

Offshore Pipelines: Actual and Future Scenarios

Roberto Bruschi – roberto.bruschi@saipem.com Lorenzo Marchionni – lorenzo.marchionni@saipem.com Antonio Parrella – antonio.parrella@saipem.com Lorenzo Maria Bartolini – lorenzo.bartolini@saipem.com

presented in DNV GL Pipeline Innovation Forum 2014 - Høvik, Norway, March 26-27th , 2014

Pavia, November 21st, 2014

SAIPEM – WHO WE ARE

Saipem is an international company leader in Services for Oil & Gas Industry.

It operates in Onshore and Offshore environment, with a strong focus in remote areas and deep waters.





OFFSHORE PIPELINE PROJECTS



FIRST THINGS FIRST....



OFFSHORE PIPELINES - PROJECT DEVELOPMENT PHASES

PROJECT TASKS AND DESIGN CHALLENGES

1) Pre-feasibility Study / Concept Development

- Pipeline system configuration (ND and number of lines)
- Flow characterization and assurance
- Route selection vs. environment and geohazard characterization
- Line-pipe material and wall thickness selection vs. fabrication technology
- Installation Capability
- 5) Detailed Design pre-construction oriented
 - Pipeline Configuration Optimization
 - Detailed Material & Procurements
 - Installation Analysis
 - Seabed Intervention Works Optimisation
 - Maintenance & Repair Strategy etc.



- Route Optimisation
- System Design and Flow Assurance
- Detailed Geo-hazards Study

- 2) Survey Campaign for Pipeline Route Corridor
 - Intervention Work Minimization
 - Geohazard Risk Reduction

3) Feasibility Study

- Route Optimisation
- Preliminary Geo-hazards Design
- Operability Study and System Design
- Material Selection and Corrosion Management
- Installation
- Seabed Intervention Works
- Seabed Intervention Works
- Pipeline Design for Operation and Installation
- Linepipe Material & LLI Procurements
- System Pressure Testing Philosophy
- Maintenance & Repair etc.

salpem

COST EFFECTIVENESS AND RELIABILITY

- Going in the Depths (3000m)
 - Iarge capacity equipment, sea & station keeping, comunication & control
- Aggressive Fluids & HP/HT
 - Long distance transportation, flow assurance, thermal insulation & heating,
- New Materials
 - High strength, light weight, corrosion resistant
- Welding & Coating
 - Corrosion, high temperatures, exotic materials
- Pipe Concepts
 - Thick walls, pipe in pipe, bundles

Integrity management

Monitoring, inspection, maintenance, repair







The Rationale of Design Flow

PREMISES FOR HSE PROJECT PLAN



NUMBERS ARE FUN, BUT ... (overcoming 10⁻⁶ syndrome)

PREPAREDNESS TO TACKLE PIPELINE DAMAGE

• REVEALED* (10⁻³/km•y < prob) – MINOR

Stable defect, not jeopardizing the structural integrity:

NO INTERVENTION IS NEEDED

• REVEALED (10⁻⁶/km•y < prob < 10⁻³/km•y) – TO BE MONITORED

Defects that are not hazardous at the moment they are revealed but may be increasing with time and potentially jeopardising the structural integrity of pipeline:

A SURVEY PROGRAMME IS NEEDED

• REVEALED (10⁻⁷/km•y < prob < 10⁻⁶/km•y) – HAZARDOUS WITH THE TIME

Defects that are not hazardous at the moment they are revealed but likely increasing with time and jeopardizing the structural integrity of pipeline:

REPAIR WITH PLANNED DE-COMMISSIONING IS NEEDED

• NOT REVEALED (prob < 10⁻⁷/km•y) – BEFORE LOSS OF CONTAINMENT HAS OCCURRED

Defect which has to be localized

REPAIR WITH EXTRAORDINARY DE-COMMISSIONING IS NEEDED



* ordinary/extraordinary survey

CHALLENGES BY DISCIPLINE ...



... FLOW ASSURANCE

- Optimization of strategic links for long distance transportation of large gas volumes across sea, including redundancy targeting flow availability.
- Control and monitoring of transportantion, including failure management and preparedness to repair.
- Integration with concept definition of complex field development, including precommissioning and operation management.
- Numerical modelling of demanding transport conditions (HP/HT, thermal insulation, corrosion, etc..), performing simulation of ordinary and extraordinary conditions, steady states and transients etc..., with care for pipeline integrity management





Original Diagram Courtesy of DeepStar

... OCEAN ENGINEERING

- Specific meteocean campaign, whether for floating or submerged structure, coupled with extensive numerical modelling, for both installation and operation & maintenance (new free spans, over-stress/strain, fatigue ...) needs.
- Confident prediction of weather windows (short and medium run) for installing critical inline structures, manifolds, subsea, etc...
- Monitoring of local conditions with risk of impact from eddies, solitons etc... on installation operations and vessels.



 Meteocean analysis for marine spread optimization during construction (pipe supply, minimum transfert time for equipment transportation

equipment, transportation ...)

 Numerical modelling of surface and nearbottom hydrodynamics, global and local (interaction with features), to assess if stabilization/protection is needed to tackle severe flow speeds





new ocean districts (East Africa, South-East Asia, Arctic)



in new meteocean environments: rough sea, ice, freak waves, cyclones, solitons.





... SEABED MECHANICS

- Active seabeds and shallow waters, impact of global erosion and local scouring on stability/integrity of pipelines and ancillaries, definition of protection measures.
- Soft soils in deep waters, embedment and sinking under loads from thermal expansion recovery, interaction with fixed or sliding structures.
- Continental slopes, slumps and debris flow/turbidity currents, crossing canyons and slits, proximity to features as mud vulcano.
- Numerical modelling of slope stability, potential trigger of mass flow and turbidity currents, downhill run out etc.., to establish safe pipeline routing and location of subsea



000975

ABUBUR

... MATERIAL & WELDING

- High grade steels, thickwalls, stringent geometric tolerances, weldability and toughness issues for linepipe, SAWL and seamless.
- Corrosion resistance alloy, metallurgical or mechanical inox lining, plastic liner and internal coating.
- Deformation capacity and fatigue strength of linepipe and girth welds, prestine and residual after installation, qualification and testing.



 Laboratory test for strain based design, specific fatigue strength requirements, sour condition, in combination with numerical modelling to assess strenght capacity aganist realistic demand.





a new world of materials and pipe concepts



- Aggressive transported fluid impact on design process is a matter of fact (corrosion allowance, HIC, SSCC, etc).
- Need for corrosion resistant alloy/pipe concepts able to meet the challenge of low pipeline failure probability target over the lifetime

New pipeline concepts for deeper waters, longer distances, harsher environments, HP/HT reservoir, sour fluids ...



















... MECHANICAL DESIGN

- General consensus on reliability based design criteria, LRFD, continuous upgrading of design formats (limit state equations, relevant parts of safety factors) in parallel with of R&D findings
- Accounting for realistic material performance on actual strength capacity, particularly Lüder plateau, uniform elongation etc...
- Dedicated calibration of partial safety factors for new applications, where design criteria are linked to environmental sensitivity and remoteness (safe life vs fail safe)

 Numerical modelling for both response analysis (realistic demand) and strength capacity assessment (actual material)







mechanical design for arctic pipelines

- Design addressed to reduce at minimum environmental impact during construction and operation
- The harsher and more remote the environment, the higher the safety target, the more extensive the experimental and numerical characterization of the environment
- Large strains induced by extreme ice load scenarios call for SNBD rather than SBD
- Experience on steel performance at low temperatures available, but recognized international qualification standards are incomplete
- Reliability-based Limit State Design specific for arctic pipelines for a rational/engineering design approach to avoid gross error (pipeline failure) or unduly conservatisms (excessive/unfeasible/expensive mitigations). How to include in LRFD and which partial safety factor?







saipem

... DESIGN FOR INSTALLATION

- Lay vessels capable to meet route alignment in difficult conditions, including steep slopes and narrow corridors
- Laying thicker and heavier pipelines under demanding performance requirements, sometimes with critical inline structures meeting stringent seabed targets
- High capacity equipment capable to handle, hold, control and protect the pipeline during installation, with real time monitoring of relevant lay parameters



 Numerical simulation of pipe laying, static under specific setting, dynamic under wave induced oscillations and slow drift counteracted by mooring lines or DPI





safe installation of subsea and sealines



... DESIGN FOR OPERATION

- Survey data based response analysis, to access compliance with design criteria under demanding process conditions (HP/HT), severe near-bottom hydrodynamics, seabed roughness and soil stability/mobility
- Analysis of interference from/to thirth party activity, whether regularl (fishing) or incidental (anchor dragging), monitoring and protection



 Advanced use of inspection and monitoring, coupled with dedicated numerical modelling, both engineering tool from early project development stage to avoid over design and perform fine tuned intervention works on the pipeline as built.





far beyond pD/2t



... PIPELINE INTEGRITY MANAGEMENT

- Strategic trunklines, external and internal survey, ٠ ordinary and extraordinary, condition assessment, mitigation measures implementation, feed back
- Field development pipeline network, old and new, ٠ external and internal survey, knowledge based assessment (product- process-layout -flow assurance-corrosion-integrity).
- Database and hardware/software to ٠ store, retrieve and process, condition diagnosis, check list for survey assistance.







