

Platform safety and risk assessment of wells with gas lift and degraded barriers

A case study from the NCS

Atle Stokke and Lars Tore Haug

03 September 2014

Traditional QRA models are not suited to reflect the increased HSE as a result of degraded well barriers

Presentation content

- Background
- Case study phase one
 - Methodology
 - Results
- Case study phase 2
 - Methodology
 - Results
- Conclusion
- General discussion

Background

- Oil producing platform with topside wells on NCS
- Experienced issues with leakage from tubing and casing hanger
- 4 production wells and 2 two injection wells with barrier integrity issues
- All producers supported by gas lift

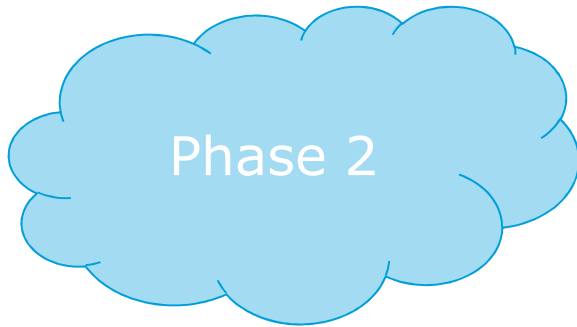
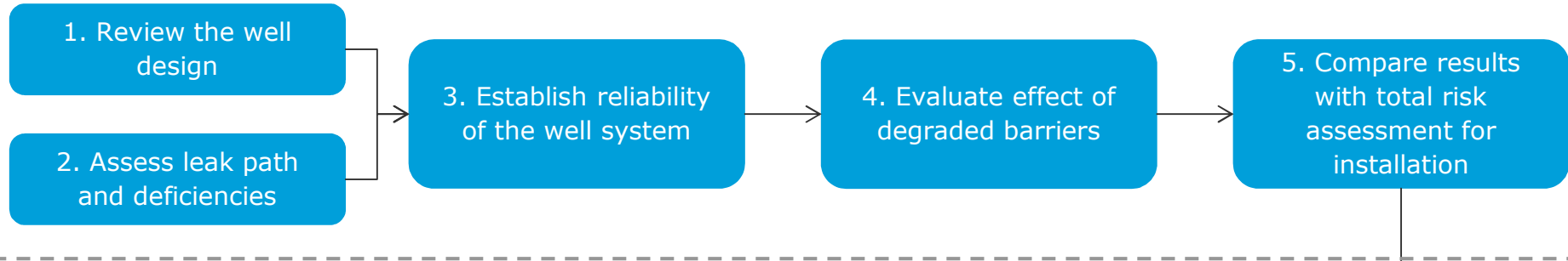


Challenge

- Develop method to identify and quantify additional HSE risk related to degraded well barriers
 - Provide decision support by applying suitable acceptance criteria

Approach

Phase 1



Phase 2



Develop new criteria

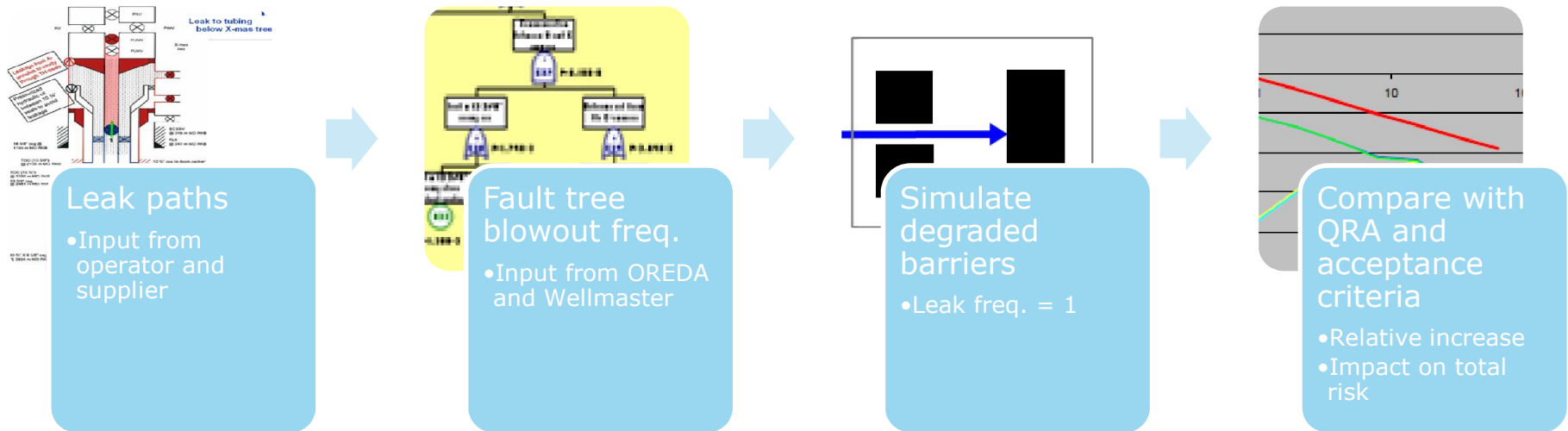


QRA suitable as risk acceptance criteria?



Conclusive analysis

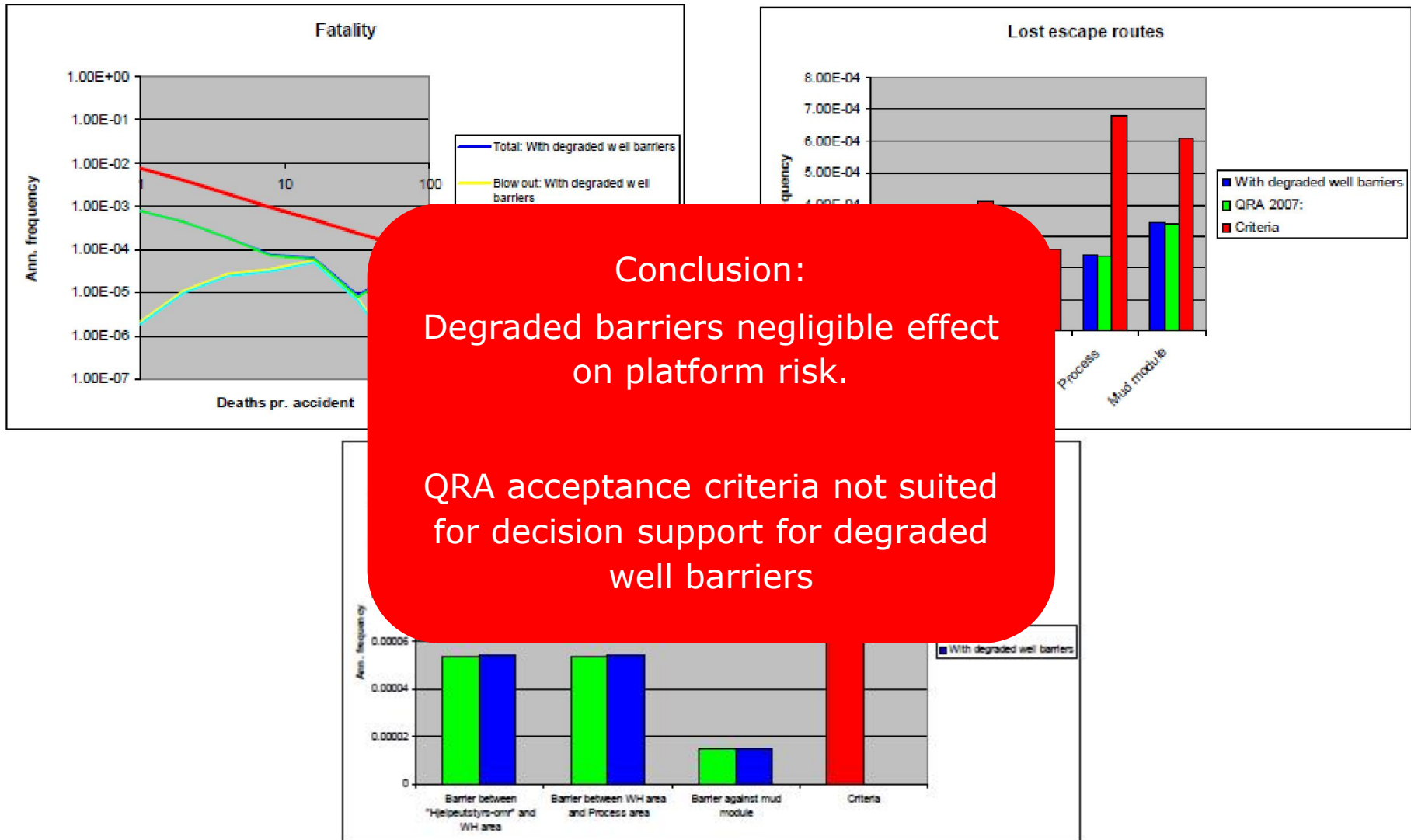
Phase 1 methodology detailed



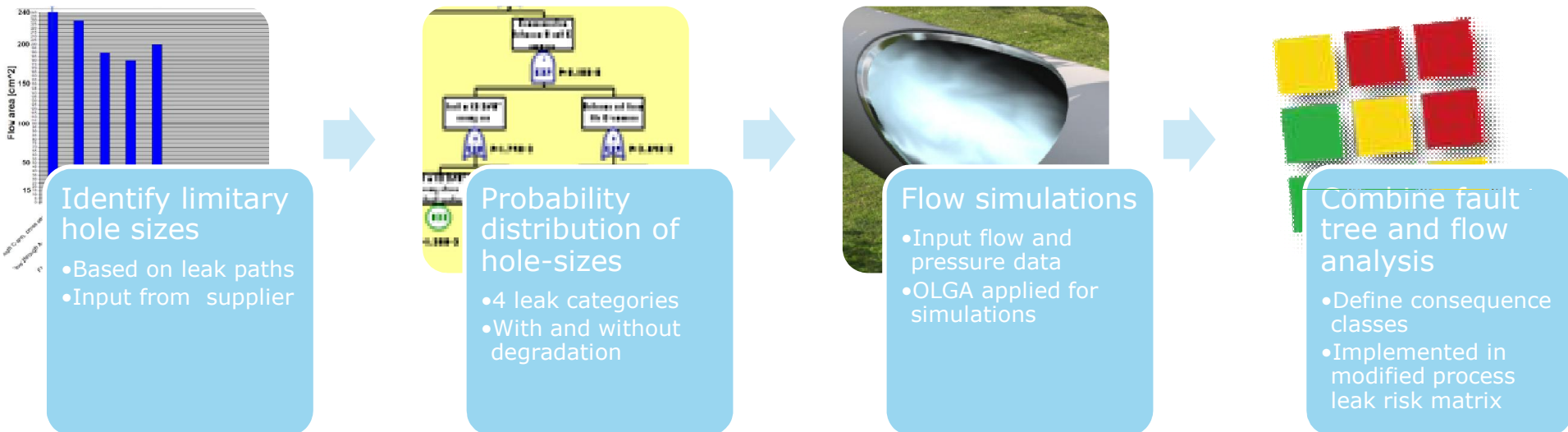
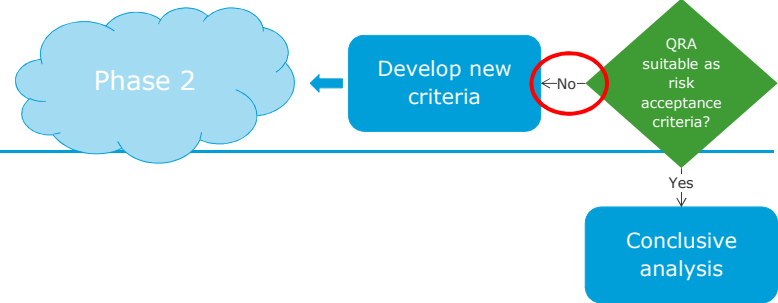
Results phase 1 – Relative increase of blowout frequency

	Blowout from reservoir	Leakage of gas lift gas
Initial blowout frequency from gas lifted wellhead and Xmas tree	1.69E-05	3.04E-03
Blow out frequency degraded wellheads and Xmas trees	3.02E-05	4.77E-02
Relative increase of blowout risk	2	15

Effect on platform risk by applying results on existing QRA



New approach – Phase 2



Consequence classes and barrier status

- **Leak rates**

- Small (0-1 kg/s)
- Medium (1-10 kg/s)
- Large (10-100 kg/s)
- Very large (>100 kg/s)

- **Reactivity of flow**

- Low (e.g. oil with high water cut)
- Medium
- High (e.g. gas)

- **Source/flow duration**

- Limited flow (A-annulus)
- Unlimited flow (well stream from reservoir, gas injector)

- **Barrier status**

- No degradation of well barrier elements
- Degradation of well barrier elements

Results – aggregated for all wells disregarding degradation

Severity	Consequence Categories			Increasing Likelihood					
	High reactivity	Medium reactivity	Low reactivity	1	2	3	4	5	6
				Oftere enn 1 gang pr 1000000 driftsår Mindre enn 1 gang pr 100000 driftsår < 10-5	Oftere enn 1 gang pr 100000 driftsår Mindre enn 1 gang pr 10000 driftsår 10-5 til < 10-4	Oftere enn 1 gang pr 10000 driftsår Mindre enn 1 gang pr 1000 driftsår 10-4 til < 10-3	Svært sjelden Oftere enn 1 gang pr 1000 driftsår Mindre enn 1 gang pr 100 driftsår 10-3 til < 10-2	Sjelden. Oftere enn 1 gang pr 100 driftsår Mindre enn 1 gang pr 10 driftsår 10 -2 til < 10-1	Mulig. Oftere enn 1 gang pr 10 driftsår Mindre enn 1 gang pr 1 driftsår > 10 -1
1	> 100 kg/s eller kortvarig > 1000 kg/s				HighR Very large leak				
2	> 10 kg/s eller kortvarig > 100 kg/s	> 100 kg/s eller kortvarig > 1000 kg/s			HighR Very large leak	HighR large leak			
3	> 1 kg/s eller kortvarig > 10 kg/s	> 10 kg/s eller kortvarig > 100 kg/s	> 100 kg/s eller kortvarig > 1000 kg/s	HighR medium leak			HighR Large leak		
4	> 0.1 kg/s eller kortvarig > 1 kg/s	> 1 kg/s eller kortvarig > 10 kg/s	> 10 kg/s eller kortvarig > 100 kg/s		HighR Medium leak	HighR Small leak, LowR Large leak			
5	< 0.1 kg/s og > 0.01 kg/s	> 0.1 kg/s eller kortvarig > 1 kg/s	> 1 kg/s eller kortvarig > 10 kg/s		LowR Medium leak				
6	< 0.01 kg/s - >20% LEL 0.2 meter unna I le (1 gr/s væske)	< 0.1 kg/s og > 0.01 kg/s	> 0.1 kg/s eller kortvarig > 1 kg/s	LowR Small leak					
7	< 20% LEL 0.2 meter unna I le (1 gr/s væske)	< 0.01 kg/s - >20% LEL 0.2 meter unna I le (1 gr/s væske)	< 0.1 kg/s og > 0.01 kg/s						

Black font: Limited flow, e.g. annulus A
Blue font: Unlimited flow, e.g. reservoir

Results – aggregated for all wells including degradation and shut in conditions (actual condition)

Severity	Consequence Categories			Increasing Likelihood					
	High reactivity	Medium reactivity	Low reactivity	1	2	3	4	5	6
				Oftere enn 1 gang pr 1000000 driftsår Mindre enn 1 gang pr 100000 driftsår < 10-5	Oftere enn 1 gang pr 100000 driftsår Mindre enn 1 gang pr 10000 driftsår 10-5 til < 10-4	Oftere enn 1 gang pr 10000 driftsår Mindre enn 1 gang pr 1000 driftsår 10-4 til < 10-3	Svært sjelden Oftere enn 1 gang pr 1000 driftsår Mindre enn 1 gang pr 100 driftsår 10-3 til < 10-2	Sjelden. Oftere enn 1 gang pr 100 driftsår Mindre enn 1 gang pr 10 driftsår 10-2 til < 10-1	Mulig. Oftere enn 1 gang pr 10 driftsår Mindre enn 1 gang pr 1 driftsår > 10-1
1	> 100 kg/s eller kortvarig > 1000 kg/s				HighR Very large leak				
2	> 10 kg/s eller kortvarig > 100 kg/s	> 100 kg/s eller kortvarig > 1000 kg/s			DG HighR Very large leak	HighR large leak			
3	> 1 kg/s eller kortvarig > 10 kg/s	> 10 kg/s eller kortvarig > 100 kg/s	> 100 kg/s eller kortvarig > 1000 kg/s	HighR medium leak			DG HighR Large leak		
4	> 0.1 kg/s eller kortvarig > 1 kg/s	> 1 kg/s eller kortvarig > 10 kg/s	> 10 kg/s eller kortvarig > 100 kg/s			DG LowR Large leak	DG HighR Medium leak	DG HighR Small leak	
5	< 0.1 kg/s og > 0.01 kg/s	> 0.1 kg/s eller kortvarig > 1 kg/s	> 1 kg/s eller kortvarig > 10 kg/s			DG LowR Medium leak			
6	< 0.01 kg/s - >20% LEL 0.2 meter unna I le (1 gr/s væske)	< 0.1 kg/s og > 0.01 kg/s	> 0.1 kg/s eller kortvarig > 1 kg/s				DG LowR Small leak		
7	< 20% LEL 0.2 meter unna I le (1 gr/s væske)	< 0.01 kg/s - >20% LEL 0.2 meter unna I le (1 gr/s væske)	< 0.1 kg/s og > 0.01 kg/s						

Results – aggregated for all wells including degradation and production from all wells (simulated situation)

Severity	Consequence Categories			Increasing Likelihood						
	High reactivity	Medium reactivity	Low reactivity	1	2	3	4	5	6	
				Oftere enn 1 gang pr 1000000 driftsår Mindre enn 1 gang pr 100000 driftsår < 10 ⁻⁵	Oftere enn 1 gang pr 100000 driftsår Mindre enn 1 gang pr 10000 driftsår 10 ⁻⁵ til < 10 ⁻⁴	Oftere enn 1 gang pr 10000 driftsår Mindre enn 1 gang pr 1000 driftsår 10 ⁻⁴ til < 10 ⁻³	Svært sjelden Oftere enn 1 gang pr 1000 driftsår Mindre enn 1 gang pr 100 driftsår 10 ⁻³ til < 10 ⁻²	Sjelden. Oftere enn 1 gang pr 100 driftsår Mindre enn 1 gang pr 10 driftsår 10 ⁻² til < 10 ⁻¹	Mulig. Oftere enn 1 gang pr 10 driftsår Mindre enn 1 gang pr 1 driftsår > 10 ⁻¹	
1	> 100 kg/s eller kortvarig > 1000 kg/s				HighR Very large leak					
2	> 10 kg/s eller kortvarig > 100 kg/s	> 100 kg/s eller kortvarig > 1000 kg/s			DG HighR Very large leak	HighR large leak				
3	> 1 kg/s eller kortvarig > 10 kg/s	> 10 kg/s eller kortvarig > 100 kg/s	> 100 kg/s eller kortvarig > 1000 kg/s	HighR medium leak				DG HighR Large leak		
4	> 0.1 kg/s eller kortvarig > 1 kg/s	> 1 kg/s eller kortvarig > 10 kg/s	> 10 kg/s eller kortvarig > 100 kg/s			DG LowR Large leak	DG HighR Medium leak			DG HighR Small leak
5	< 0.1 kg/s og > 0.01 kg/s	> 0.1 kg/s eller kortvarig > 1 kg/s	> 1 kg/s eller kortvarig > 10 kg/s			DG LowR Medium leak				
6	< 0.01 kg/s - >20% LEL 0.2 meter unna l le (1 gr/s væske)	< 0.1 kg/s og > 0.01 kg/s	> 0.1 kg/s eller kortvarig > 1 kg/s				DG LowR Small leak			
7	< 20% LEL 0.2 meter unna l le (1 gr/s væske)	< 0.01 kg/s - >20% LEL 0.2 meter unna l le (1 gr/s væske)	< 0.1 kg/s og > 0.01 kg/s							

Conclusion of the study

- This well risk model presents the risk of leakage from all platform wells and identifies the effect of degraded well barriers.
- The results are aggregated from a study of failure probability of individual well barriers and the corresponding flow potential.
- This model may be operationalised to cover the changes in the well barrier situation and may be used as risk based decision support for handling of well integrity issues during production.
- Only the identified leak barrier elements were handled, not general degradation due to aging.

Well integrity management – OLF GL117

Category	Principle
Red	One barrier failure and the other is degraded/not verified, or leak to surface
Orange	One barrier failure and the other is intact, or a single failure may lead to leak to surface
Yellow	One barrier degraded, the other is intact
Green	Healthy well – no or minor issue

OLF GL 117

Limited focus on consequence side and no differentiation between wells types – what will flow and how much?

Need for a more risk based approach...?
Is the answer application of ISO 16530-2?

Thank you for your attention

Atle Stokke

Atle.stokke@dnvgl.com

+47 99 69 15 10

www.dnvgl.com

SAFER, SMARTER, GREENER