

A Comparison of Reliability and Function Testing Requirements for Wells Jahon Khorsandi, Risk Management Engineer

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Agenda

Reliability & function testing of well barriers:

- Background
- Requirements: NORSOK D-010 (Rev. 4)
- **Requirements:** NORSOK S-001 (Ed. 4)
- **Comparison** of alternatives



Greater Ekofisk Area





Background:

Barriers (Management Regulations §5):

- What barriers are needed
- Strategies and principles for their design, use and maintenance
- The function(s) the barriers are intended to fulfill
- Performance requirements for the barriers to be effective



Source: PSA (2017), Barrierenotat



Source: Sintef (2016) Report no. A27623, adapted from PSA (2013), Barrierenotat





Background - Function Testing:

- What: Safeguard barrier performance
 - Verify barrier function, identify and correct failures.
- **Why:** Ensure barriers are in place to maintain acceptable levels of risk throughout an asset's (operational) lifecycle.



Source: PSA (2017), Barrierenotat



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Background – Maintenance Requirements:





NORSOK Standard D-010 Rev. 4. June 2013 Well integrity in drilling and well operations This NORSOK standard is developed with broad petroleum industry participation by interested parties in the Norwegian petroleum industry and is owned by the Norwegian petroleum industry represented by the Norwegian Increasing percent increases and a borner of the increasing increases increases increases of the increases o Standards Norway Telephone: + 47 67 83 86 00 Strandveien 18, P.O. Box 242 Fax: + 47 67 83 86 01 N-1326 Lysaker NORWAY Email: petroleum@standard.no Vebsite: www.standard.no/petrole Copyrights reserved

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Function Testing:

8.7.1 Leak and function testing of well barrier elements

Minimum test frequency is defined for the WBEs in section 15. The test frequency should be regulated based on:

- a) experience data;
- b) changes of the well flow composition increasing risk of deposits, scale, corrosion, erosion and high production and injection rates.

The historic performance and reliability data used to justify a change in the test frequency shall be documented.

15.8 Table 8 – Downhole safety valve

The valve shall be leak tested at specified regular intervals as follows:

a) monthly, until three consecutive qualified tests have been performed;

thereafter

b) every three months, until three consecutive qualified tests have been performed;

thereafter

c) every six months;





Q: What is the rational behind the 1-1-1-3-3-3-6M...test frequency?





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Reliability and Availability:

8.7.1 Leak and function testing of well barrier elements

If a safety critical valve type has a failure rate on the installation which exceeds 2% within a 12 month period, measures shall be taken to improve the reliability of the valve type in general.

Q) What is the link between the test frequency, the reliability requirement, and risk?



NORSOK STANDARD S-001 Edition 4 February 2008 Technical safety IN NORSOK standard is developed with broad petroleum industry participation by interested parties in the This NORSOK standard is developed with froat percent industry participation by melessed parties in the konvegian petroleum industry and is owned by the Norwegian petroleum industry represented by The Norwegia Di Industry Association (OLF) and The Federation of Norwegian Industry. Please note that whilst every effort ha een made to ensure the accuracy of this NORSOK standard, neither OLF nor The Federation of Norwegia ndustry or any of their members will assume liability for any use thereof. Standards Norway is responsible for t tion and publication of this NORSOK standa Standards Norway Strandveien 18, P.O. Box 242 Telephone: + 47 67 83 86 00 Fax: + 47 67 83 86 01 N-1326 Lysake mail: netroleum@standard ne NORWAY Copyrights reser

4.6 Integrity – availability and reliability

Reliability, Availability & Function Testing:

The minimum requirements to availability and reliability for safety functions/systems shall be determined based on IEC 61508 or IEC 61511 or other specific safety analysis/risk assessments as relevant for the safety function in question.

All relevant safety function/systems shall be subject to testing at regular intervals. Test intervals should be determined based on relevant standards, criticality analysis and experience. For instrumented safety systems, see OLF Guideline No. 070.



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Safety Instrumented Systems:





Reliability of Safety Instrumented Systems:

Risk reduction framework - IEC 61508:



Source: Adapted from Norsk Olje og Gass – 070 (As shown in Figure A.1 in IEC 61508-5)

Safety Integrity Level (SIL):

Applicable for safety instrumented systems

If a system has an important function, it should be reliable, and the <u>more important</u> the function, the <u>more reliable</u> it should be.

	Safety Integrity Level (SIL)	Prob. of Failure on Demand (PFD _{avg}) – low demand systems
ez	4	10 ⁻⁵ ≥ to < 10 ⁻⁴
nporta	3	10 ⁻⁴ ≥ to < 10 ⁻³
ased In	2	10 ⁻³ ≥ to < 10 ⁻²
Incre	1	$10^{-2} \ge to < 10^{-1}$

Requirements:

- Quantitative (PFD)
- Semi-quantative: Architectural constraints (HWFT)
- Qualitative: Avoidance and control of systematic faults

Safety Integrity Level:

Top-down Approach (Functional Safety):



Functional boundary



Component vs. Function:

Q: Which system has a higher likelihood of shutting in the flow?

Q: Which system should be tested more often – to achieve the same level of safety?



Determining SIL Requirements:

IEC 61508, IEC 61511:



Source: NOROG-070 (ref. Figure 2 from IEC 61508-1)

Norwegian Petroleum Industry:

- Norsk Olje og Gass Guideline 070:
 - Minimum SIL requirements for the most common instrumented safety functions





ESD demand HPU ESD node (wellhead control panel)	Master valve	Wing valve	To inlet separator
		"Isolation of wel" sub-function	Production manifold

Example: Standard Production Well (ref. NOROG-070)

PFD +	PFD	+	PFD ₁₀₀₃
	Solenoid, ESD Solenoid 1 Solenoid 2 Solenoid 3		

Safety Integrity Level (SIL)	Probability of Failure on Demand (PFD _{avg})	
4	10 ⁻⁵ ≥ to < 10 ⁻⁴	
3	10 ⁻⁴ ≥ to < 10 ⁻³	
2	10 ⁻³ ≥ to < 10 ⁻²	
1	10 ⁻² ≥ to < 10 ⁻¹	



Source: Norsk Olje og Gass - 070



SIL – Function Testing:

Implications of the PFD for determining test frequencies:

Proof-testing based on component performance & PFD requirement.





NORSOK D-010 vs. NORSOK S-001/NOG-070 – Function Testing





NORSOK D-010 vs. NORSOK S-001/NOG-070 – Function Testing



