Astrimar

Quality, not the Quantity

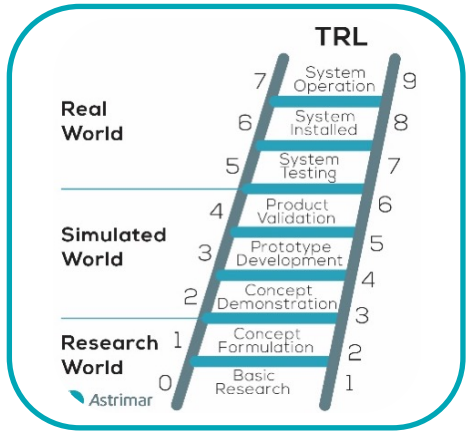
Long term monitoring and confidence in new well barrier technologies

SPE Aberdeen Well Decommissioning Conference
June 2023

Brian Willis

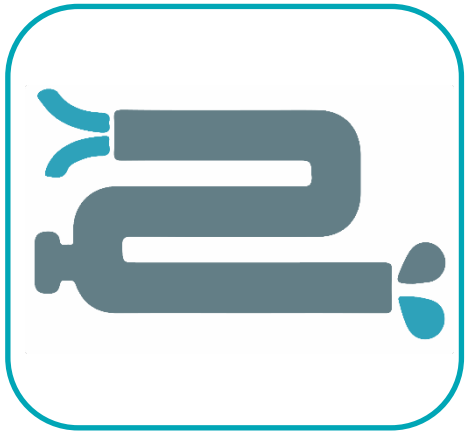
About Astrimar

Technology qualification



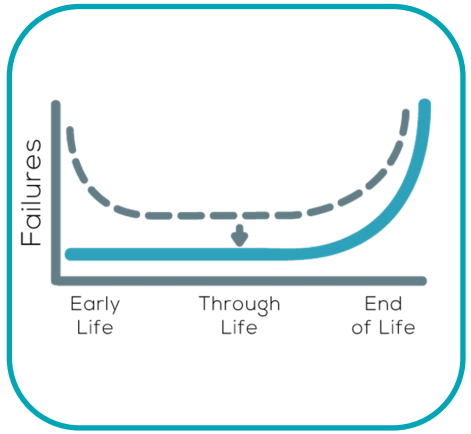
Projects and design

Operations integrity management



Life extension, decommissioning & re-use

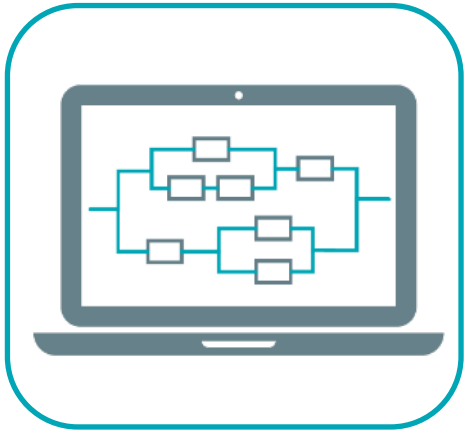
Reliability best practice guidance



Data analysis

Risk and reliability engineering analysis

Specialist reliability tools



Astrimar's experience at supporting better P&A

2012
- Supporting qualification of alternative plugging materials
- Development of reliability models for well plugs

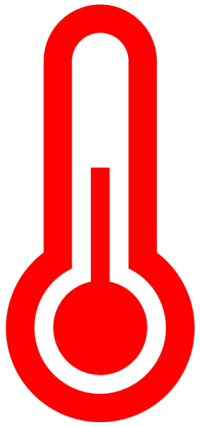
2017
- Supporting qualification of bismuth alloy casing plug and bismuth alloy wellbore plug
- Development of initial STEM-flow barrier reliability models

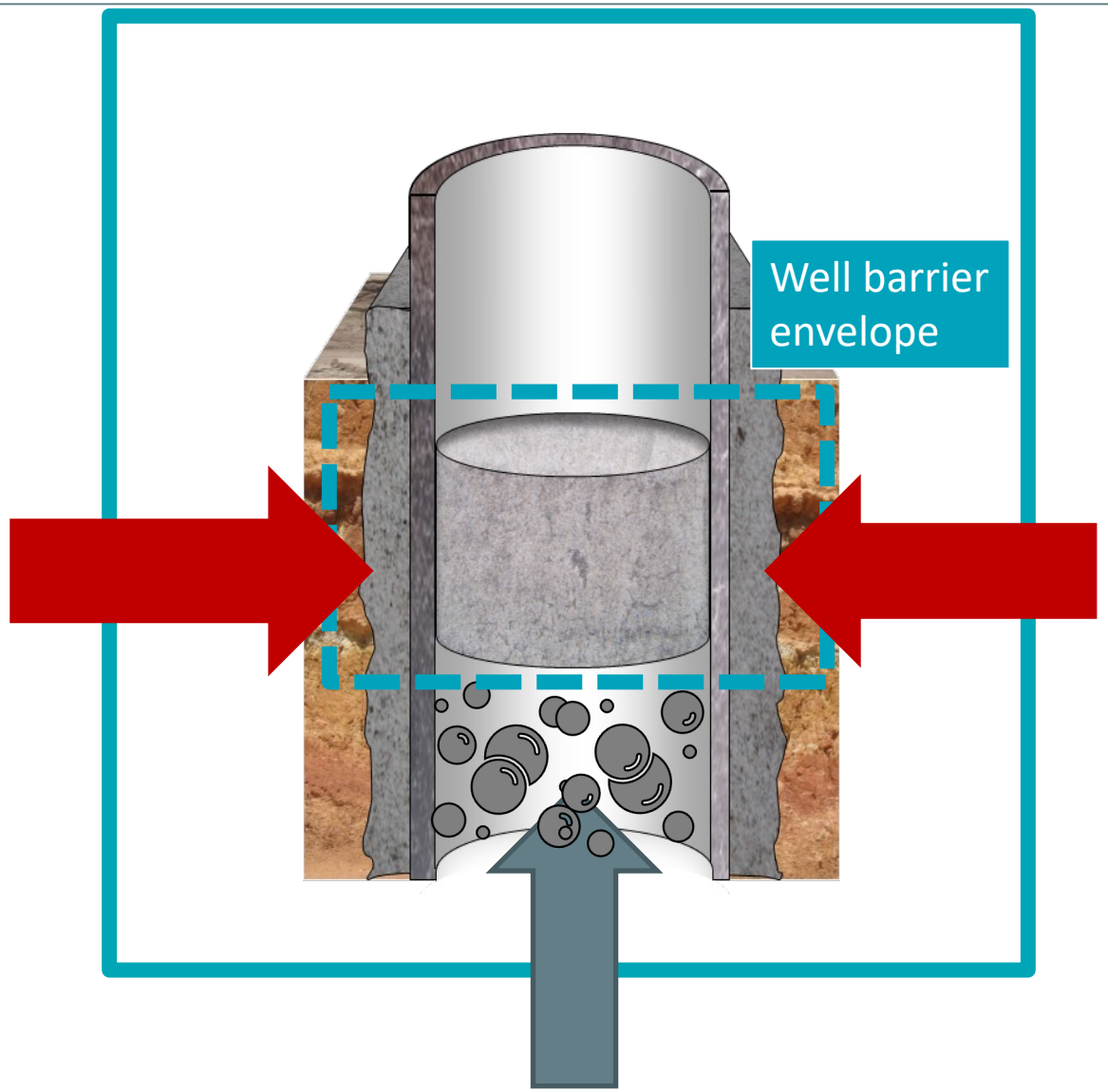
2019
- STEM-flow plug and barrier reliability models and material database
- Assessment of cement barrier design options, including annulus cement logs for NS operator

2020
- Creation of risk-based well P&A guidance for NS Major
- Multiple non-routine barrier design comparisons with recharge and cross-flow potential
- Workgroup member to update OGUK guidance documents

2023
- Multiple projects on risk-based well P&A assessments and well barrier qualification for developers and operators
- Workgroup member on OEUK CCUS risk assessment guidance

Requirement for (alternative) well barriers



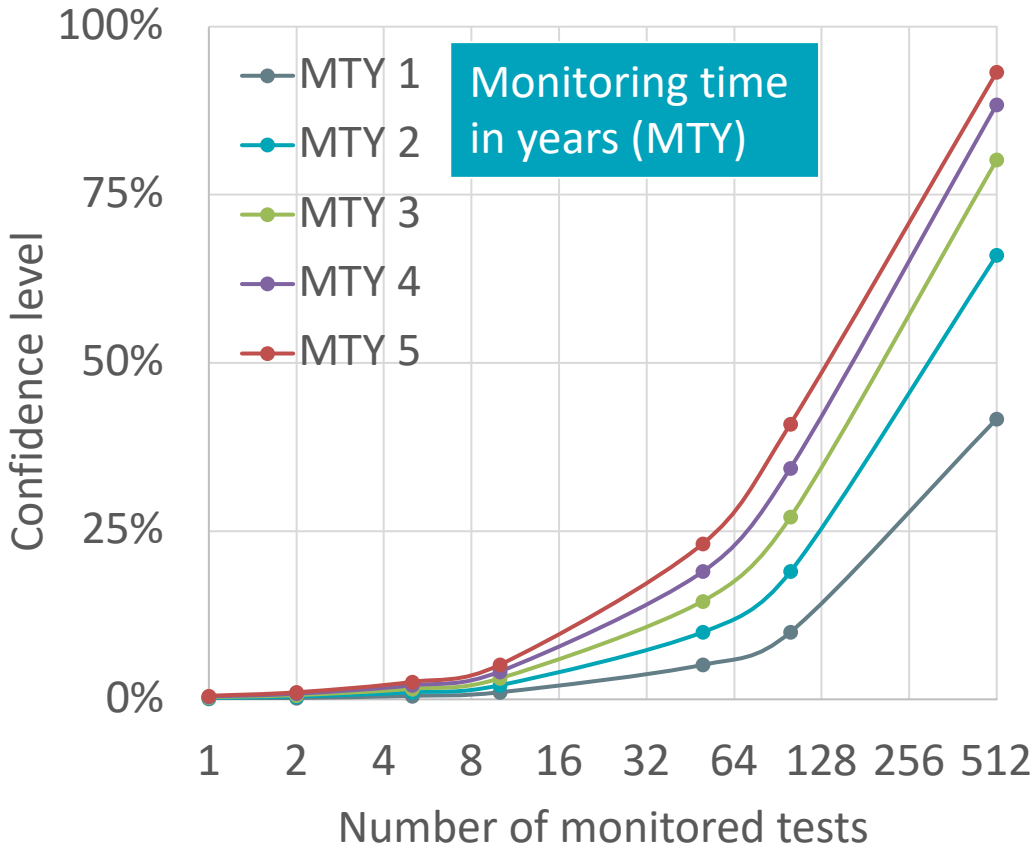


Deployment & installation

Testing & verification

Claimed confidence in operating life from monitoring

Assumed 100 years operating life and 90% reliability



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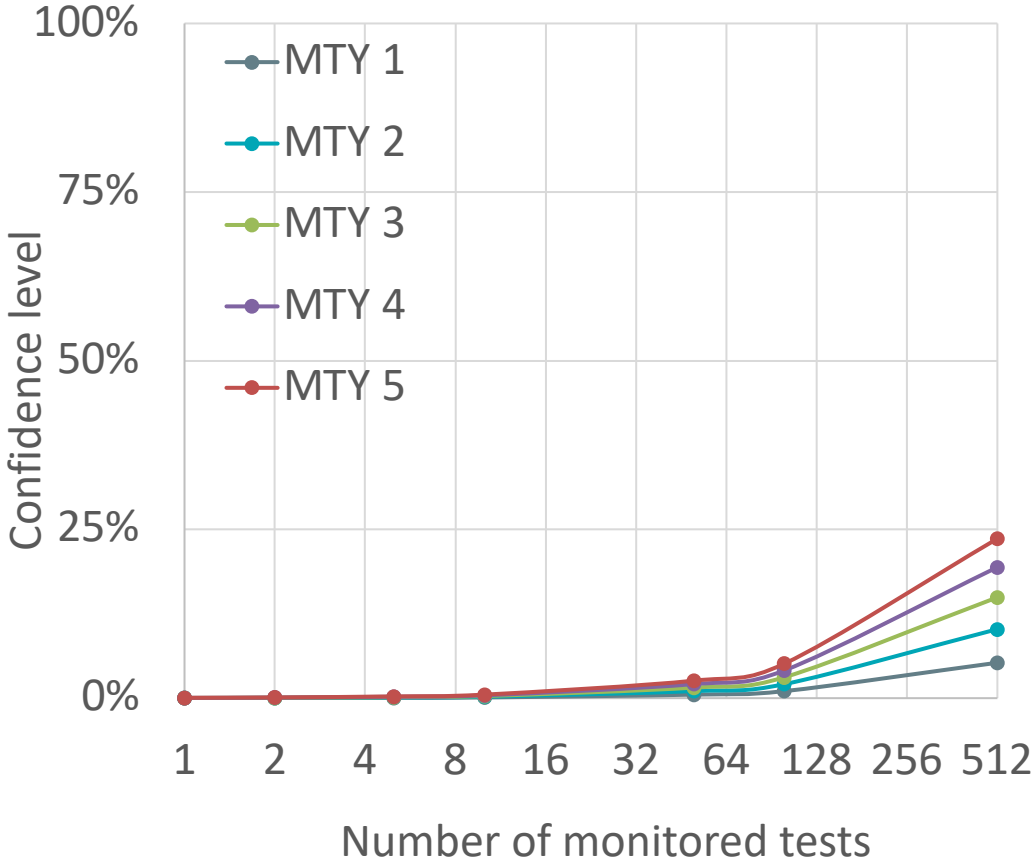
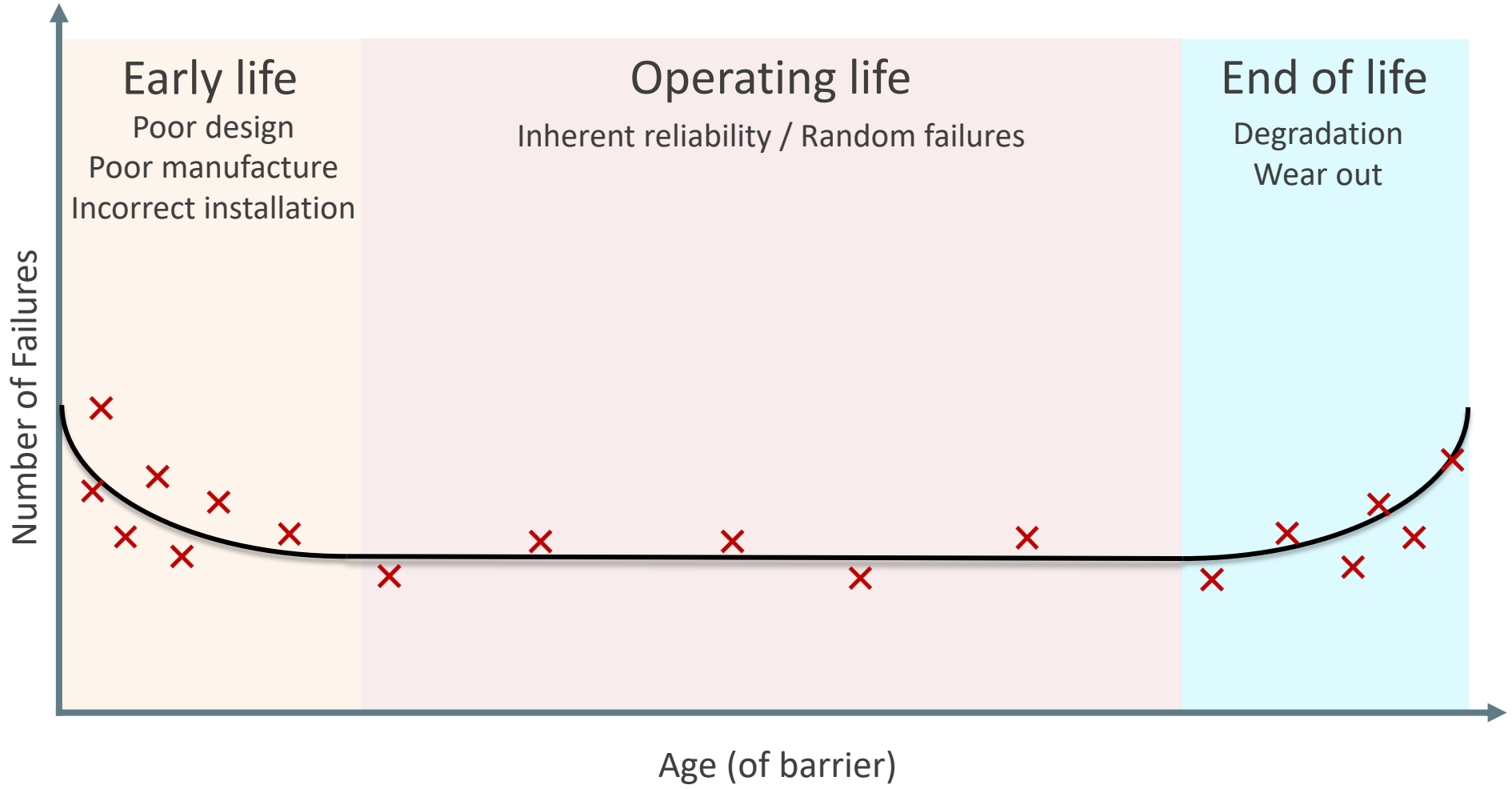
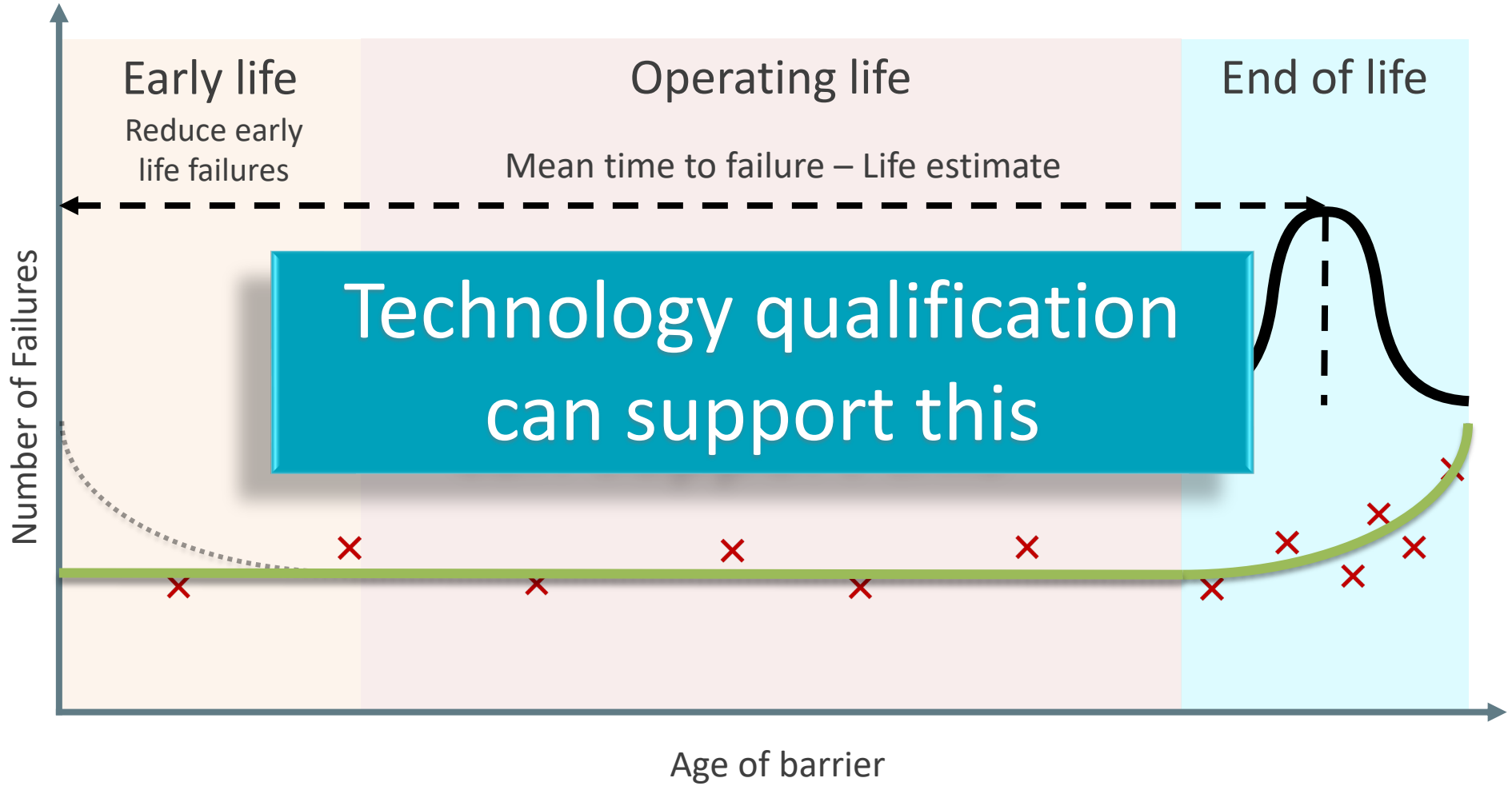


New technologies – Generic typical experience

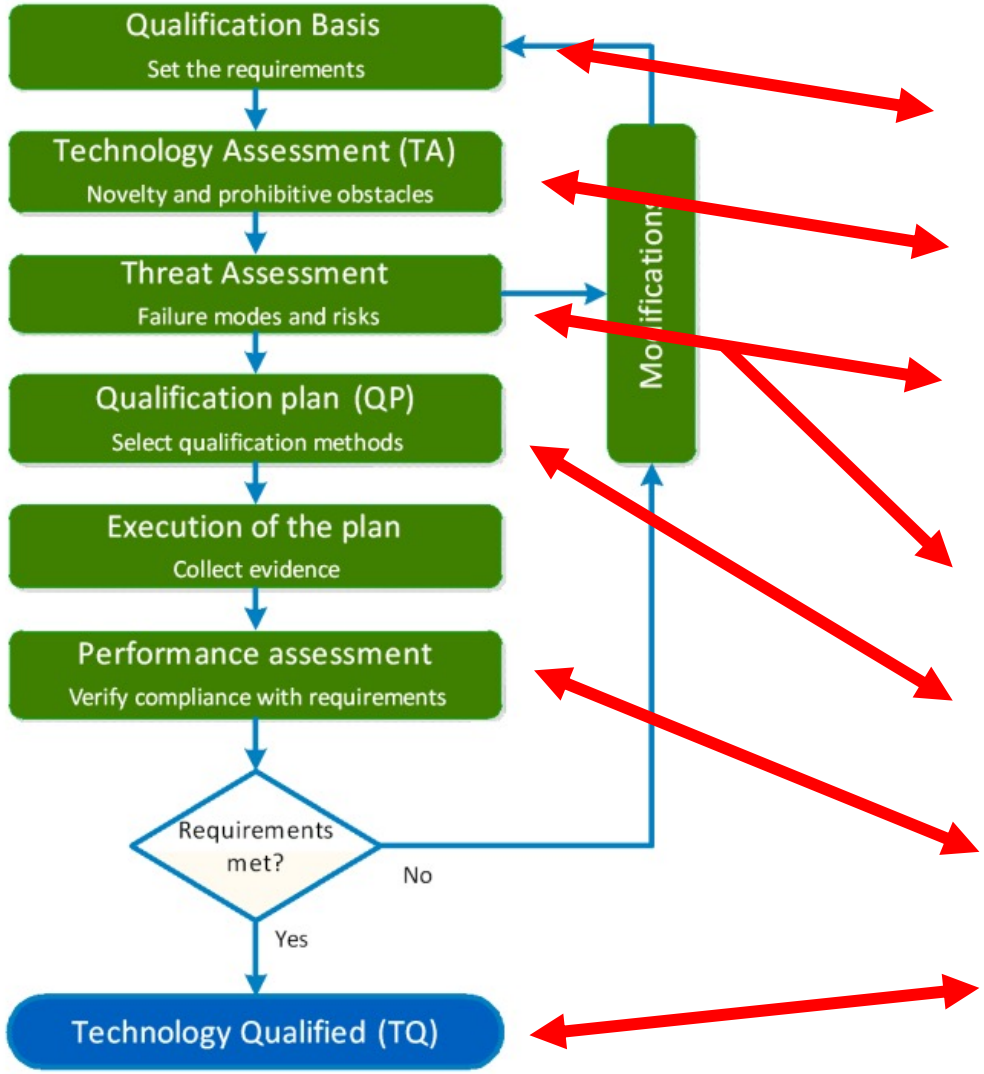


New technologies – The goal for alternative barriers



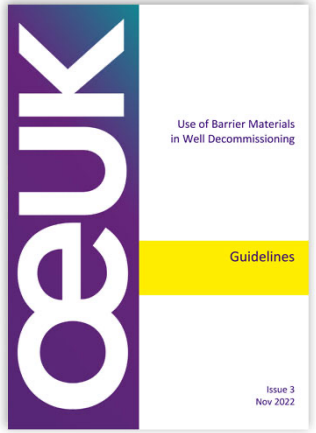
Guidance on Technology Qualification

DNV-RP-A203 (2021)



OEUK - Use of Barrier Materials in Well Decommissioning (Issue 3)

1	Defining the qualification boundary - function, performance, and reliability criteria
2	Technology maturity - Assessing against the qualification boundary
3	Failure mode assessment – How can the technology fail to deliver its requirements, the likelihood, risk and consequence
4	Risk analysis – Evaluation of the risk and residual uncertainty
5	Qualification plan – Testing and analysis to address risks
6	Evaluation of the results – Managing residual uncertainty
7	Documentation and Assurance (if no further testing or modifications are required)



What is a “Qualified” well P&A technology?

TRL 3 TRL 4 TRL 5 TRL 6 TRL 7 TRL 8 TRL 9

Material Qualification
- OGUK guidelines
- Q-FMECA
- Lab testing

+

Deployment Qualification
- ISO14310
- Q-FMECA
- Field trials

⇒

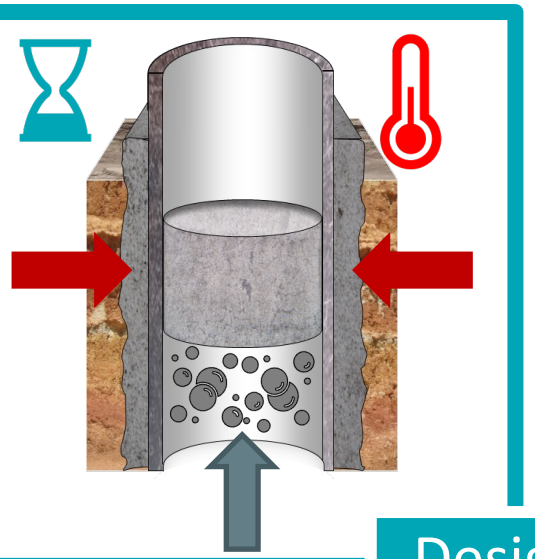
Qualified Barrier Technology
- Field deployment

- ✓ Standard material testing
- ✓ Long term integrity
  - Creep
  - Corrosion
- ✓ Conformation and leak rate
- ✓ Model simulations

- ✓ Deployment process and reliability
- ✓ Verify position and seal
- ✓ Full scale at T&P
- ✓ Plug performance simulation
- ✓ Well performance simulation

- ✓ Platform & subsea deployment
- ✓ Established good practice
- ✓ Demonstrated reliability
- ✓ Monitor for early life failures

Case study: Qualification of alternative barrier materials



Design

Q-FMECA

Increasing Consequence	Increasing likelihood 1	2	3	4	5
5	0	0	0	0	0
4	1	7	2	0	0
3	9	14	8	4	0
2	8	13	3	2	0
1	6	1	0	0	0

Material
- OGUK Guidelines
- Corrosion
- Creep

Functional
- Leak
- Pull out
- Conformity

Deployment
- Robustness
- Reliability
- Verification

Qualification test data

HIGH LEVEL TRL					TRL DISTRIBUTION
OVERALL TRL	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5
TRL 2	Completed	Completed	In progress	In progress	Not started

TRL PROFILE	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5
Percentage of elements completed towards achieving each TRL	100%	100%	60%	0%	0%
Elements not started	0	0	0	2	5
Elements in progress	0	0	2	3	0
Elements completed	5	5	3	0	0

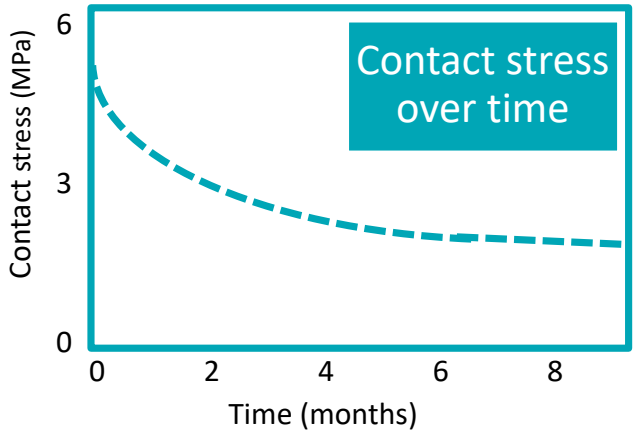
Initial TRL 2

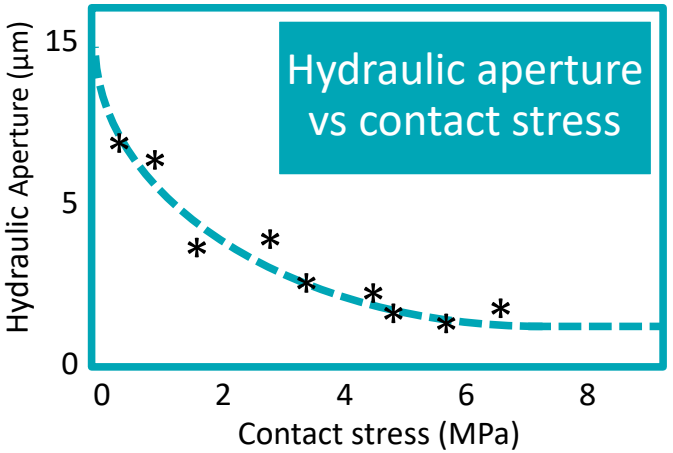
Case study: Qualification of alternative barrier materials

Interpret

- Leak rate & micro annulus
- Controlling creep
- Deployment
  - Settling
  - Long - term

Translate





Assurance with RAPAT®

Rapid Acceptance of Products & Technologies

HIGH LEVEL TRL	TRL DISTRIBUTION							
OVERALL TRL	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8
TRL 5	Completed	Completed	Completed	Completed	Completed	In progress	In progress	Not started

TRL PROFILE	TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8
Percentage of elements completed towards achieving each TRL	100%	100%	100%	100%	100%	0%	0%	0%
Elements not started	0	0	0	0	0	2	2	5
Elements in progress	0	0	0	0	0	2	3	0
Elements completed	5	5	5	5	5	0	0	0

TRL 4 achieved: Technology concept demonstrated to be valid															
Validated but Untested Technology Proposed															
Physical and/or virtual prototype constructed to demonstrate form, fit and functional performance Software technology prototype developed for realistic testing with simulated hardware/software system interface	Completed	Functional performance, durability and life tests undertaken to confirm performance, reliability, operating/destruct limits and degradation rate/limits as appropriate	Completed	All analysis completed including e.g. FEA, engineering calculations and reliability analysis	Completed	Required in-service & performance monitoring defined Software configuration management defined	Completed	Risks from manufacture/assembly/transit/storage/installation, identified and addressed Risks from software compilation/deployment/installation identified and addressed Potential for human error addressed	Completed						
TRL 5 achieved: Technology is prototype tested for robustness and reliability															
Technology Product Proposed															
Manufacturing specification for production items created	N/A	Technical risk assessment (e.g. FMECA) updated to reflect product manufacture/assembly/transit/storage/software compilation and delivery	In progress	Manufactured product (or prototype) tested in simulated or intended operating environment to confirm function/performance within acceptable limits Software technology/process tested on full-scale realistic problems, partially integrated with wider system hardware/software	In progress	Operational performance data collection process established	Not started	Required manufacture/assembly acceptance testing defined (e.g. x-ray/ct screening) Manufacturing/assembly testing process demonstrated to detect and correct/remove defective items Manufacturing/assembly process demonstrated to be acceptable	Not started						
TRL 6 achieved: Technology product validated in realistic environment															
Technology Product Ready for System Integration															
Technical risk assessment (e.g. FMECA) updated to ensure interfaces with wider system are addressed	In progress	Function/performance tested when connected to/integrated with wider system - not necessarily in full operational environment Software technology will integrated and tested with operational hardware/software systems	In progress	Mechanical, hydraulic, optical, electronic, software, tooling and human interfaces addressed to confirm product/software/process does not impact performance of wider system and wider system does not impact performance of product/software/process	In progress	Operational performance/reliability data collection initiated	Not started	Requirements/system integration testing confirmed for manufactured product/compiled software/approved process	Not started						
TRL 7 achieved: System integration testing completed															
Actual System Ready for Installation and Commissioning															
Technical risk assessment (e.g. FMECA) updated to ensure installation/commissioning/deployment risks addressed	Not started	Installation/testing/commissioning undertaken with wider system ahead of actual deployment/operation/mission/use. Software technology fully integrated with operational hardware/software with functionality tested in simulated and operational scenarios	Not started	Any remaining interface/function qualification completed that could not be done before/at start of deployment/operation/mission/use (e.g. testing with actual fluid or environment all loads)	Not started	Detailed in-service inspection/monitoring/sampling defined and verified	Not started	Confirmation that product/software/process is able to work or intended reliability not compromised by installation/commissioning/deployment process	Not started						
TRL 8 achieved: Actual system installed, tested and commissioned															

Current TRL 5

Outcomes and benefits

COST EFFECTIVE WHILE MANAGING ACCEPTABLE RISK

ENABLES ALTERNATE DESIGNS AND SOLUTIONS

SUPPORTS RISK MANAGEMENT OF NEW MATERIALS AND DEPLOYMENT METHODS

OPTIMISES USE OF DATA TO PREDICT BARRIER PERFORMANCE

UNDERSTANDS IMPACT OF UNCERTAINTY OVER TIME

RISK ASSESSMENTS TO DEMONSTRATE ALARP

Astrimar

Thank you for listening

Questions ?

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