2H offshore

Riser & Conductor Engineering

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Understanding Fatigue Risks (in wellheads…)

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Agenda

- Sources of fatigue
- Fatigue assessment
- Understanding risk
- Case study

Sources of Fatigue

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Fatigue Sources: Wave Fatigue

Vessel Motion

The wave motion acting on the vessel. The vessel motion (RAO) then acts on the riser.

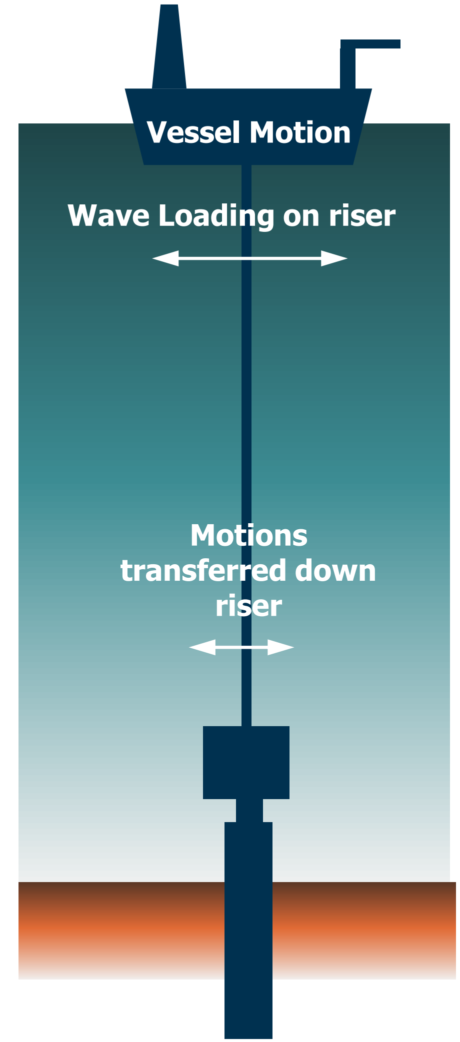
Wave Loading

The wave loading acts directly on the riser due to the drag of the riser system.

High Damage

Water depth <300m
Most commonly occurring waves Tp ~ 7s, Hs ~ 3m

Riser/BOP resonance



Fatigue Sources: VIV Fatigue

Current Loading

Current loading acting on a drilling riser causes vortex shedding. Vortices create pressure wave across structure.

Natural Frequency

VIV fatigue of concern when vortex shedding frequency matches one or more natural frequencies of the riser.

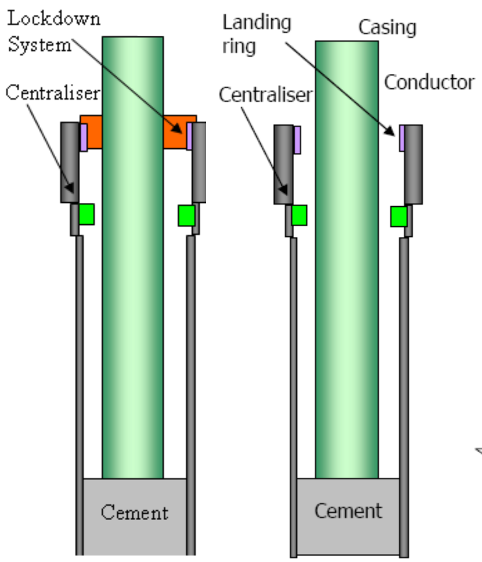
High Damage

- Currents >1m/s
- Small diameter risers
- Riser/BOP resonance
- Water depth >300m
- On-Off Effect

Challenges for Existing Wells

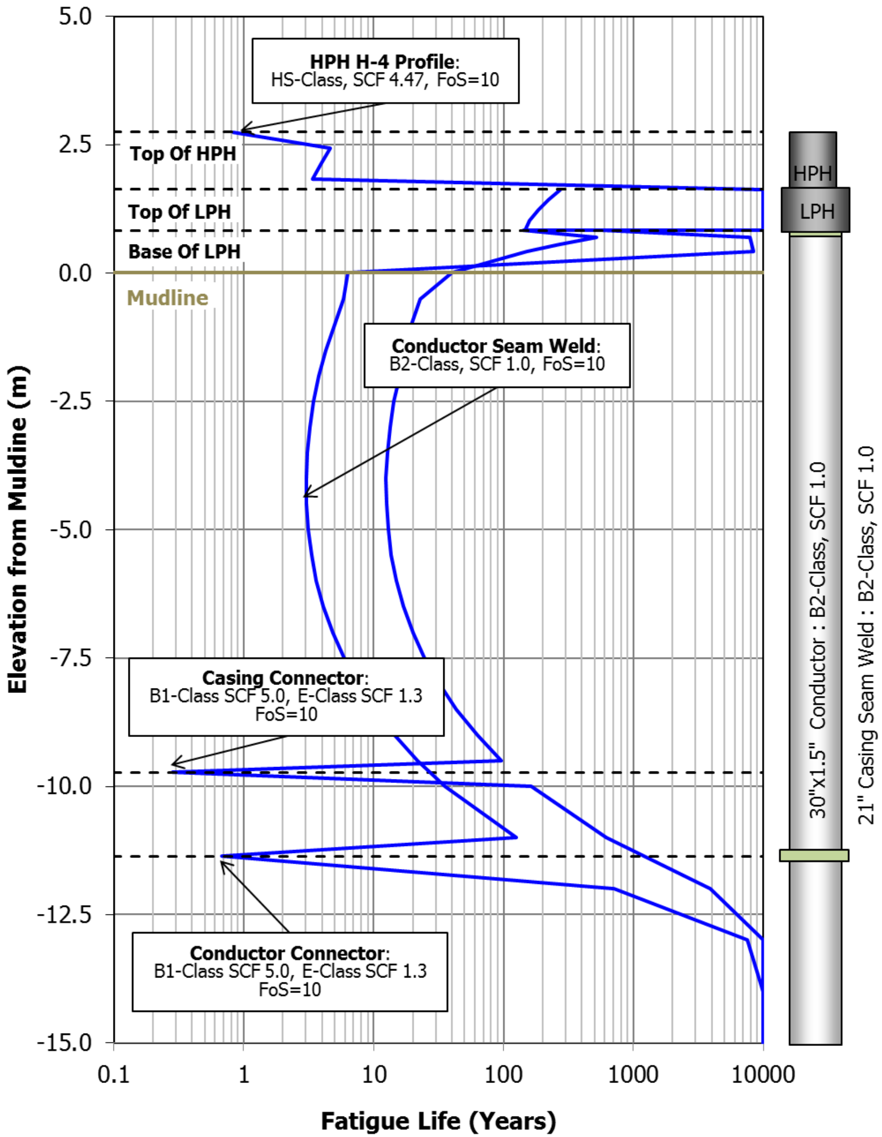
- Design is fixed
  - Can not design-out fatigue through component selection

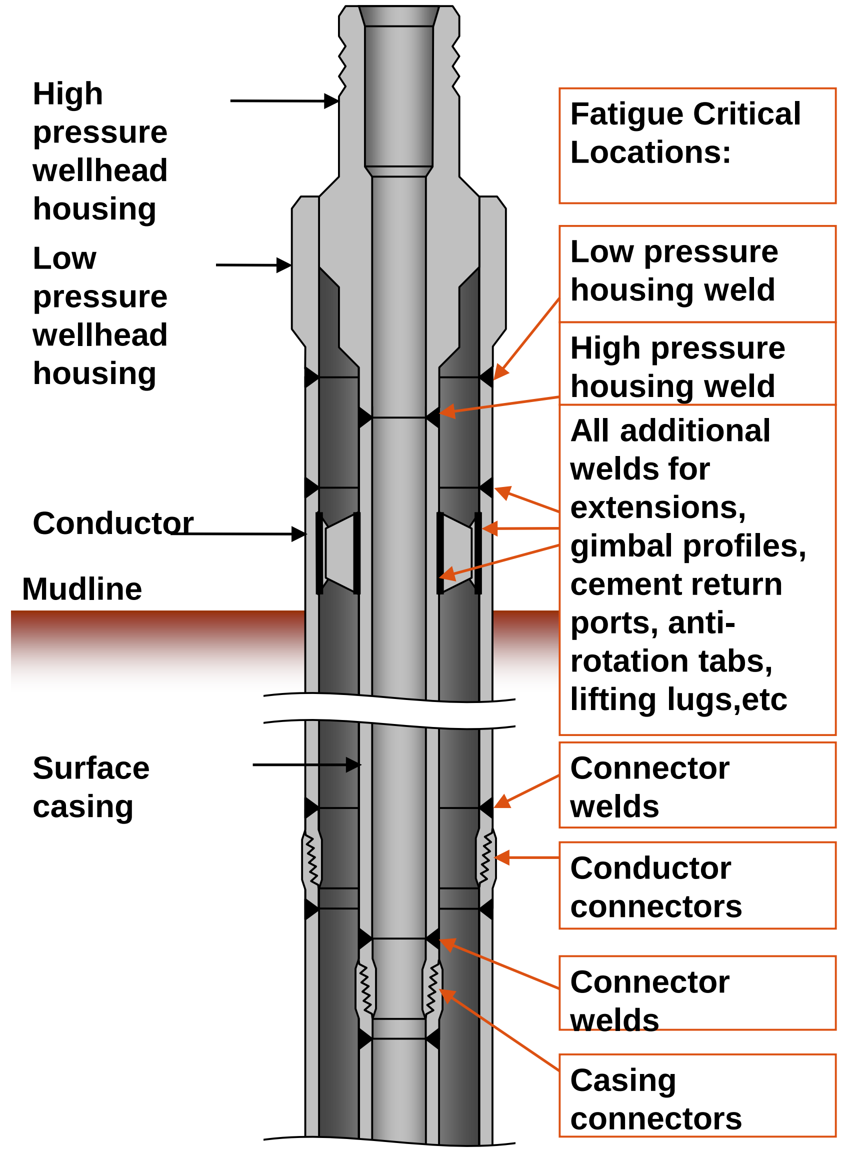
- Limited data
  - No records of the environmental loading history for the wellhead
  - Limited availability of equipment design and as-built data
  - Lost details of intervention operations performed
  - Unknown current condition, e.g. cement levels etc.



- Unconventional, lower-specification equipment
  - Relatively poor weld quality
  - Large SCFs at housing hotspots
  - Smaller conductors and non-rigid lock wellheads
  - Not designed for loads from larger, heavier modern BOP stacks with natural frequencies close to wave periods

Typical Points of Concern





Fatigue Assessment

S-N Curve Method

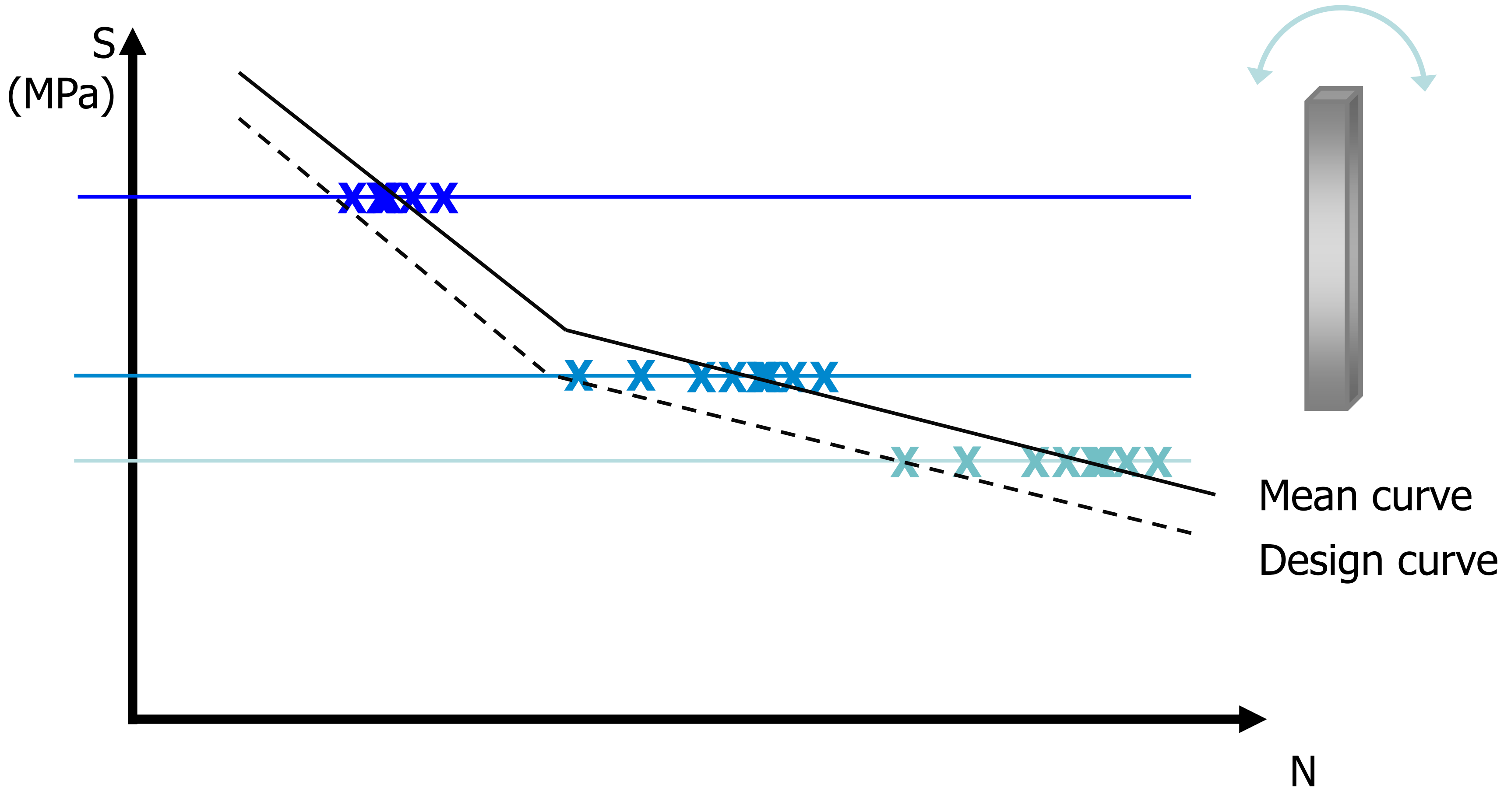
Design Codes / Fatigue Testing

1. Test samples and quantify the number of stress cycles to failure at different stress ranges
2. Draw best-fit lines through the results (an S-N curve)

Global Analysis and Post-processing

1. Generate a stress timetrace for the loads expected
2. Compare the number of expected cycles (n) to the allowable number of cycles (N) at each stress range
3. Add the results from all stress ranges to generate damage expected
4. Apply a safety factor to account for variability

S-N Curves



Design Code Safety Factors

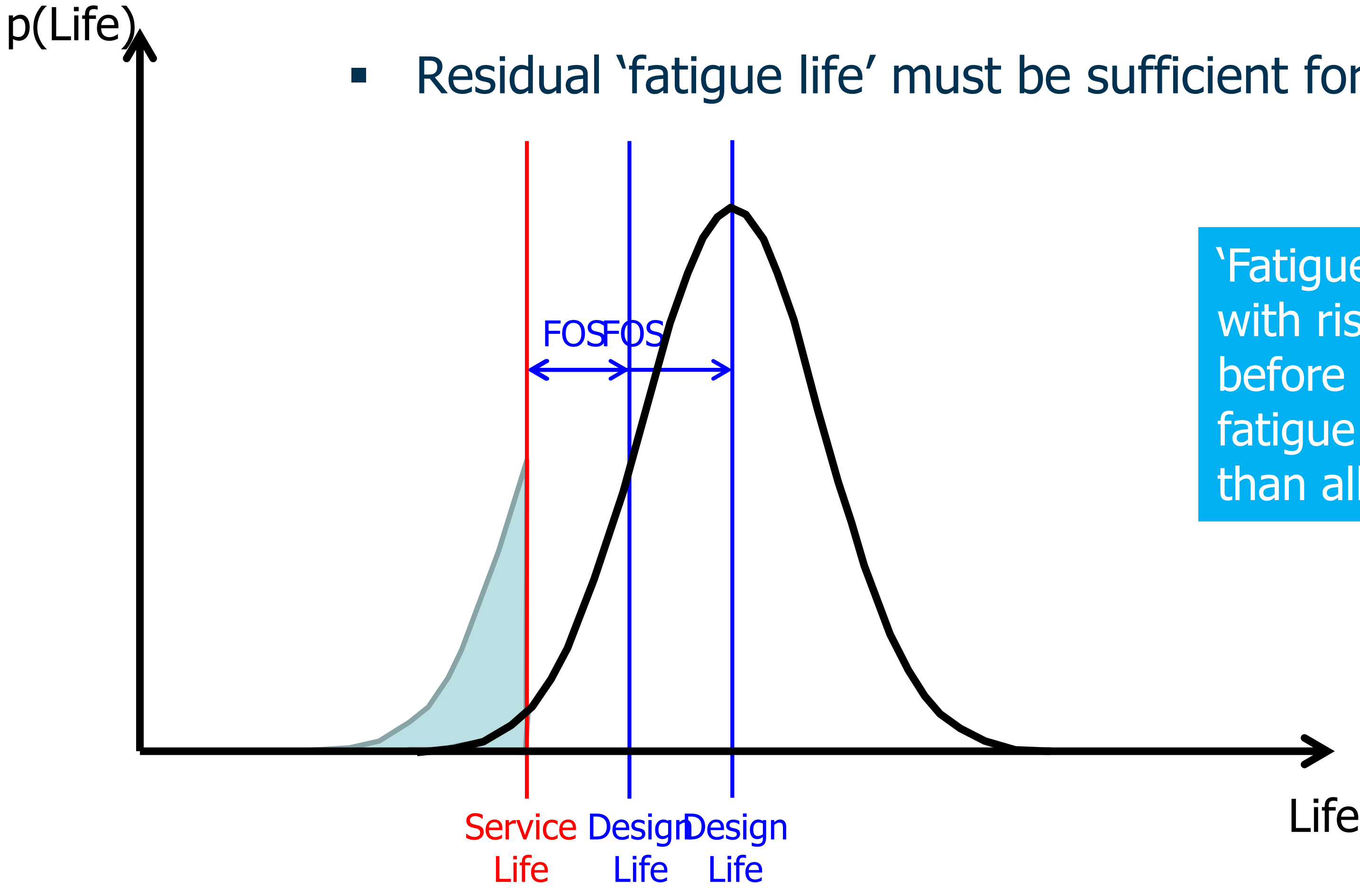
- To account for variability in loading
- To account for uncertainties in design data
- To ensure the probability of failure associated with the fatigue life result is appropriate for the activity
- Typically factors of safety between 3 and 10 are used in fatigue analysis, based on code guidance

DNVGL-RP-C203 **API-RP-2RD** **DNV-OS-F201**

Defining the Objective: Fatigue Life Requirement

- Need to assess current baseline of fatigue accumulation in installed equipment

- Residual 'fatigue life' must be sufficient for planned P&A



'Fatigue Life' = time with riser connected before the chance of a fatigue failure is higher than allowable

Case Study

Background

- Abandonment operations planned for E&A well in the CNS
- Water depth 90m
- Wells drilled in mid 1980s with a 3rd generation semi-sub MODU
- Operations took place in winter and lasted 36 days
- Wells left temporarily suspended

- 3rd generation semi-submersible MODU to be used for P&A

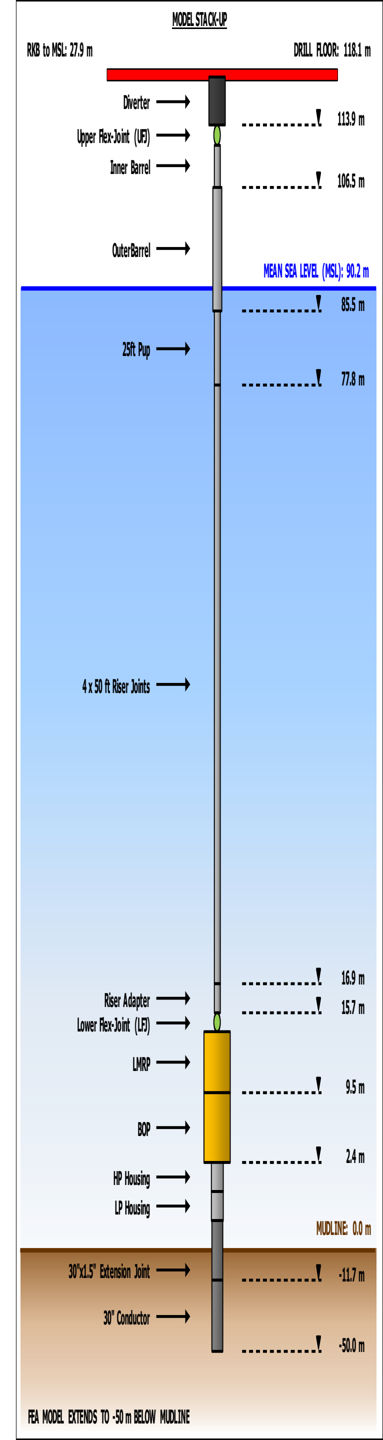
- Analysis performed to calculate remaining fatigue capacity for abandonment operations

Table 2-3 Classification of safety classes

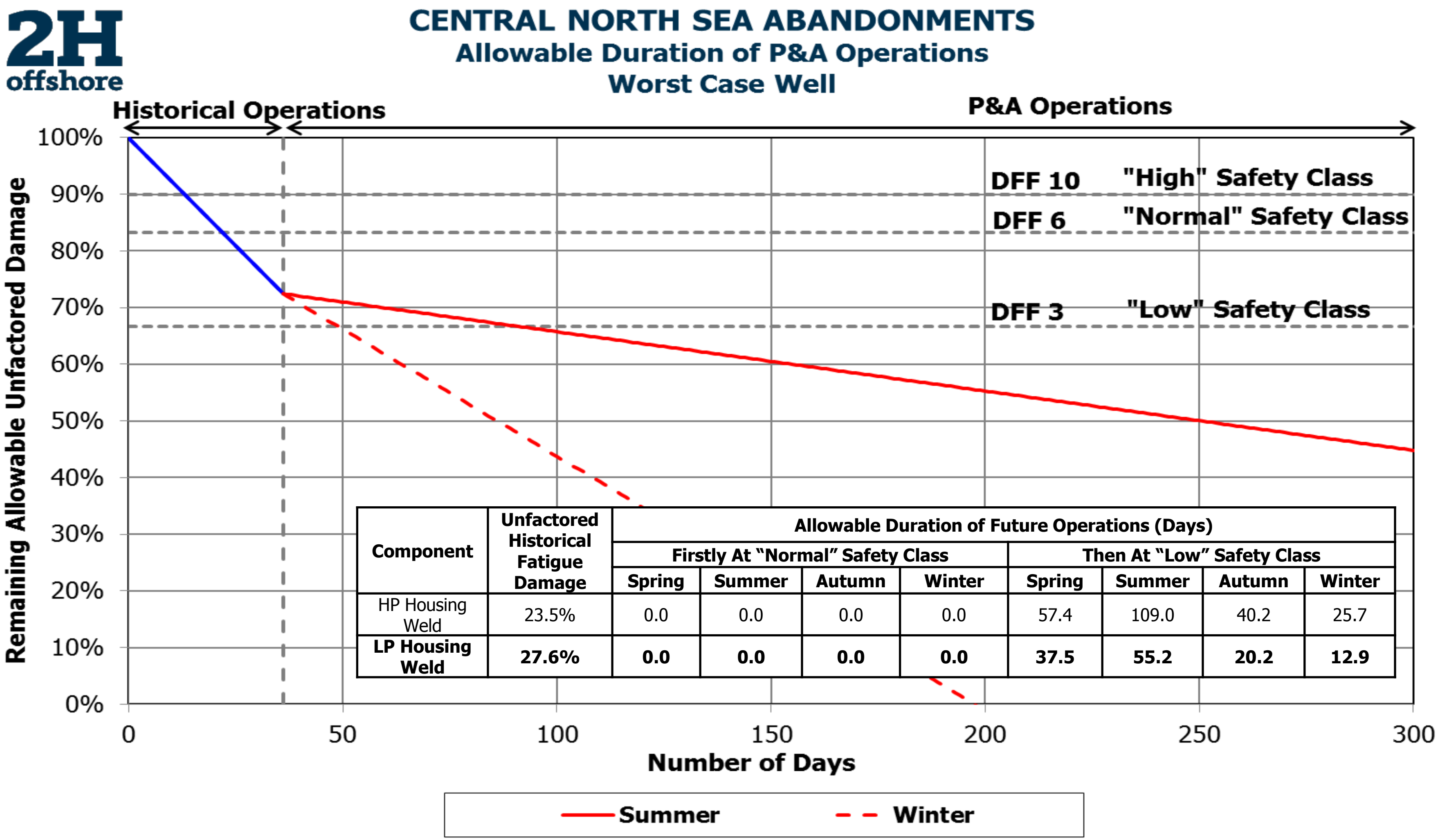
Safety class	*Definition*
Low	Where failure implies low risk of human injury and minor environmental and economic consequences.
Normal	For conditions where failure implies risk of human injury, significant environmental pollution or very high economic or political consequences.
High	For operating conditions where failure implies high risk of human injury, significant environmental pollution or very high economic or political consequences.

Overcoming Old-Well Challenges

- Design is fixed
- Limited data
  - Dates of drilling campaign known, but no weather data
  - Hindcast data procured for period of previous operations
  - Data screened to extract extreme seas above disconnect limit
  - Daily drilling reports used to extract riser tension
  - Sensitivity analysis of cement shortfall – confirm lower bound
- Unconventional, lower-specification equipment
  - Manufacturer input to confirm fatigue details for known components
  - Load path response of critical components examined



P&A Fatigue Life Results



Component	Unfactored Historical Fatigue Damage	Allowable Duration of Future Operations (Days)							
		Firstly At "Normal" Safety Class				Then At "Low" Safety Class			
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
HP Housing Weld	23.5%	0.0	0.0	0.0	0.0	57.4	109.0	40.2	25.7
LP Housing Weld	**27.6%**	**0.0**	**0.0**	**0.0**	**0.0**	**37.5**	**55.2**	**20.2**	**12.9**

Analysis Informed Recommendations

Risk assess whether a “low” safety class is appropriate at the start of operations.

- Yes:
  - Proceed with operations with no further mitigations
  - Schedule P&As of onerous wells in summer months

- No:
  - Reconfirm SCF of HP and LP housing welds using old part numbers and procedures – likely to be available?

  and/or
  - Proceed with P&A of less onerous well first, in summer months
  - Conduct structural monitoring to calibrate analytical model
  - Refine fatigue damage calculation for more onerous wells

Summary

- Fatigue analysis of subsea wells, prior to P&A, complicated by old equipment, lack of data.
- Codes define an acceptable level of fatigue usage depending on risk of operations.
- Informed selection of analysis methodologies and understanding of safety philosophies can give efficient and effective quantification of risk.
- Analysis results can form a key part of operational planning.

Questions?

Thank you

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