Flexible Riser Life Extension with FlexIQ

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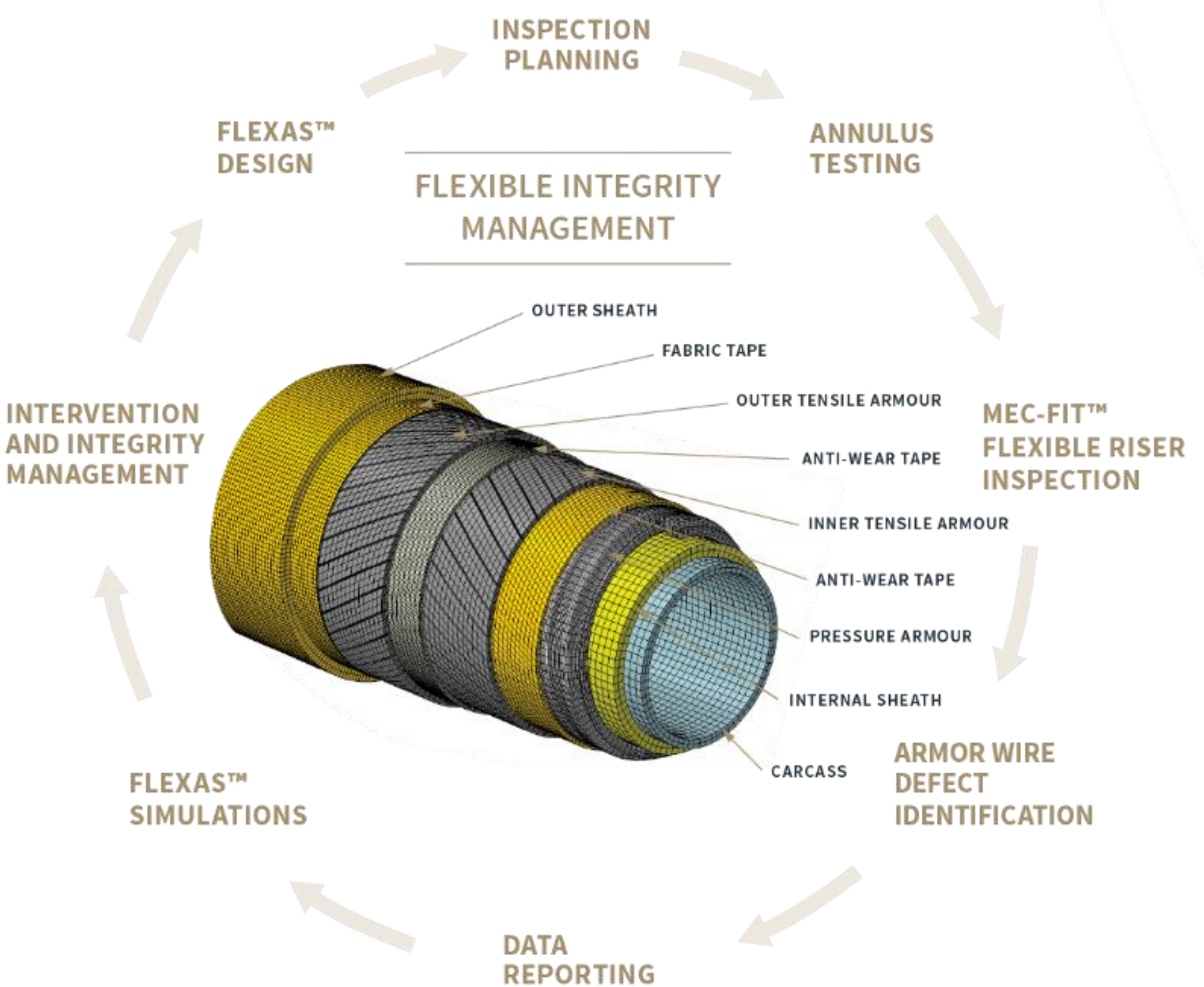
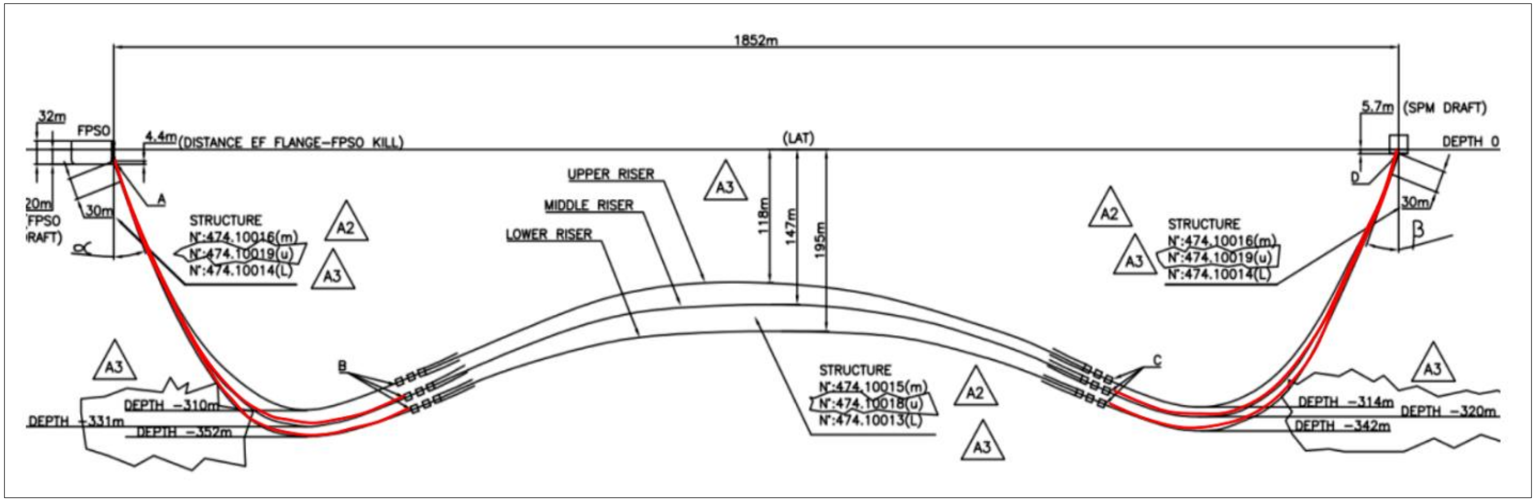
What is FlexIQ ?



Case Study - Project Overview



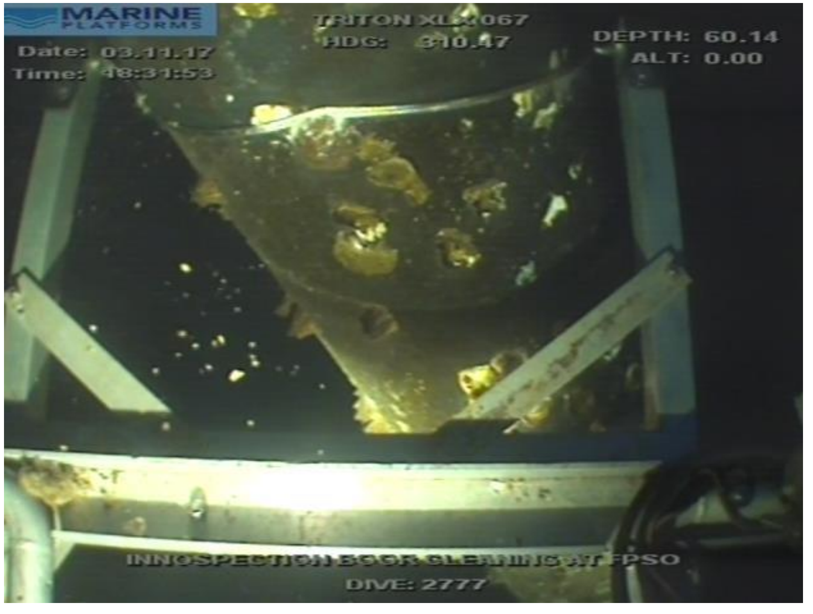
Scope of Work (related to red highlighted sections):

- **Marine growth cleaning**
- **Inspection – 100% scanning with MEC-Hug tool**
- **Integrity assessment of the tensile armour wires using the FLEXAS™ numerical solver**
- **Risk Based Assessment (to look at all other components of the flexible riser system)**

Case Study – Riser Details

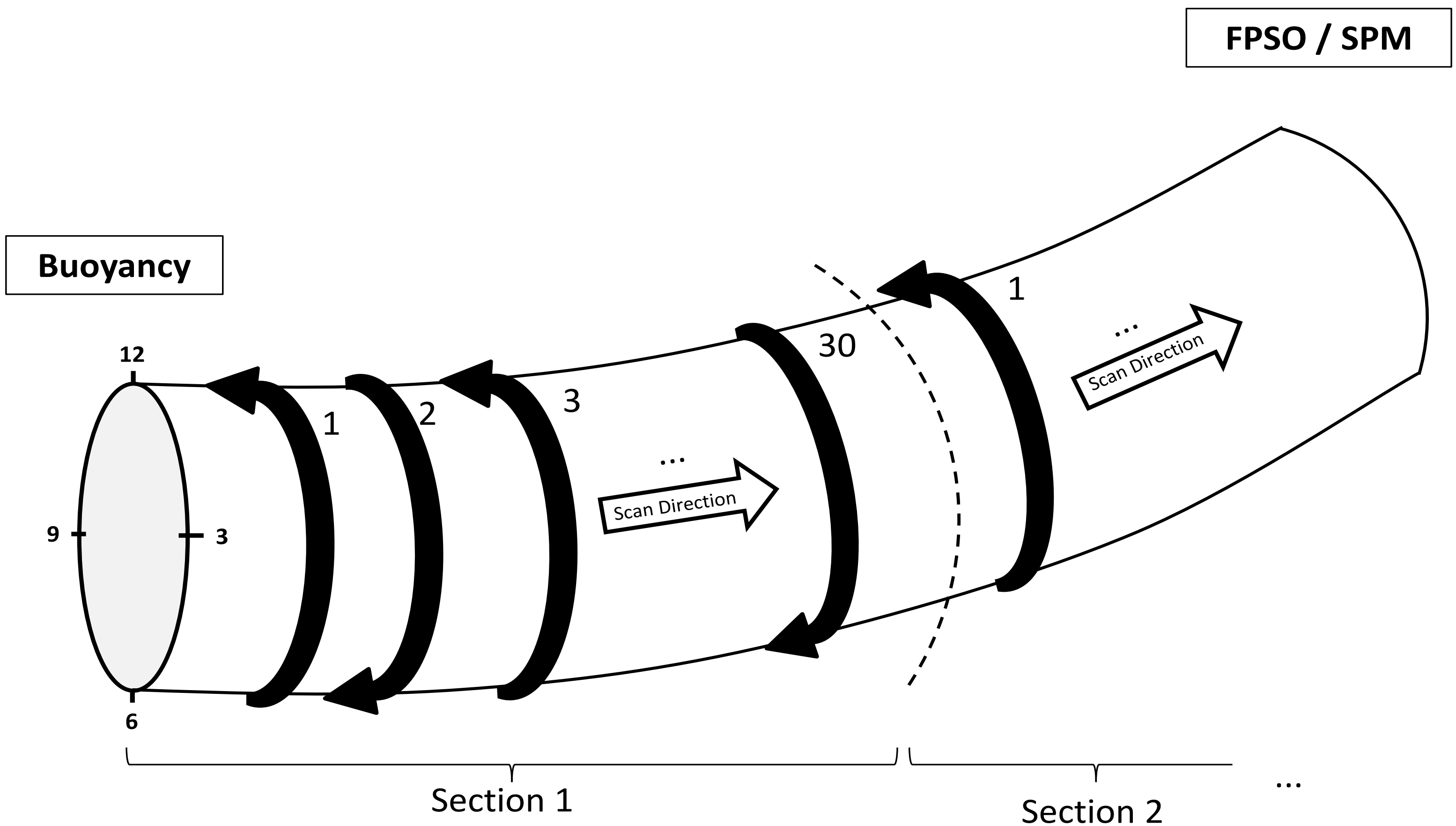
Specification	Middle Riser	Lower Riser
Riser ID	18.75"	18.75"
Riser OD	23"	23"
Total Length	2,240m	2,240m
Buoyancy Section Length	1,080m	1,026m
Length Inspected	2 x 580m	2 x 607m
Inner Tensile Lay Angle	54.8 degrees	54.8 degrees
Outer Tensile Lay Angle	55 degrees	55 degrees
Tensile Wire Thickness	3.6mm	3.6mm

Marine Growth Cleaning



- “Cheese wire system”
- ROV based
- Cleaning completed in 4 days (working day and night shift)

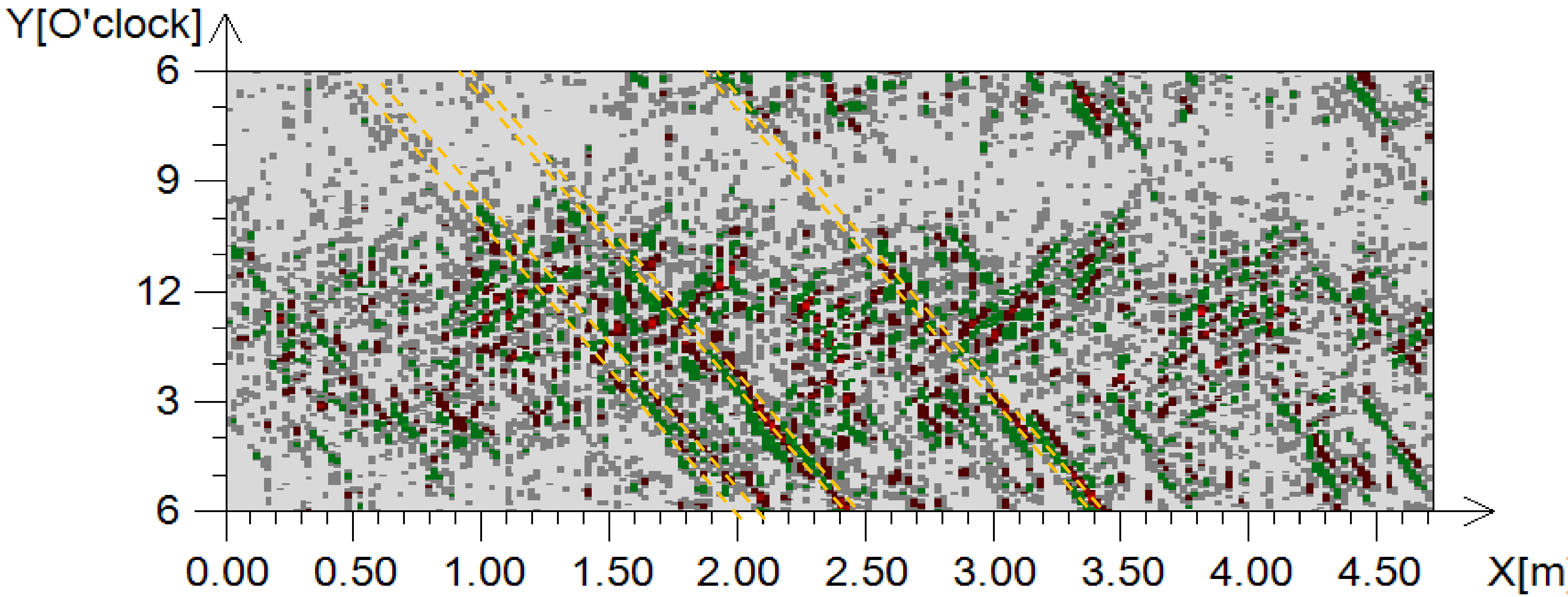
MEC-FIT Inspection – Order of Scanning



MEC-FIT Inspection

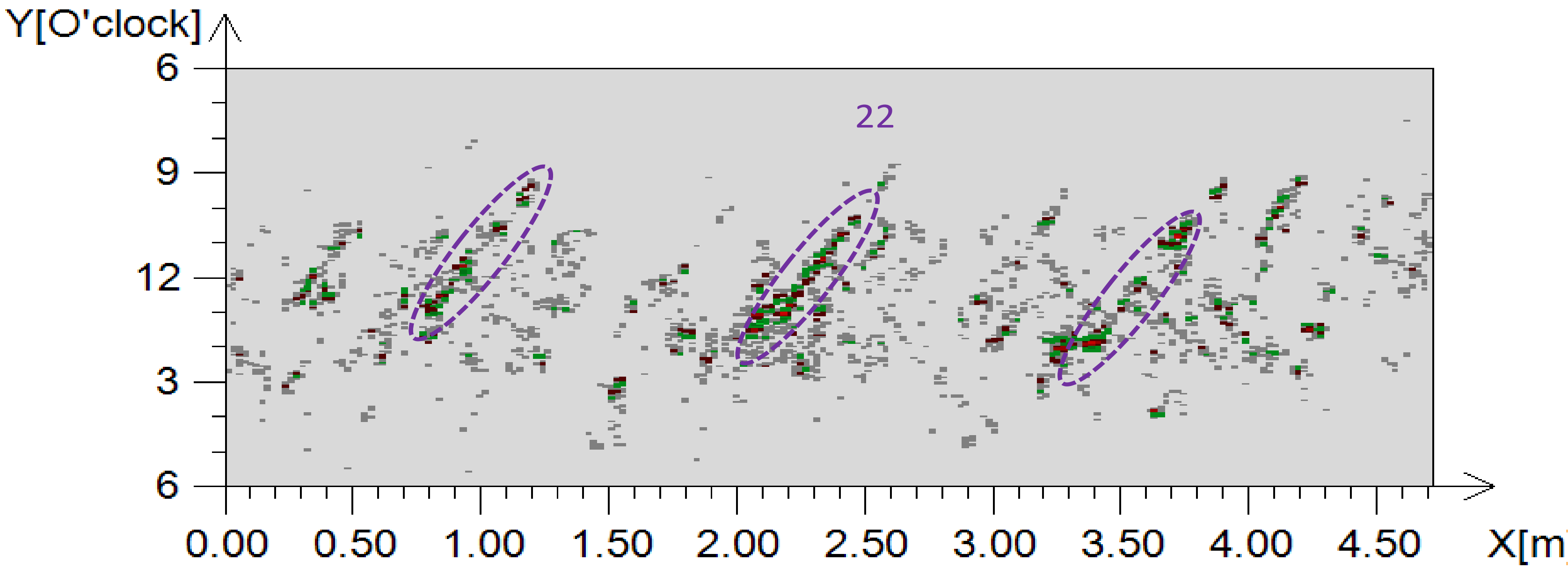
– **Inspection completed in 16 days (working day and night shift)**

Reporting – Scan Images



Larger tensile wire gapping within the inner layer.

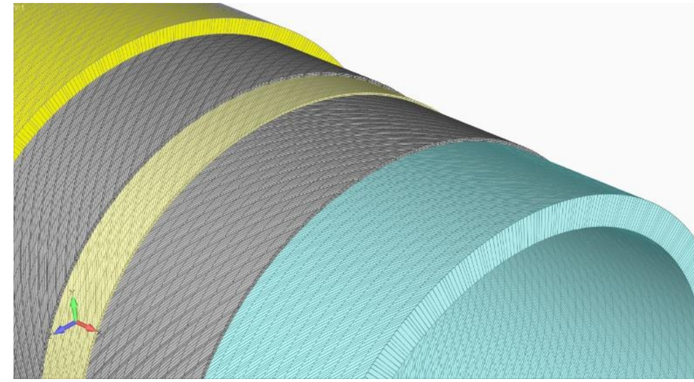
Reporting – Scan Images

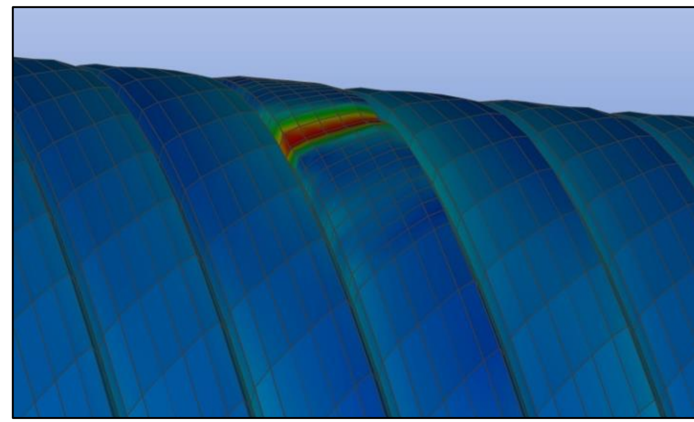


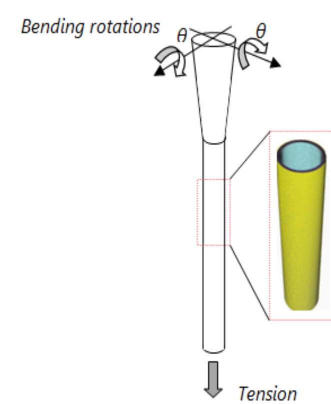
Reoccurring pattern at the pitch length of the outer tensile layer (that corresponds to the helical step of the wiring).

FLEXAS™ Numerical Simulation

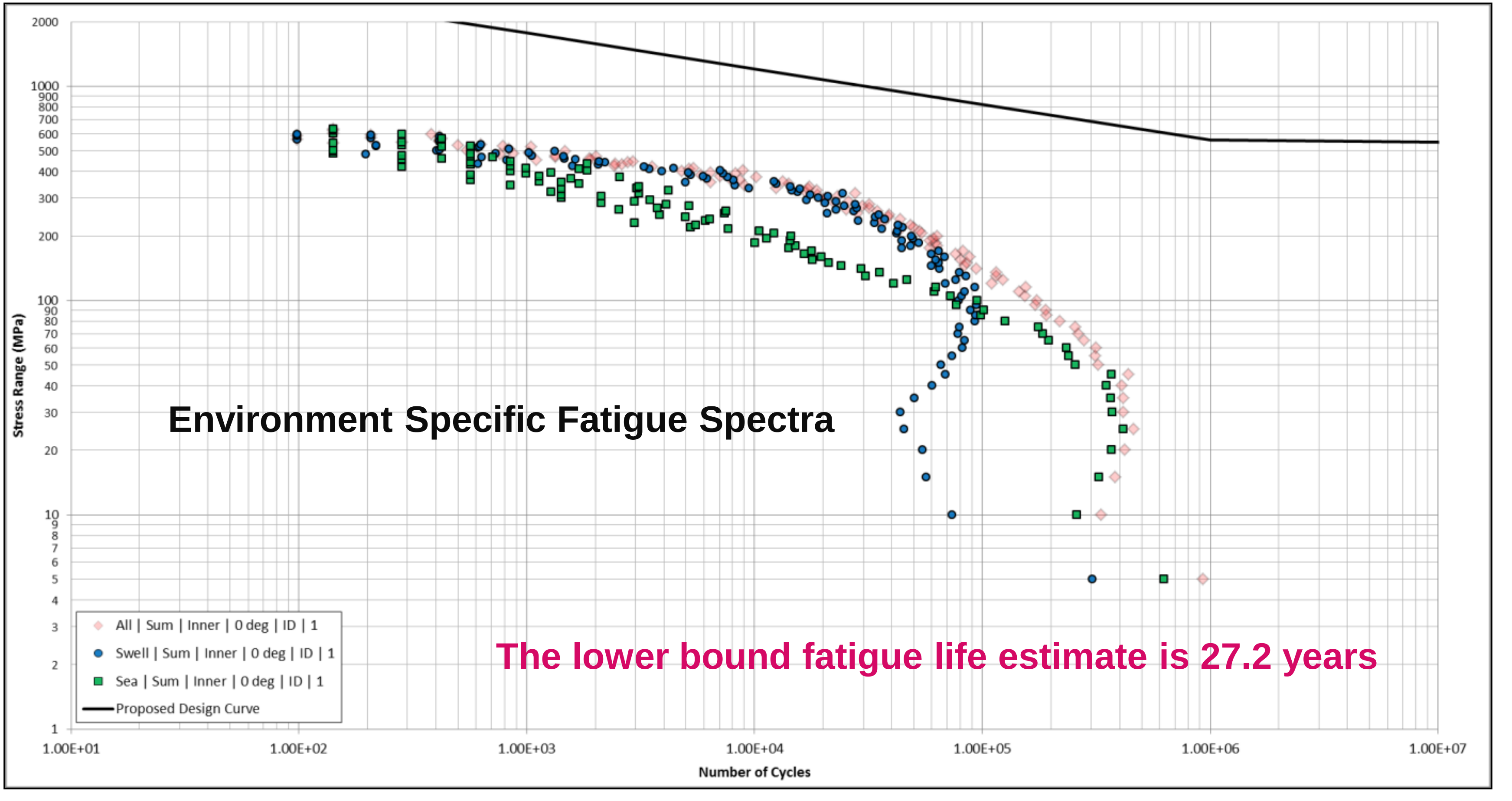
- **Allows accurate computation of tensile armour wire stress time-histories.**
- **Takes into account mechanical stimulation by irregular waves (possible through a finite element model using Nonlinear Dynamic Sub-structuring).**
- **Modelling technique**
  - ➢ **Global model: system level simulation**
  - ➢ **Local model: high fidelity simulation of an isolated section**
- **Lower flexible BOOR section near the SPM hang-off is selected for further detailed local analysis.**





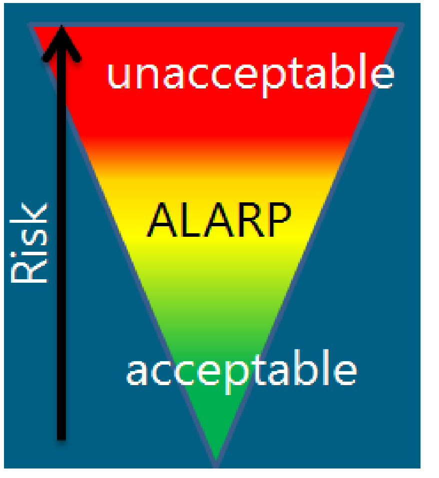


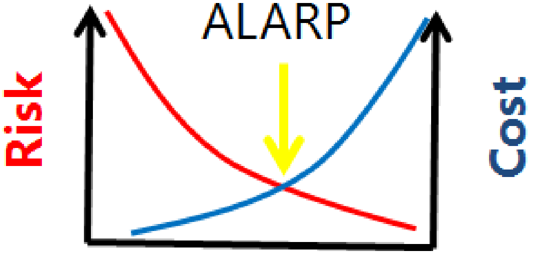
Tensile Armour Wire Fatigue Life Calculation



Layer by Layer Risk Based Assessment (RBA)

- Identifying and assessing degradation threats in a logical manner for each layer of the flexible (all credible degradation mechanism from API 17 N are considered).
- Assessment of "non-inspectable" layers (such as carcass, internal plastic sheaths) which are important to the integrity of the flexible.
- Allows to select specific mitigation actions to keep the risk level to ALARP (As Low As Reasonable Practicable).





Layer by Layer Risk Based Assessment (RBA)

Unmitigated Risk Matrix

Consequence					
Very High 5	TA3, C1	IP1, C3, EF10	TA1, C2		
High 4		EF1, EF2, EF3, EF4, EF6 EF9	EF7		
Medium 3			BS1, CL1	OS1	EF5
Medium Low 2	BS2	TA2			
Low 1		AW1			
Note: Numbers after layer names indicates different degredation modes	1 Low	2 Medium Low	3 Medium	4 High	5 Very High
	Probability				

Mitigated Risk Matrix

Consequence					
Very High 5	TA3, C1, **C3**	**TA1**, **C2**, IP1, EF10			
High 4		EF1, EF2, EF3, EF4, EF6, EF9	EF7		
Medium 3		**BS1, EF5**	**OS1**, CL1		
Medium Low 2	BS2	TA2			
Low 1		AW1			
Note: Numbers after layer names indicates different degredation modes	1 Low	2 Medium Low	3 Medium	4 High	5 Very High
	Probability				

Three high risk elements:

- **TA1: single or multiple wire rupture**
- **C2: carcass collapse**
- **EF5: vent blockage**

Conclusions

- **The FlexIQ approach demonstrates that combining methods of advanced inspection and analysis as part of an integrity assessment is a valid solution for increased understanding of flexible riser condition as part of a life extension program.**

- **Life extension of flexibles beyond design life depends primarily on the flexible pipe condition, rather than it's age.**

- **The FlexIQ approach has demonstrated that life extension can be achieved by implementing a comprehensive risk based integrity plan that includes routine inspections, monitoring and maintenance activities.**