ABSTRACT

The Nord Stream Project (NSP) twin pipeline system running from Vyborg, Russia, to Lubmin, Germany, cross several areas affected by severe seabed unevenness which are located mostly in the Russian and Finnish sectors of the pipelines route in the Gulf of Finland. As a consequence the pipeline vertical configuration typically presents several consecutive free spans separated by different lengths of pipeline sections where on seabed. The discontinuities in support points induce bending stress on the pipeline which may be unacceptable when both static and fatigue strengths are considered.

The remedial works, consisting of seabed preparation and free span reduction by means of gravel dumping, were designed at the detailed design stage based on the predicted as-laid pipeline configuration and seabed properties. However several major uncertainties existed at the design stage that could threaten pipeline integrity in the temporary condition and also through the design life. The presence of very softy clays could threaten the geotechnical stability of the rock intervention works. The unpredictability of the soft clay strength and the presence or not of thin sediments layers over rock outcrops could change the final pipeline configuration. Also several large unavoidable boulder fields were crossed where the final pipe profile could not be reasonably predicted. Therefore, detailed engineering analysis was extended and integrated into the project execution phase and the design continuously updated and optimized on the basis of the actual pipeline configuration measured during the survey campaigns performed just after pipeline installation.

The scope of the detailed design review using the as-found pipeline configuration (both as-laid and post-hydrotest) was to check the pipeline integrity during its whole lifetime and, at the same time, to target the most cost efficient solution. Actually, it is typical for the execution of large offshore projects the necessity to minimize demobil/stand-by time for big vessels and equipments in order to optimize the overall construction schedule and reduce cost consequences. Therefore, a real-time analysis (i.e. carried out during the construction phase) allowed to:

- Prevent undue conservatism in the original design that would have been required to take account of all the above uncertainties.
- Detect and correct unpredicted pipeline configurations that would have threatened pipeline integrity.
- Take a prompt decision regarding the need, quality, planning and entity of the remedial work to be carried out.
- Plan availability and mobilization of particular equipment necessary for this type of operation, as well as to programme in due time the supply of materials for the intervention.

This paper presents the procedure set up during follow-on engineering to analyze the large amount of data collected during the ordinary survey (i.e. just after construction and in operation) and extra-ordinary survey (i.e. after pressure test) of such a long pipeline system (i.e. about 1220km).

KEY WORDS: pipeline; survey data; intervention works; free-span; on-bottom roughness; global buckling.

NOMENCLATURE

ASL: As-Laid
BE: Best Estimate
BOP: Bottom Of Pipe
CSBL: Central Seabed Level
DTM: Digital Terrain Model
FEM: Finite Element Model
GUI: Graphic User Interface
IAL: Immediately After Laying
IW: Intervention Work
KP: Kilometer Post
LB: Lower Bound
OBR: On-Bottom Roughness
PH: Post-Hydrotest
TOP: Top Of Pipe
WD: Water Depth
UPH: Uplift
UB: Upper Bound