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Onshore Pipeline High-Grade Steel for Challenge Utilization

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High-pressure pipeline transportation is one of the key technologies to connect remote gas fields and deliver gas at competitive prices to consumer markets. Arctic regions will become more attractive in the near future as large gas resources are located there. Long onshore pipeline systems, characterized by high-strength steels (above API 5L grade X80, i.e., exceeding 555 MPa yield strength) operated at high internal gas pressure (more than 10–12 MPa) in many cases appear to be the most convenient transportation option. This paper highlights the latest follow-up from a long-lasting R&D program launched by Eni, together with industrial/technical partners, on the exploitation of commercially available options with high-grade steels for onshore applications even in harsh environments. The results obtained in this R&D program can be useful even for applications in Arctic onshore or offshore scenarios.

NOMENCLATURE

CT	Compact Tension
CTOD	Crack Tip Opening Displacement
CWP	Curved Wide Plate
D	Outer Diameter
D/t	Ratio of outer diameter to wall thickness
FL	Fusion Line
HAZ	Heat-Affected Zone
HSAW	Helical Submerged Arc Welding
LNG	Liquefied Natural Gas
LSAW	Longitudinal Submerged Arc Welding
n	Steel strain hardening exponent
PGD	Permanent Ground Deformation
RT	Room Temperature
SBD	Strain-Based Design
SENB	Single Edge Notch Bending
SENT	Single Edge Notch Tension
t	Pipe wall thickness
TGD	Temporary Ground Deformation
UOE	U-O Expansion pipe forming
UF	Usage Factor
WM	Weld Metal
Y	Pipe yield strength

INTRODUCTION

Natural gas has the chance to be one of the most important and strategic fuel sources in the years to come, even if the growth of the renewable source will play a fundamental role in the "next green power energy," being the "greenest" among fossil fuels. Natural gas represents a continuous and reliable energy source on an economically viable base and a long-term span. Energy industries have analyzed several potential routes for gas exportation from giant midcontinental fields to final "end-user markets" via either pipeline or liquefied natural gas (LNG) ships. To be economically viable, these analyses include constructability and environmental impact evaluations, route optimization, proper material selection, and optimum hydraulic diameter and wall thickness selection, as well as sizing of intermediate gas-compression stations.

High-pressure pipeline transportation is one of the key technologies to connect remote gas fields and to deliver gas at competitive prices to consumer markets. Several independent technical and economical evaluations have shown how natural gas pipeline transportation systems based on:

- traditional construction techniques,
- low-alloy high-strength C-steel (above API 5L grade X80),
- operating gas pressure higher than 10 MPa, and
- pipeline length of more than 1,000 km

are the only solutions to exploit "stranded gas fields."

This solution allows pipeline projects to meet all the requirements and compete on the "gas to market" for distances greater than 1,000 km, even for large-volume transportation. The main economic advantage of high-pressure gas transportation consists of reduced capital expenditure (CAPEX), saving in construction costs, and operational expenditure (OPEX), as a result of a reduced number of intermediate compression stations.

This paper highlights the latest follow-up from a long-lasting R&D program launched by Eni, together with industrial/technical partners, on the exploitation of commercially available options with high-grade steels for onshore application even in harsh environments. The idea was to fill existing gaps in several fields dealing with pipeline integrity, based on an advanced design approach mixed together with "in field" practical requirements. The paper highlights mainly the most relevant aspects linked to the following:

- design (strain-based and oriented for large ground movements)
- integrity issues (fracture initiation and propagation prevention)
- harsh environmental operating and design conditions such as those in Arctic regions

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