Pipeline system pressure tests

JIP-Replace

Pre read for SUT-Perth

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against regulatory requirements, standards and specifications

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new technologies, data, and operational concepts

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on safety, technology, risk efficiency, and performance

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System Pressure Test

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Introduction

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STANDARD

DNV-ST-F101

5.2.2 Pressure test philosophy and criteria

5.2.2.1 The pressure containment structural integrity of the pipeline system is ensured by:

- design criteria and safety factors
- manufacturing requirements
- pressure testing all pressure containing parts by
  - strength test prior to being installed in the pipeline system; by strength pressure test (mill pressure test for pipe joints [7.5.1] and FAT/hydrostatic test for components [8.7]), or through qualification programs and
  - gross error leak test; system pressure test, see [5.2.2.2] and [10.10.3], and hydrostatic test for pipeline assemblies, see [7.5.1]. For single connections, making up parts of the pipelines after system pressure test, the following apply:
    - girth welds shall have additional NDT (golden weld), see [10.5.3]
    - pipeline components shall be back seal tested after installation.

Unless waived by [5.2.3] or [7.5.1.6].

Submarine pipeline systems

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Introduction

5.2.3 Replacement of system pressure test

5.2.3.1 For pipelines where the disadvantages of the system pressure test are extraordinary, replacement of the system pressure test with alternative means are allowed subject to agreement. The alternative means shall document the same safety level as with the system pressure test.

5.2.3.2 To replace the system pressure test, the pipelines shall fulfill the following criteria:

1) Only C-Mn steel pipes with SMYS ≤ 485 MPa or lined and clad pipes with C-Mn backing steel pipes with SMYS ≤ 450 MPa shall be used.
2) Only seamless pipes or SAWL pipes expanded to above 0.5% strain shall be used. Expansion is not required for buckle arrestors produced with SAWL

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pressure is not required as the full pressure containment capacity is not utilized, see hold (Equation (5.7)).

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4) Pipeline sections shall only contain non-welded connections if these are leak tested after installation in the pipeline system to 5% above the local incidental pressure. Back-seal testing may, subject to agreement, be an acceptable leak test of non-welded connections.

Guidance note:

Back seal test is a severe test that fails more frequently than a proper leak test would do. It also requires connections and fit-ups that in all may make it a less preferable test.

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5) Welding, including repair, shall not be performed using cellulosic electrodes.
6) Girth welds shall be inspected by automated ultrasonic testing (AUT) to consistently and accurately measure flaw size.
7) The pipeline system design shall be based on well proven solutions with a good track record and shall not include any new design elements.
8) Girth welds shall not be exposed to accumulated nominal plastic strain from mill pressure test to commissioning exceeding 2% before commissioning e.g. reeled pipelines are excluded.

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Joint Industry Project - Participants

Operators	Contractor/Manufacturer	Authorities
INPEX	Sumitomo Corporation – Enriching lives and the world	NOPSEMA
TOTAL	wood.	PETROLEUM SAFETY AUTHORITY NORWAY
equinor	MITSUI & CO.	HSE
ExxonMobil	海油工程 COOEC	anp – Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
Chevron	SAIPEM	
eni	MARUBENI ITOCHU STEEL	
Woodside	INTECSEA – WorleyParsons Group	
Shell		
Nord Stream 2 – Committed. Reliable. Safe.		

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JIP Replace

- State of the Art review
- Failure review
- Cleaning, Gauging, Drying and Inerting review (not tonight… sorry)
- Guideline

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State of the Art review

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State of the art review

- Norman Wells: 870 km onshore pipeline (Canada 1985). Permafrost areas.
- Gulf of Aqaba: 14.5 km offshore pipeline (2003). Long spans in deep water and environmental concern
- GulfTerra (Phoenix): 122 km offshore pipeline segments of the deep-water Phoenix Gas Gathering System (Phoenix).
- Stittsville and Deux Rivières Loops: around 30km each onshore pipeline (2005). Cold temperature and environment.
- TurkStream: (previously South Stream) 2 x ~930 km offshore pipeline (2018-2019).
- Nord Stream 2: 2 x ~1234 km offshore pipeline (2021). Large volume, environmental and segmented testing

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State of the Art findings

- The pipelines were generally long and large diameter gas export lines.
- All applies industry recognised pipeline code for design, manufacturing and installation.
- Where information was available, it was stated the they used 3rd party involvement, in some cases certification.
- All rely on strict QA/QC procedures throughout the project.
- None have reported leaks after commissioning. (However, five cases do not build reliable statistics)
- The most recent projects used the FMECA approach to identify additional safeguards.

Failure Review

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Summary data gathering

- Oil and gas database
  - very limited number of case
  - Voluntary reporting of incident
  - Various level of incident description
  - Small failure considered as part of normal operation
- Conference paper
  - Good incident description
- JIP participant
  - Very little description
- DNVGL internal
  - Good incident description

47 cases:

- **32 success i.e. leak during SPT**
- **5 near misses**
- **3 leak after SPT**
- **2 induced by SPT**

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Failure review by component all

Looking at 2015-2019: 13 cases

- 7 mechanical leak path
- 2 mechanical leak path after SPT
- 2 through thickness crack (not concluded)
- 1 crack delayed hydrogen cracking (near miss)
- 1 Large opening drop object (Pipeline crushed by drilling jack-up spud can)

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Failure review against DNVGL-ST-F101 code requirements

- For most of the failure cases, code clauses were identified
- The case without clauses are cases for which the failure was not described with enough details to derive a potential failure cause.
- Most of the clauses identified for the pipelines and spools are mandating a level of equipment and procedure qualification.

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Guideline

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Replace methodology

Select pipelines design with good track record, due to material selection, design and installation method

Providing a methodology for how to develop a comprehensive quality management plan, referred to as the Replace Plan

Replace methodology

Select pipelines design with good track record, due to material selection, design and installation method

- **Prerequisites:** Requirements to the pipeline design that shall be met. These exclude pipelines that do not have a good track record.
- **Requisites:** Requirements mostly linked to quality assurance and quality control that shall be met. Some of these will exclude pipelines that do not have a good track record, and some will be reflected in the Replace Plan.
- **Additional Safeguards:** Based on Replace project specific FMECA, mitigation measures shall be identified and implemented. These will constitute the main part of the Replace Plan.

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Repla

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2) Only seamless pipes or SAWL pipes expanded to above 0.5% strain shall be used. Expansion is not required for buckle arrestors produced with SAWL.
3) Mill pressure test shall be performed according to [7.5.1] and not waived in accordance with [7.5.1.6].

Guidance note:

Buckle arrestors shall be tested to minimum the same pressure as the connected pipe joint in the mill pressure test. Higher pressure is not required as the full pressure containment capacity is not utilized, see hold (Equation (5.7)).

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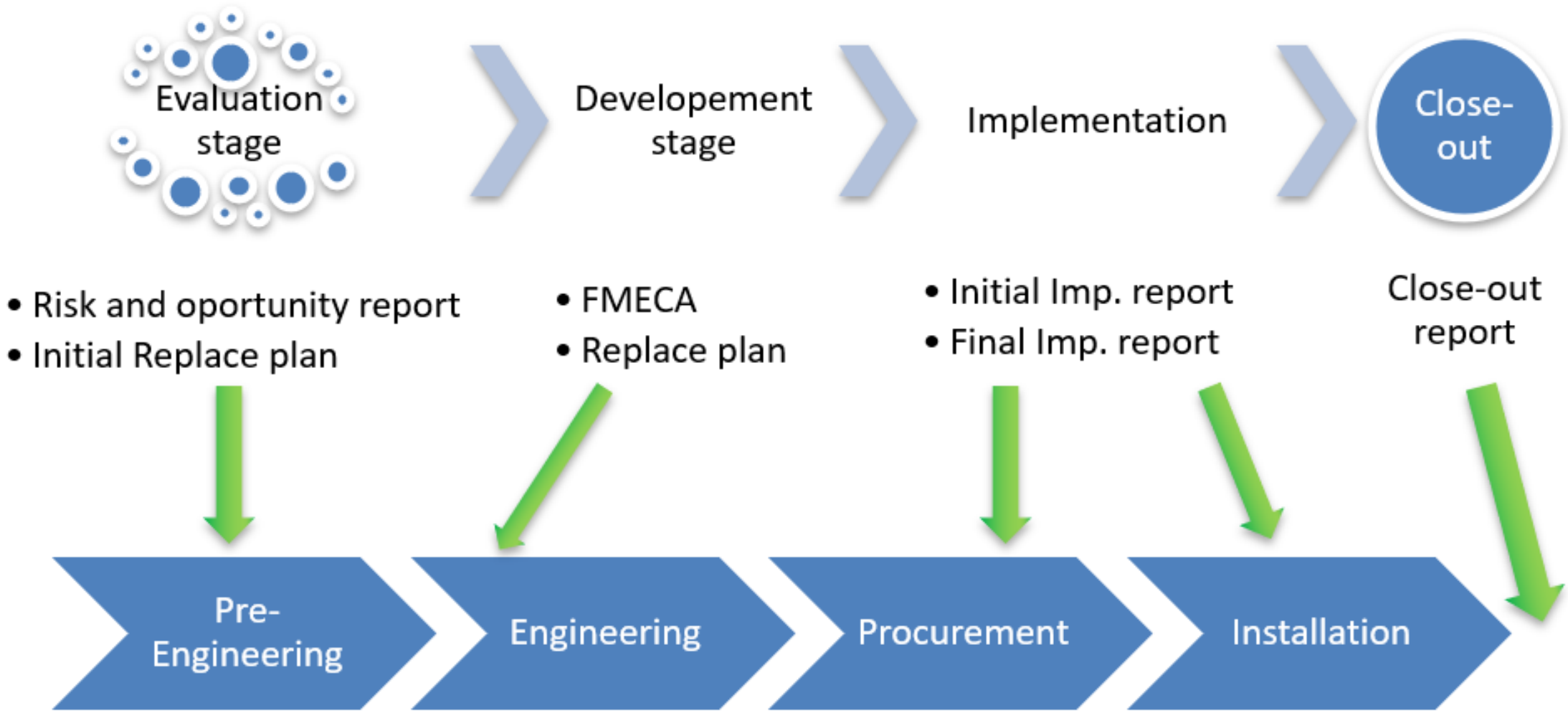
Replace methodology



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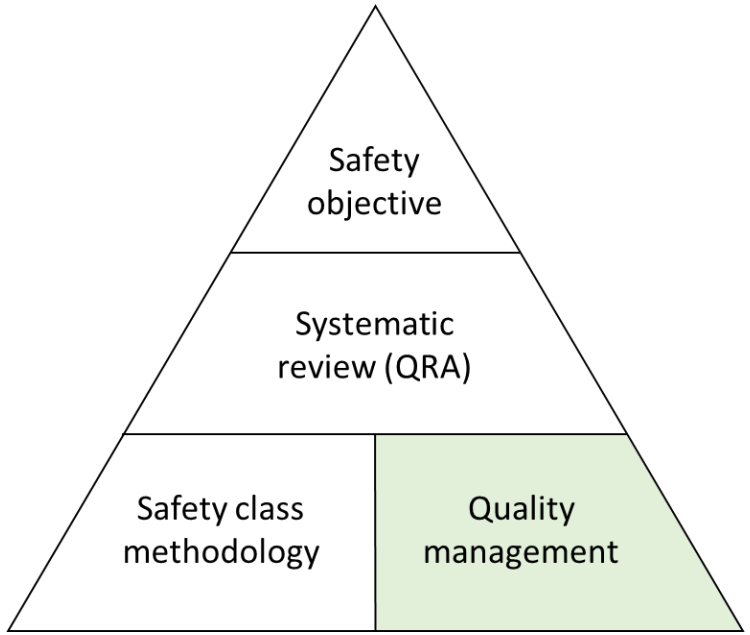
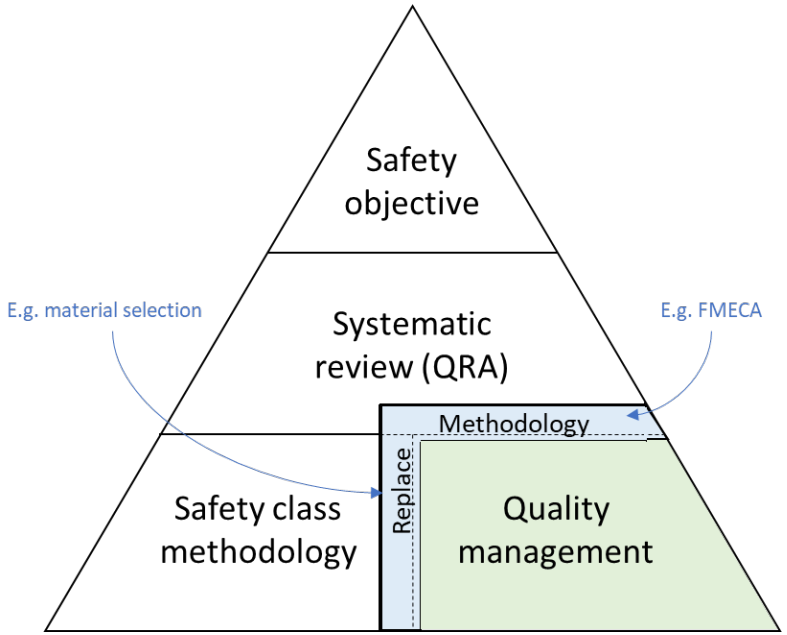
Replace methodology

- DNV-ST-F101 allows for replacing the SPT with alternative means for pipeline systems where the disadvantages with performing the SPT are significant.
- The Replace Methodology is illustrated using the safety hierarchy in DNV-ST-F101.



Normal approach with a SPT



Replace Methodology

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Conclusion

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Conclusion

- The main advantages of the SPT are that:
  - ✓it is universally accepted by the industry
  - ✓it provides evidence of final system assembly completion i.e. contractual obligation.
- The main disadvantages of the SPT are:
  - ✓safety risk exposure of personnel carrying out the SPT
  - ✓environmental impact of chemicals associated with water treatment and their discharge after testing
  - ✓possible integrity risk related to internal corrosion
  - ✓schedule of test activities for some pipelines, particularly for longer gas pipelines
- For long pipelines the system pressure test sensitivity over the 24h hold is limited to large defect as smaller leak can be difficult to detect.

Conclusion

- Similarly, the advantages of the alternative means for hydrotest replacement can be summarised as:
  - ✓Reduced safety risk exposure for personnel carrying out alternative means as compared to hydrotest activities
  - ✓Reduced environmental impact
  - ✓These measures to improve the pipeline integrity (relative to the hydrotest) by application of methods likely to reveal smaller defects or other issues not revealed by the hydrotest, i.e. potential for improved quality
  - ✓Reduced schedule requirements

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Thank You

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