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Leveraging API17J for effective design of flexible lines

Pressure definitions for high-pressure and deep water applications

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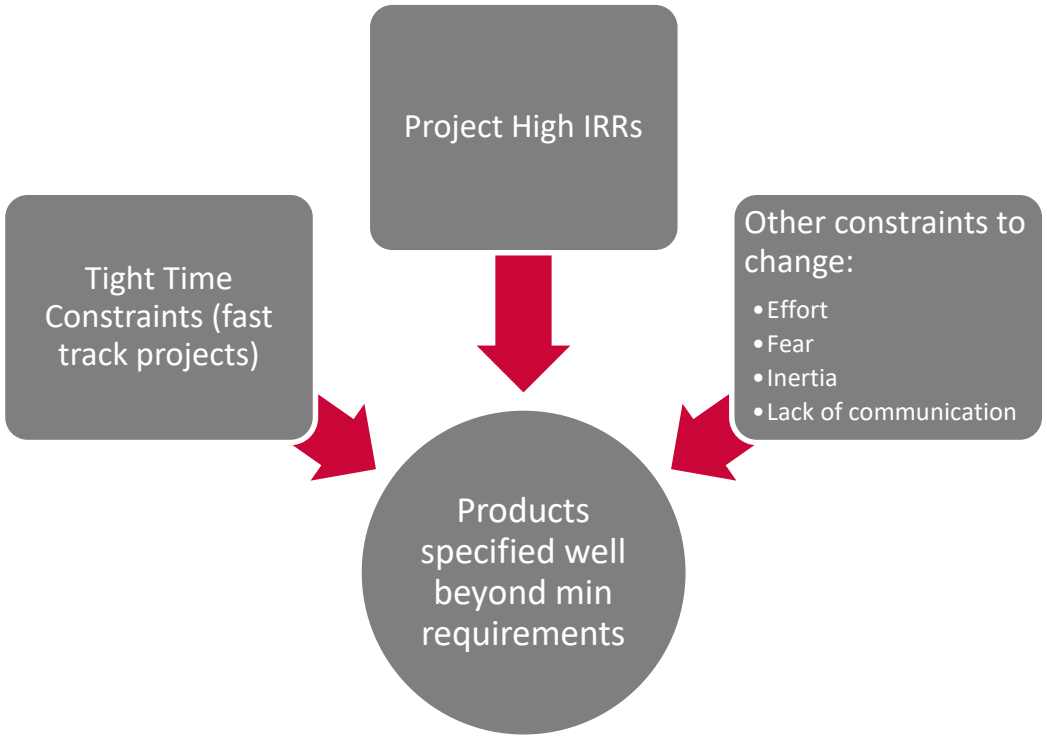
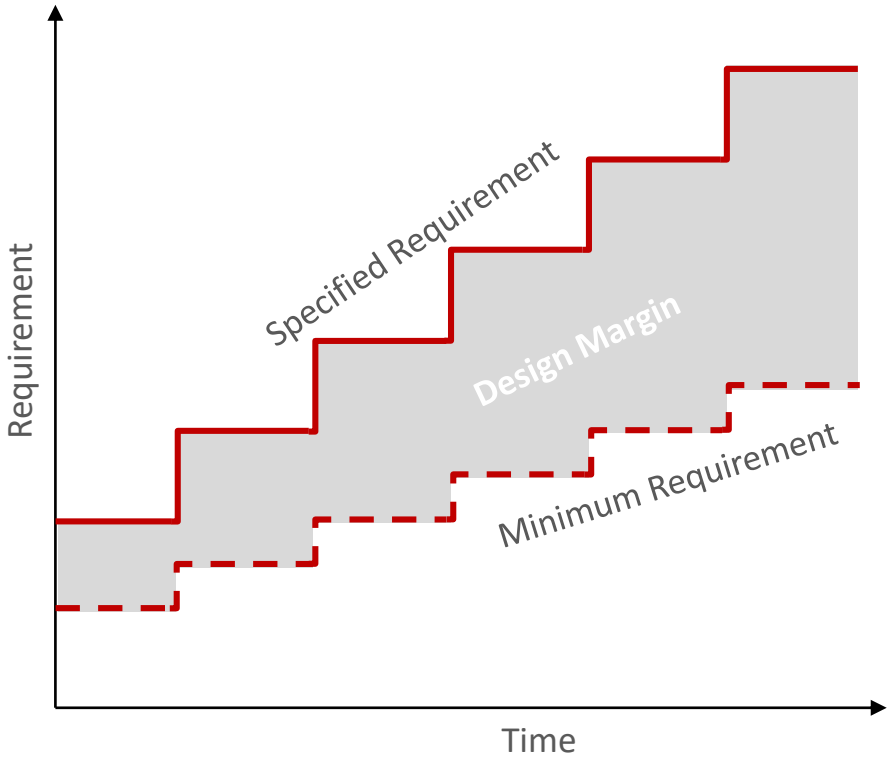
…That's the way it's always been around here…

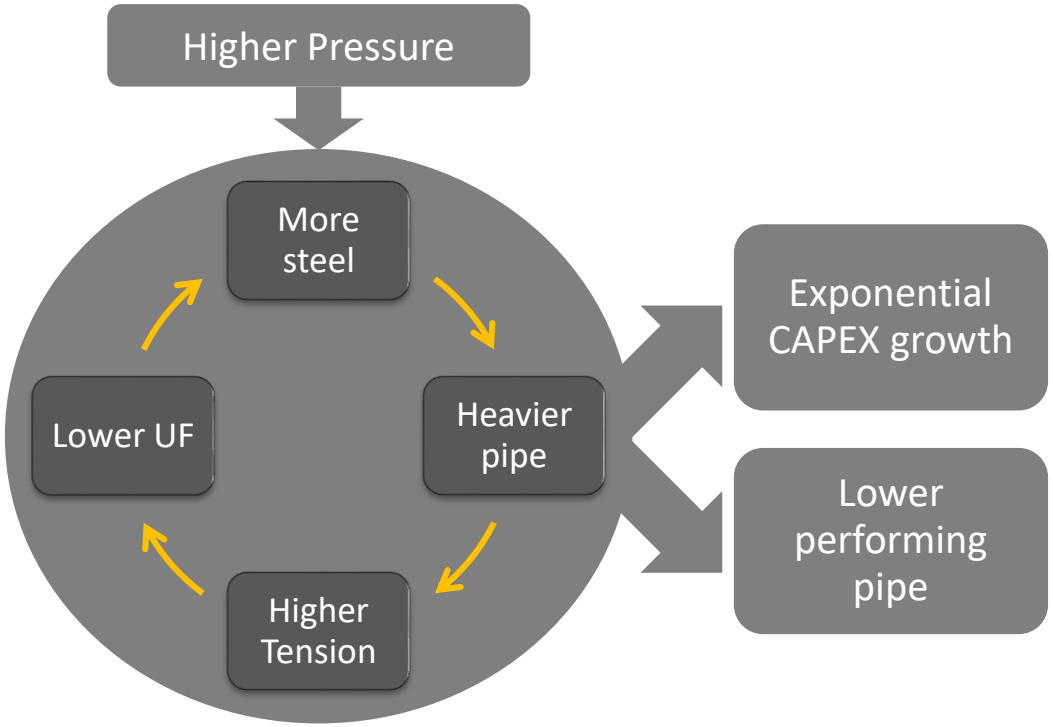
The way it was done when oil was at 100$/bbl



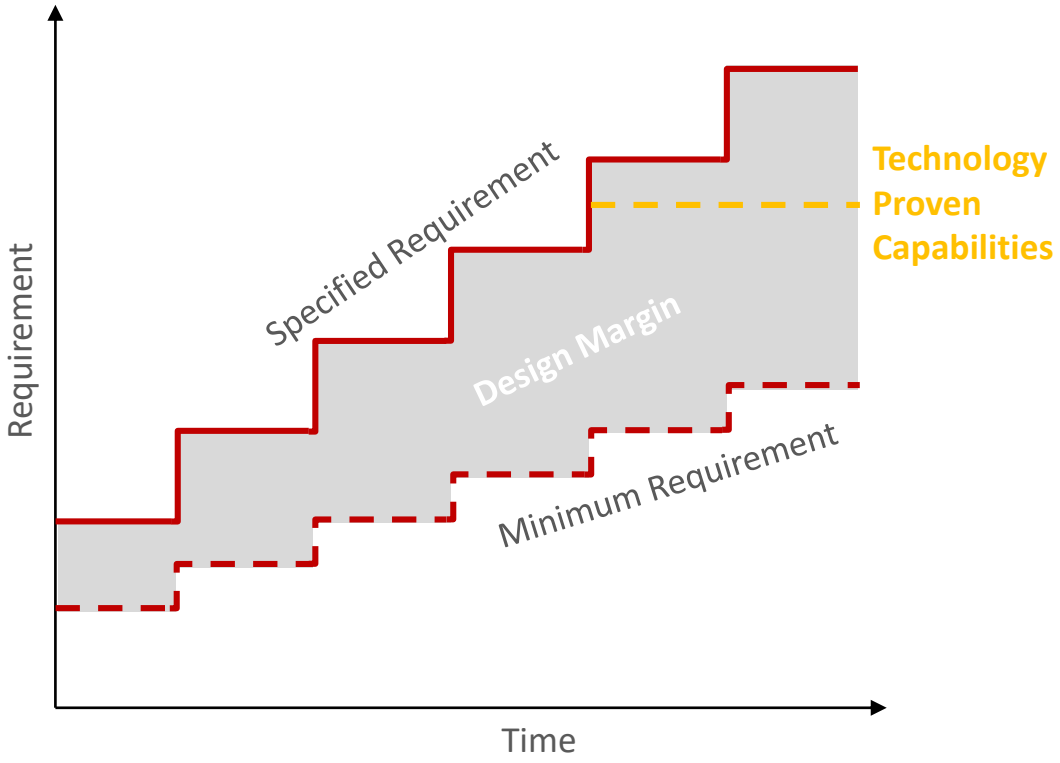


When to challenge consolidated practices for flexible pressure specifications?

High pressure comes at a cost in deep water applications



When Specified requirement unnecessarily beyond technology proven boundaries



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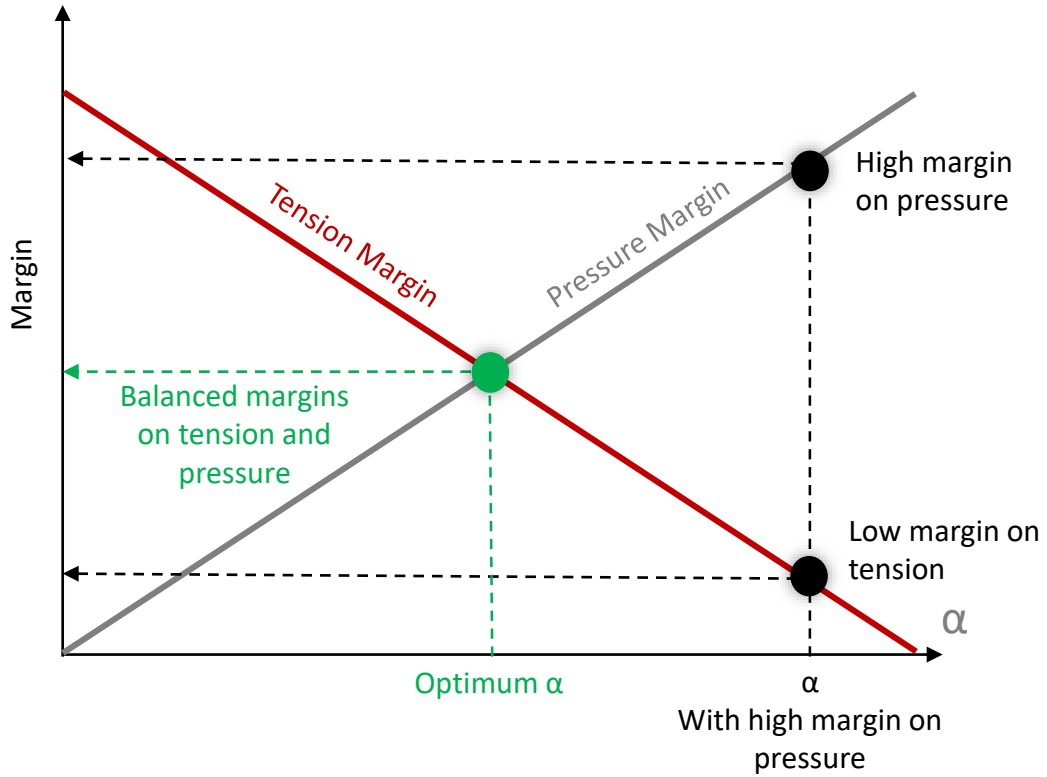
High margin on pressure comes at the cost of reduced margin against environmental loads and fatigue



Agenda

- *Absolute vs Differential Pressure*
- *Incidental Pressure*
- *Maximum Operating Pressure*
- *Case Study*
- *Conclusions*

ABSOLUTE VS DIFFERENTIAL PRESSURE?

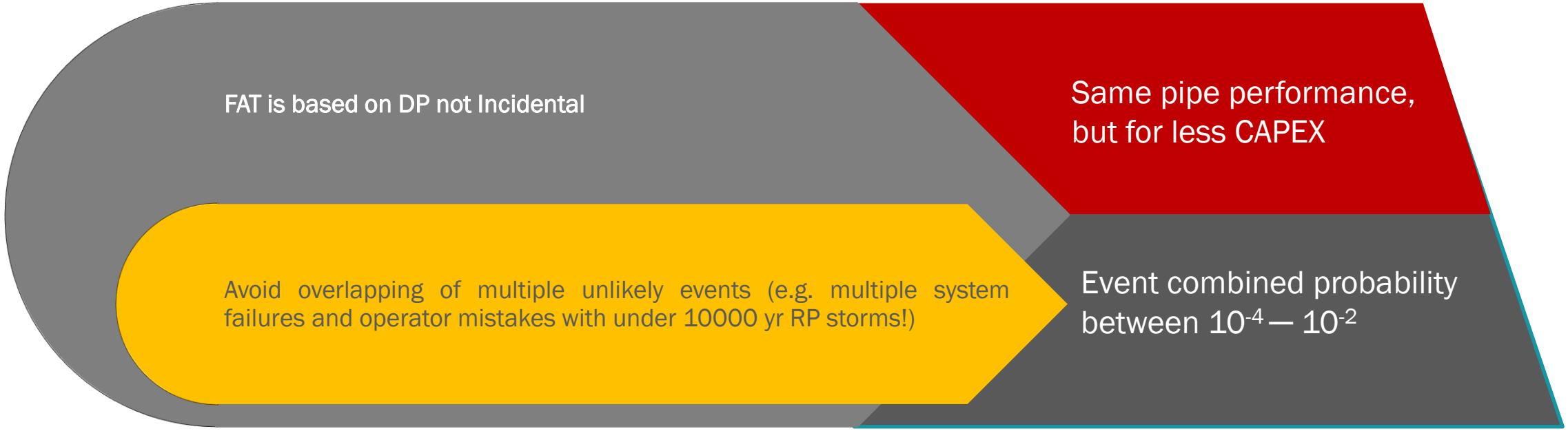
Flexibles shall be purchased using the absolute or the differential Pressure?

Pressure Sheath sees Absolute pressure*	Design Pressure is absolute. (DP)
Carbon Steel wires see differential pressure	Specifying Design Pressure is not sufficient, Maximum Differential Pressure (MDP) shall be defined too and would drive the sizing of steel layers and the maximum tension that can be applied in extreme conditions.

*Intact outer sheath or dry annulus condition

Incidental Pressure

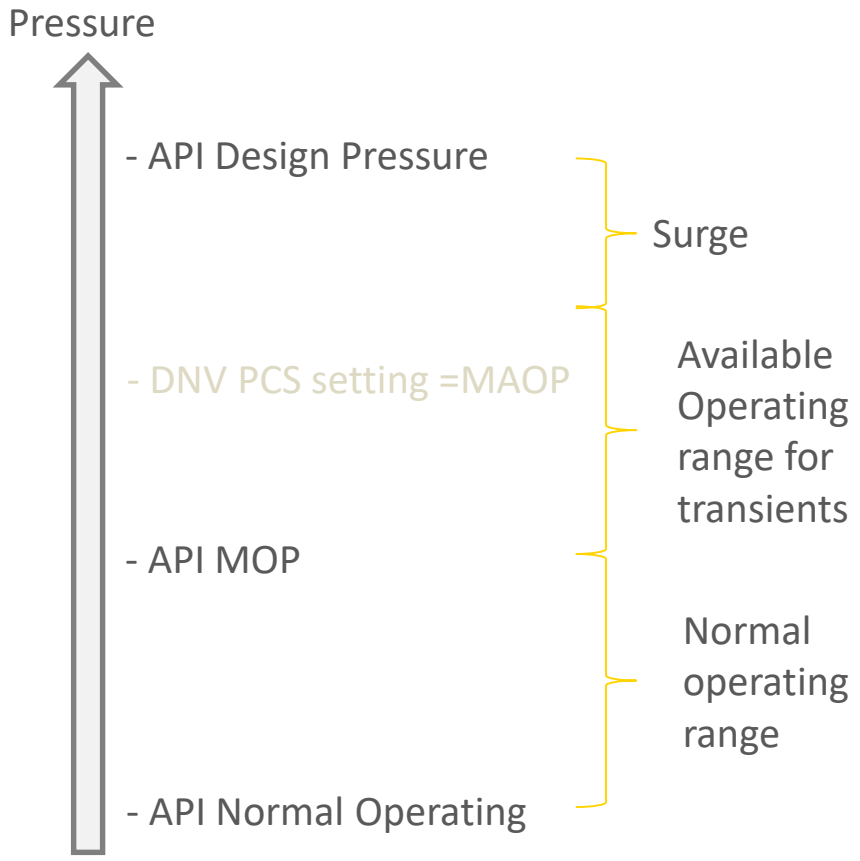
Incidental Pressure (IP) is often neglected, however its importance grows with water depth:



Maximum Operating Pressure

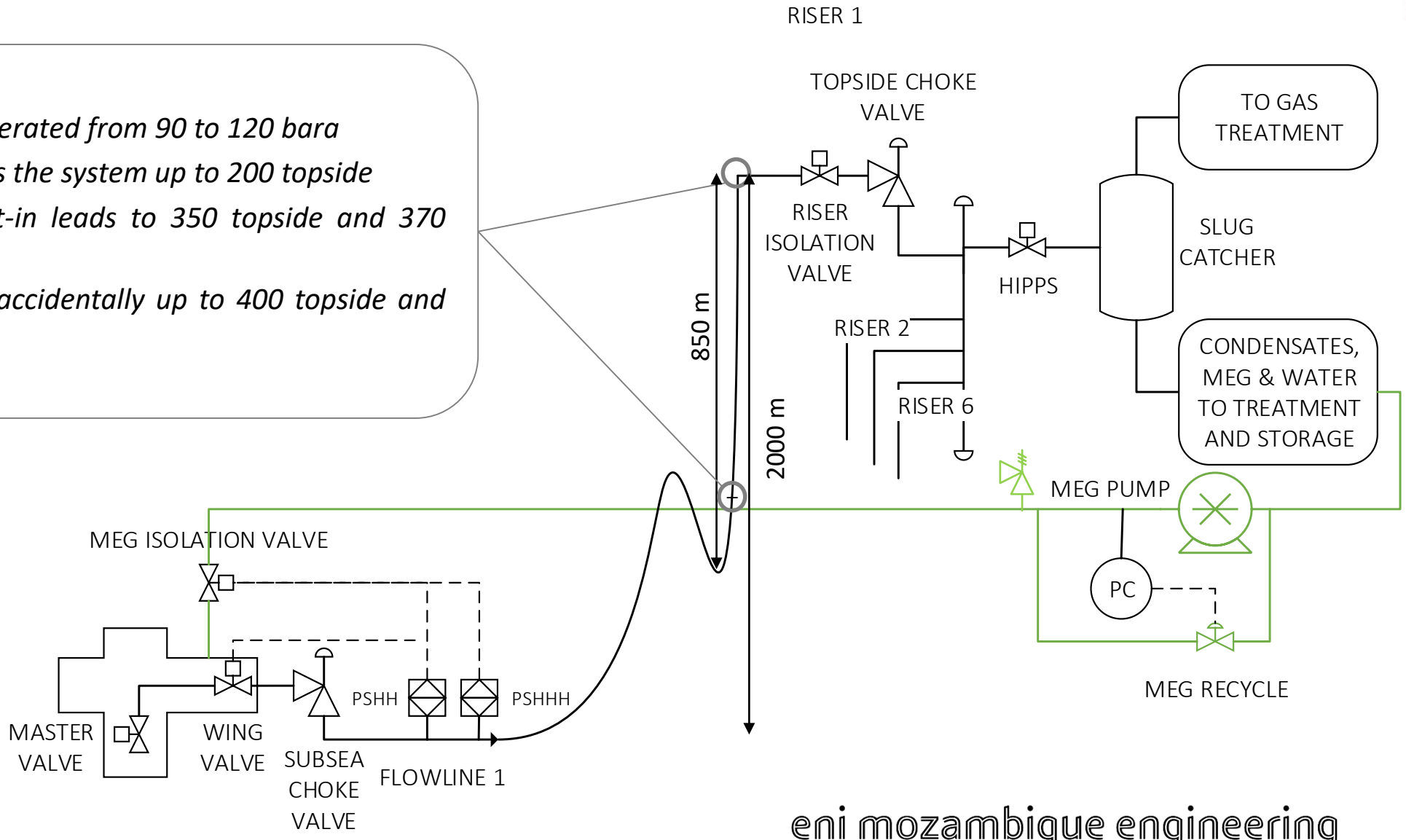
MOP / API	MAOP / DNV
The maximum internal pressure, at a reference location, to which the pipe is subjected during permanent normal operation	Maximum allowable operating pressure is equal to the design pressure minus the pipeline control system (PCS) operating tolerance.

- *MOP is not equivalent to MAOP from DNV:*
  - *It does not need to cover transient conditions such as planned or un-intended shut-ins*
  - *Flexible pipes can be operated up to Design Pressure (minus surge)!*



Case Study (1/3): The field

- *Slug catcher can be operated from 90 to 120 bara*
- *PSHH on the well limits the system up to 200 topside*
- *Well un-intended shut-in leads to 350 topside and 370 bara at 700 m WD*
- *MEG can be injected accidentally up to 400 topside and 477 bara at 700 m*



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Case Study (2/3): Stress analysis inputs

- *Slug catcher can be operated from 90 to 120 bara*
- *PSHH on the well limits the system up to 200 topside*
- *Well un-intended shut-in leads to 350 topside and 370 bara at 700 m WD*
- *MEG can be injected accidentally up to 400 topside and 477 bara at 700 m*

Specification A	Specification B
NOP	MOP
N/A	N/A
MOP	DP
DP = 477 bara @700 m	IP = 477 bara @ MSL MDP[2] = 407 bara
FAT[1] = 1.05*1.5*DP =751 bara	FAT = 1.05*1.5*MDP =641 bara

Goal: Comparing the impact of the two pressure specifications on the ability of the flexible to withstand tension

Max Tensions:

- *Recurrent 700 kN (associated to MOP)*
- *Extreme 1000 kN (associated to DP)*
- *Abnormal 600 kN (associated to IP)[3]*

1) 1.05 for pump pressure peak
2) MDP can be also specified as Design Differential Pressure (i.e. 350 bara)
3) Environmental conditions less onerous due to combined probability

Case Study (3/3) Assessment

- *Step 1: choose Armour wire angle to have 0.91 at FAT. All other parameters of the flexible are the same*
- *Step 2: check Utilization Factors against maximum allowed by API*
- *Step 3: what is the tension the pipe can withstand at maximum UF?*
- *Step 4: if we assume constant dynamic amplification factor, what is the maximum water depth that the two pipes can go?*

	Specification A	Specification B
α	43°	36°
UF at predefined tensions		
Recurrent (0.67)	0.666	0.320
Extreme (0.85)	0.817	0.677
Abnormal (0.85)	0.706	0.630
Allowable tension [kN] at max UF		
Recurrent (0.67)	714	2103
Extreme (0.85)	1120	1693
Abnormal (0.85)	1120	1447
Water Depth achievable [m] at max UF		
Recurrent (0.67)	867	2553
Extreme (0.85)	952	1439
Abnormal (0.85)	1587	2051
Overall	867	1439

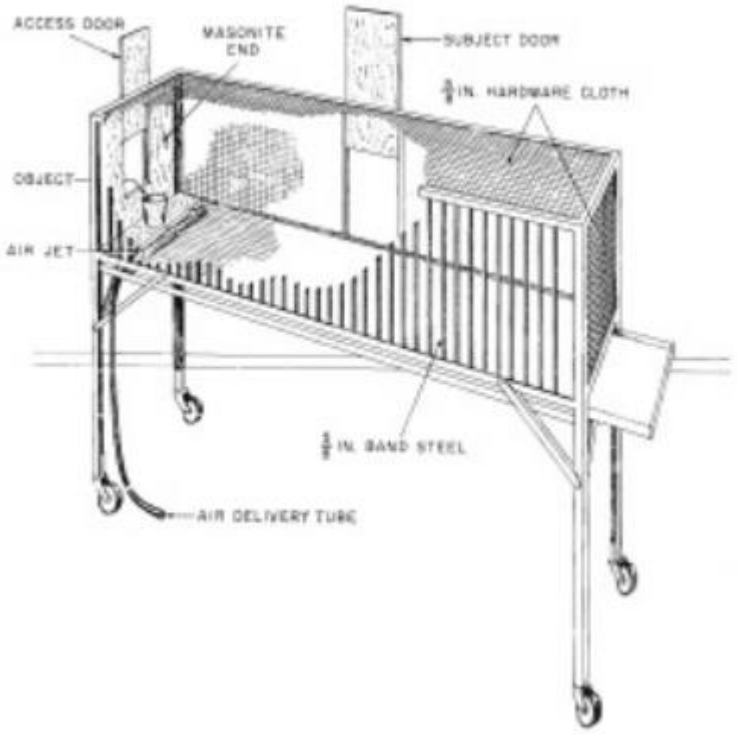
Conclusions

- *Conservative pressures ≠ better pipe performances*
- *While suppliers are developing new technologies to move deeper and access high pressure reservoirs, clients should leverage at maximum available technology*
- *Detailed pressure specifications are essential to access deep water and high pressure fields and improve pipe performance (e.g. fatigue life)*
- *Understanding of flexible operating conditions is key, which can be achieved only with tight disciplines integration*

Close out

…Actually…

- *50% of the Monkeys shown admonition behaviours*
- *The other 50% shown observational learning*



It's important to challenge what we get told

References

- *API 17J 4th Edition, May 2014*
- *Stephenson, G. R. (1967). Cultural acquisition of a specific learned response among rhesus monkeys. In: Starek, D., Schneider, R., and Kuhn, H. J. (eds.), Progress in Primatology, Stuttgart: Fischer, pp. 279-288.*
- *Fergestad, D. Svein A. L., Handbook on Design and operation of flexible pipes, June 2017*

Questions?

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Backup – Calculations input

- *Tensions are typical for the configuration and water depth*
- *Methodology as per Fergestad, D. Svein A (ref [3])*
- *0.05 uncertainty safety factor is considered in addition*
- *0.9 Corrosion factor accounted for operational cases*
- *Wire thickness is 3.6 mm*
- *Pressure Armour had an effective thickness of 9 mm*

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Title

Subtitle

Location, Date