline system.

EIL observation:

Hence, de-rated MAOP as per inputs furnished by Entity has been considered for capacity determination. Refer Annexure- VII [Entity presentation] for details

(x) The entity shall submit the details of maximum achievable system capacity and section wise capacity of the natural gas pipeline so determined, under the steady state simulation with the details of variable or constant parameters, to the Board in the specified format at Schedule A along with the hydraulic gradient and system flow diagram for the pipeline system including compressor stations, metering and regulating stations as applicable.

Entity Action:

The entity has submitted capacity so determined, in the specified format at Schedule A.

EIL observation:

Noted.

6.3 Results

Entity data / inputs has been verified by EIL w.r.t stepwise methodology given in Clause no. 5.(5) and supported data / inputs submitted by Entity/PNGRB. Tabulated below are the comparative capacity assessment figures (rounded-off figures) at an interval of one year as carried out by entity & EIL:

| Assessment years | Pipeline Capacity as determined by Entity (in MMSCMD) | Pipeline Capacity as assessed by EIL (in MMSCMD) | Remark |
|------------------|---|--|--|
| | Entity | EIL | |
| | Software used - Pipeline Studio (TGNET) | Software used - Pipeline Studio (TGNET) | |
| 2015-16 | 5.70 | 11.41 | Size of Pipeline section of Tatipaka -Chinchinad P/L was 18" in assessment year 2015-16 which has been changed to 24" in the next assessment year. |
| 2016-17 | 9.58 | 12.10 | |
| 2017-18 | 8.15 | 17.37 | Sources increased by 8 no's and deliveries reduced by 7 no's |
| 2018-19 | 8.77 | 19.37 | Odalarevu source added |
| 2019-20 | 8.09 | 19.37 | |
| 2020-21 | 8.41 | 19.37 | |
| 2021-22 | 8.41 | 19.37 | |
| 2022-23 | 7.44 | 19.37 | |
| 2023-24 | 6.97 | 19.37 | |

Notes :

- As the pipeline capacity was arrived as per PNGRB regulation [based on MAOP considerations], hence variation in determined capacity for various assessment years is due to change in sources and /or deliveries and / or network length and / or network configuration etc.
- For assessment year 2018-19, Odalarevu source Impact for KG Basin pipeline network is in range of 2 MMSCMD

- It was observed that Bantumilli source was not shown in KG Basin pipeline network for the above assessed capacity assessment years.
- Size of Pipeline section of Tatipaka -Chinchinad P/L was 18” [Length 19.7 KM Approx.] in assessment year 2015-16 which has been changed to 24” in the next assessment year. The Impact on the capacity is in range of 1 MMSCMD
- Tatipaka -Oduru – KJ point section [Length 75.7 KM Approx.] was changed from 18” [original size] to 24” [replaced size] in the Assessment year 2017-18. The Impact on the capacity is in range of 0.27 MMSCMD .

□□□

7.0 SUMMARY

7.0 SUMMARY

This report presents the observations arrived at by EIL for the data/inputs furnished by Entity/PNGRB w.r.t. provisions of applicable Petroleum and Natural Gas Regulatory Board (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010. Accordingly, following results are summarized based on capacity assessment carried out by EIL :

PNGRB regulation i.e. Petroleum and Natural Gas Regulatory Board (Determining capacity of Petroleum, Petroleum products and Natural Gas Pipeline) Regulations, 2010 defines the step wise methodology for the determination of Pipeline capacity.

Hence, year wise methodology adopted by Entity has been reviewed by EIL against defined step wise methodology given in the regulation of capacity determination as clause no. 5.(5). Entity was requested to determine the capacity following the stepwise methodology given in Clause no. 5.(5) (methodology for calculation of pipeline capacity).

Entity data / inputs has been verified by EIL w.r.t stepwise methodology given in Clause no. 5.(5) and supported data / inputs submitted by Entity/PNGRB.

Tabulated below are the comparative capacity assessment figures (rounded-off figures) at an interval of one year as carried out by entity & EIL:

| Assessment years | Pipeline Capacity as determined by Entity (in MMSCMD) | Pipeline Capacity as assessed by EIL (in MMSCMD) | Remark |
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| | | | |
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- For assessment year 2018-19, Odalarevu source Impact for KG Basin pipeline network is in range of 2 MMSCMD
- It was observed that Bantumilli source was not shown in KG Basin pipeline network for the above assessed capacity assessment years.
- Size of Pipeline section of Tatipaka -Chinchinad P/L was 18" [Length 19.7 KM Approx.] in assessment year 2015-16 which has been changed to 24" in the next assessment year. The Impact on the capacity is in range of 1 MMSCMD
- Tatipaka -Oduru – KJ point section [Length 75.7 KM Approx.] was changed from 18" [original size] to 24" [replaced size] in the Assessment year 2017-18. The Impact on the capacity is in range of 0.27 MMSCMD .

