Very Large Size Valves and Actuators – Design and Testing

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ABSTRACT

The Nord Stream Pipelines offshore the Baltic Sea have been designed for a life of 50 years. Special focus was put in the selection of the mainline actuated valves: The design of the pipelines isolation system was driven by the achievement of high levels of safety, reliability and availability. 48-in, Top-Entry metal-seated Ball Valves and Double-Expanding Gate Valves were selected. The supply of these valves involved very challenging developments for the design, manufacturing and testing of valves and actuators, also considering the demanding environmental conditions on the Russian side. This paper summarizes the most relevant issues related to the design and testing of valves and actuators.

INTRODUCTION

The twin Nord Stream Pipelines, 48-in dia., 1,200+ km long, connecting Vyborg (Russia) to Greifswald (Germany) offshore the Baltic Sea, have been designed with the segmented pipeline concept (with Design Pressures of 221 barg to 177.5 barg), for a life of 50 years. Special focus was put at the early design stage in the selection of the mainline actuated valves, which have the functions of pipeline Pressure Protection (PPS), Emergency Shut-Down (ESD) and Isolation. The development of the isolation system of the pipelines was driven by the achievement of high levels of safety, reliability and availability over the system design life.

48-in, Top-Entry metal-seated Ball Valves (PPS & ESD) and Double-Expanding Gate Valves (Launch & Receive Traps isolation) were selected as the most appropriate valve types for their operational function. The main issues related to valve design were:

- Achievement of very good metal-to-metal seal performance recovering the inherent massive deflections consequence of the valve size, combined with a high operating pressure.
- Guarantee of long term operation, avoiding any need of maintenance shut-down.

This was obtained through:

- Special design of seat-to-ball sealing surfaces to keep the lowest possible contact stress, reducing wear during operation.
- Redundancy of pressure barriers both internally and toward the environment.
- Low fatigue usage factor of all elements.
- Introduction of features to flush clean the sealing surfaces.
- Enhanced material selection to avoid any deterioration of critical valve areas in long-term service.

Valves were subject to Prototype Testing (including the application of large external bending moment, and the verification of valve maintainability under bending) and extensive Factory Acceptance Test (FAT).

Double-acting spring-activated electro-hydraulic actuators (fail-to-close) were selected for the PPS & ESD valves. The valve design torque of 750,000+ Nm led to select an actuator torque of 1,250,000 Nm. The key issues for the selection and design of the actuators were high reliability and availability of the control system. The main design issues were:

- Study of the best kinetic system to suit the valve torque requirements, limiting the actuator dimensions, and optimization of accumulators sizing.
- Optimization of the spring-pack design for torque requirements.
- Material selection for low temperature application.
- Design for easy handling and installation.
- Design of the Hydraulic Power Unit (HPU) and control system to suit the high reliability project requirements with fault tolerant control system in 2oo3 configuration.
- Detailed fault analysis to ensure the required SIL 3 level.
- Design and manufacture of test equipment for Prototype Testing.

Actuators were subject to extensive Prototype Testing (3,000 + 3,000 full cycles at the min and max design temperatures) and integrated FAT.