Nord Stream Project - Segmented Pipeline System: Sizing vs Design for Operation

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ABSTRACT

In presence of state-of-the-art control system and rational operational strategy, the long distance and the significant pressure drop involved in the Nord Stream Project suggested an offshore pipeline designed with design pressure segments, with the aim to minimise the steel demand. The design pressure segmentation concept, already adopted in long distance large diameter Norwegian trunklines to Germany (Europipe II) and to the UK (Langeled), is based on the fact that the downstream part of a long transmission pipeline never experiences pressures close to the values required at export point. Therefore the pipeline can be mechanically sized with reference to different design pressures, stepwise decreasing while moving from upstream towards downstream end, which consequently allow decreasing the pipeline steel thickness.

In order to maximise the cost saving of the overall EPCI project, the number and the extension of the pipeline segments and the relevant design pressure values have been optimised in the Nord Stream Project taking into account the results of:

- Thermo-hydraulic and mechanical analyses.
- Considerations about steel pipe procurement.
- Specific requirements during pipeline installation and pre-commissioning activities.

During the optimisation of the stepwise design pressure, it was enhanced the no-need of mid-way gas compression and relevant intermediate service platform (along the pipeline route). This was based on technical and economical evaluations of pros and cons with respect to:

- Construction.
- Pre-commissioning.
- Operations.
- Abandonment.

The reference code for Nord Stream Project design (DNV-OS-F101) allows a pipeline to be divided into segments with different design pressures and without physical barrier (like shut-down valves) between the segments, provided that there is an adequate system to protect the pipelines from overpressure. On this purpose, Nord Stream pipeline system is provided with a safety instrumented overpressure protection system, namely Pressure Safety System (PSS), which continuously monitors pipeline inlet and outlet pressures and automatically closes the pipeline inlet shut-down valves in case pressure set points are reached. Pressure set-points implemented in the look-up tables of the PSS have been determined by means of hydraulic analyses during the project engineering phase with the purpose to ensure the compliance with the Incidental Pressure anywhere in the pipeline in case of incidental events (e.g. blockage at line outlet, blockage or restriction in the pipeline, high inlet pressure due to the sudden increase of inlet flow rate).

Nord Stream pipeline system is also provided with a real-time pipeline hydraulic model which continuously computes the process parameters along the pipeline on the basis of field measurements at pipeline inlet and outlet. This hydraulic model allows the operator the continuous monitoring of the transport conditions inside the pipeline system (including flowing pressure profile and settle-out pressure profile) and comparisons with the operating limits which have been determined during the project engineering phase.

ACRONYMS

- CSP Compression Station Portovaya
- DNV Det Norske Veritas
- GRT Greifswald Receiving Terminal
- ISP Intermediate Service Platform
- JT Joule-Thompson
- KP Kilometer Post
- LRFD Load and Resistance Factor Design
- ND Nominal Diameter
- NS Nord Stream
- MAII Maximum Allowable Incidental Inventory
- MAIP Maximum Allowable Incidental Pressure
- MCC Main Control Centre
- MSL Mean Sea Level
- PAS Pipeline Application System
- PC Personal Computer
- PHS Pipeline Hydraulic Simulator
- PSS Pressure Safety System
- R&D Research and Development