wood.

Havtil Norwegian Ocean Industry Authority

Flexible pipe integrity

Latest updates from the Sureflex JIP

Sureflex

26th November 2025

What do we know, data-driven insights...

Donald Rumsfeld

- US Secretary of Defense
- (1975-1975, 2001-2006)

"Reports that say that something hasn't happened are always interesting to me, because as we know, there are ***known knowns****; there are things we know we know.*	***What do we know?*** *Do we have trusted data to support decisions?*
We also know there are ***known unknowns****; that is to say we know there are some things we do not know.*	***What do we think we know?*** *What should we know (but don't)?*
But there are also ***unknown unknowns*** *- the ones we don't know we don't know.*	***What are the potential threats?*** *(and how might we mitigate them?)*
And if one looks throughout the history of our country and other free countries, ***it is the latter category that tend to be the difficult ones****."*	***What future threats to consider?***

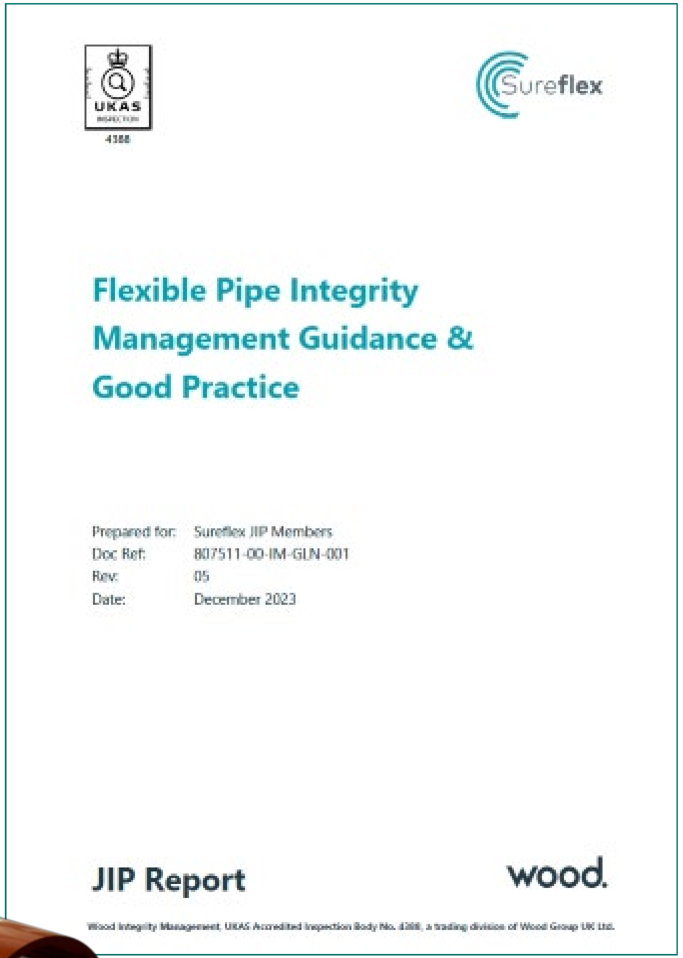
Sureflex JIP

Developing industry guidance and good practice for integrity management of flexible pipe systems

Gathering, desensitising, and sharing data:

- Population and Damage / Failure statistics
- Integrity Management guidance and good practice
  - Data-driven lessons learned
- Operator Case Studies and emerging threats
- Inspection, Monitoring, Repair Technologies

Improved operational integrity, preventing incidents


UKAS INSPECTION 4388

Sureflex

Flexible Pipe Integrity Management Guidance & Good Practice

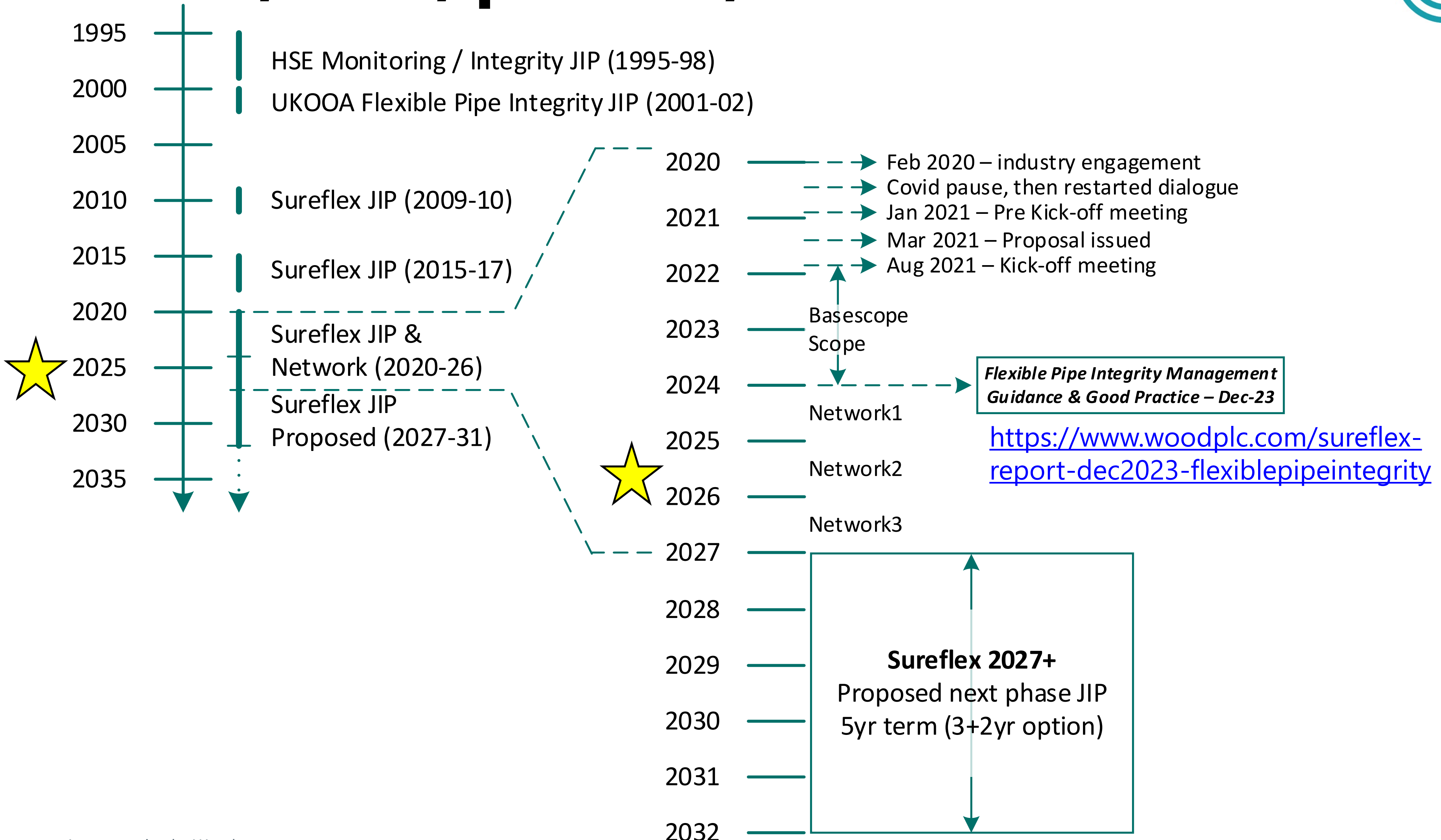
Prepared for: Sureflex JIP Members
Doc Ref: 807511-00-IM-GLN-001
Rev: 05
Date: December 2023

JIP Report

wood.

Wood Integrity Management, UKAS Accredited Inspection Body No. 4388, a trading division of Wood Group UK Ltd.

Sureflex JIP; Past, present, and future…



Sureflex JIP participants (50+)

Current Members (21)

- Operators (13)
- Suppliers (3)
- Regulators (3)
- Certifiers & Installers (2)

Additional (mostly non-member) contributors (12) – named in Dec2023 report

- Operators (6)
- 3rd party contractors (5)
- Regulator (1)

Plus input from inspection, monitoring, maintenance, repair vendors (20) – named in Dec2023 report

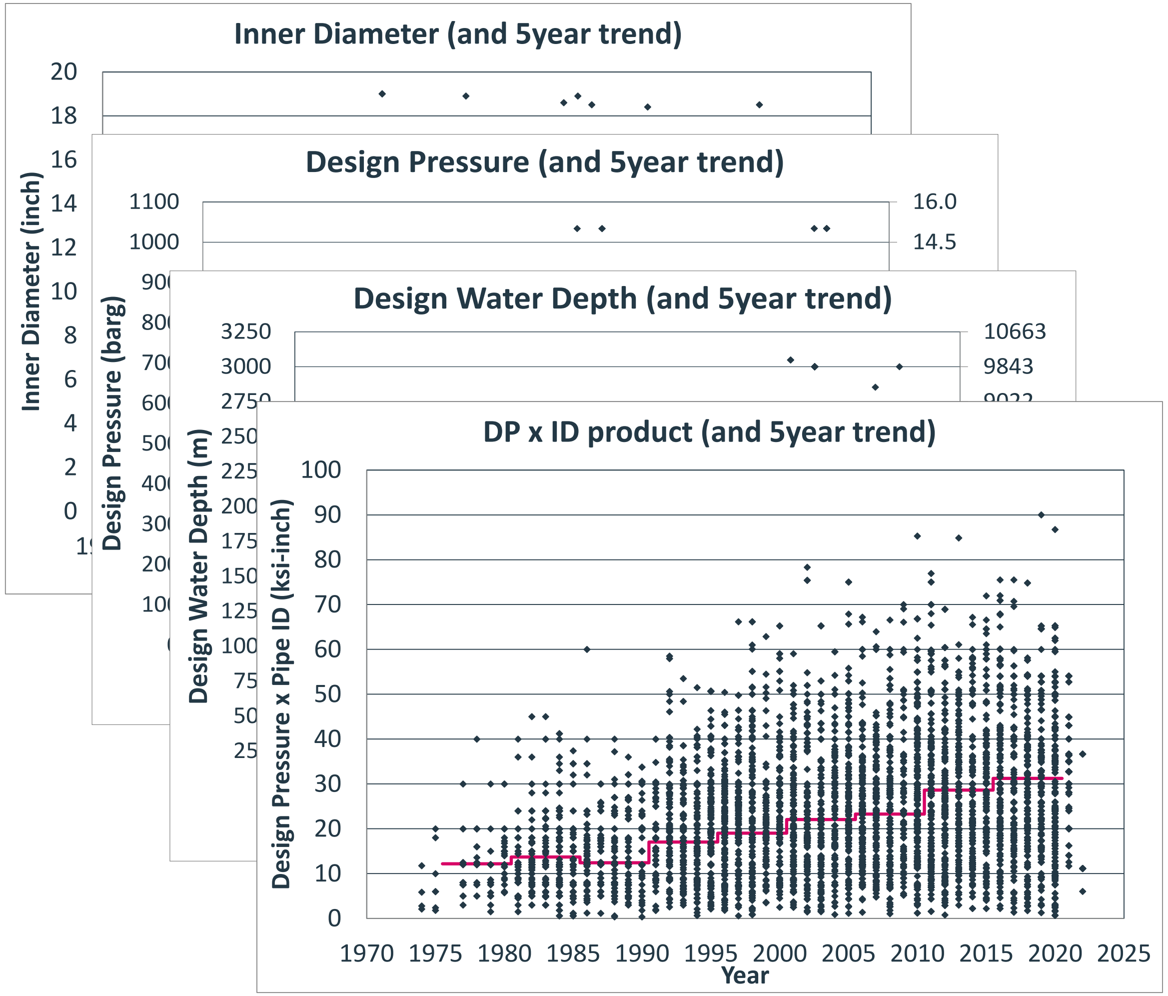
Summary of population database

20,672 km of supplied pipe

22,597 pipe sections

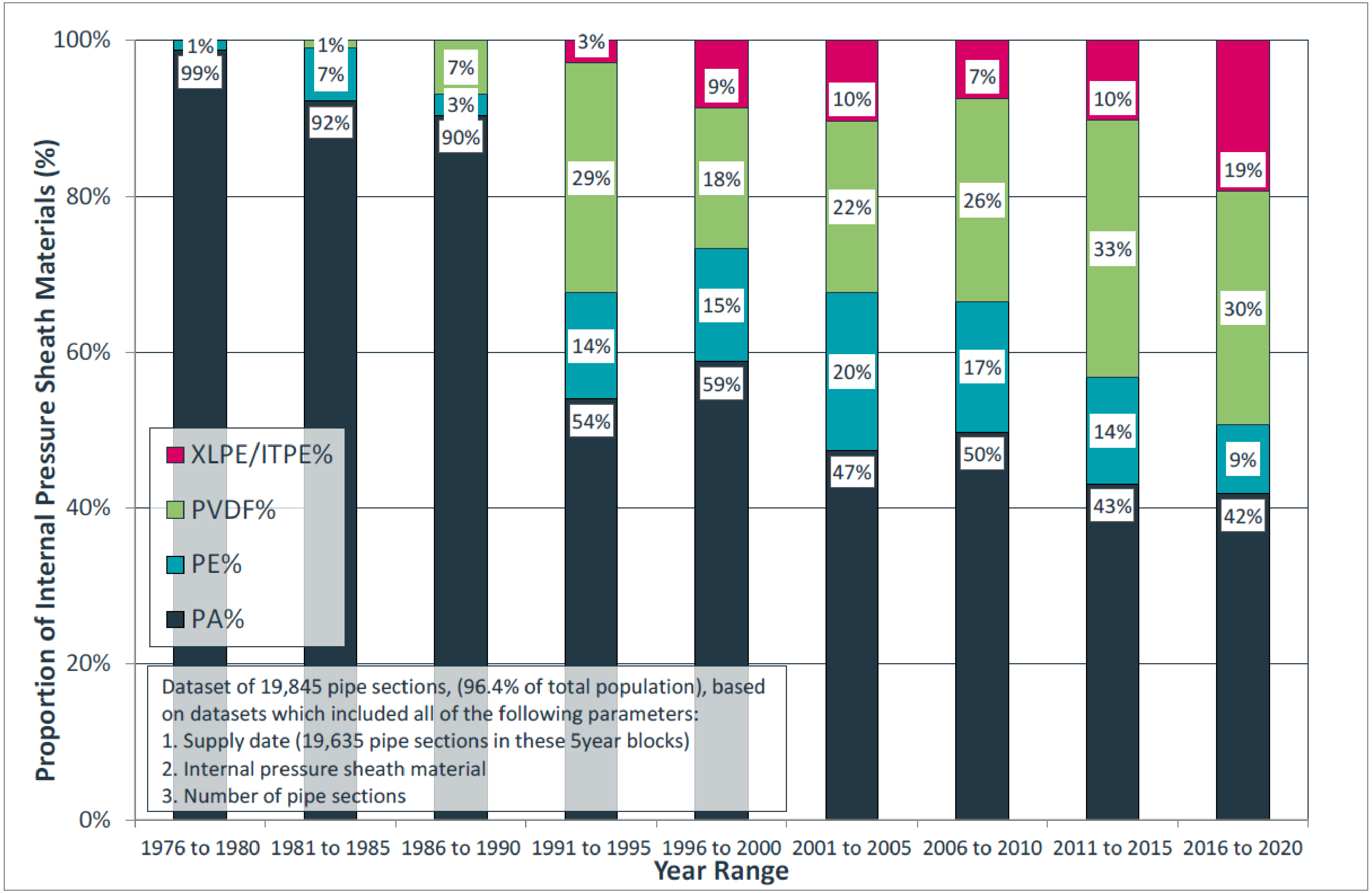
Pipe Type	Total Flexible Pipes Supplied								Average Pipe Section Length
	Sections of Pipe				Length				
	(number)		(% of total)		(km)		(% of total)		(metres)
Riser – Static	307	6,599	1.4%	**29.2%**	290	5,064	1.4%	**24.5%**	946
Riser – Dynamic	6,292		27.8%		4,774		23.1%		759
Flowlines	11,197	15,209	49.6%	**67.3%**	14,653	15,201	70.9%	**73.5%**	1,309
Jumpers	4,012		17.8%		547		2.6%		136
Riser (unspecified)	73		0.3%		21		0.1%		289
Unspecified	716		3.2%		385		1.9%		539
Totals	**22,597**		**100%**		**20,672**		**100%**		**-**

Design parameter trends, experience of use (examples)



Design Pressure Range (ksig)	ID Range (inches)	Water Depth Range (m) ≥ 0 ≤ 100	> 100 ≤ 200	> 200 ≤ 300	> 300 ≤ 400	> 400 ≤ 500	> 500 ≤ 750	> 750 ≤ 1000	> 1000 ≤ 1250	> 1250 ≤ 1500	> 1500 ≤ 1750	> 1750 ≤ 2000	> 2000 ≤ 2250	> 2250 ≤ 2500	> 2500 ≤ 3000	> 3000 ≤ 3500	SUMS by DP
> 0 ≤ 2 ksig	≥ 1 and ≤ 2.5 inch	22	68	10				1									1726
	> 2.5 and ≤ 5 inch	209	103	12	7	2	5	2	33			1					
	> 5 and ≤ 7.5 inch	148	87	5	2	5	3	18	7	3	14			1			
	> 7.5 and ≤ 10 inch	244	145	30	14	5	10	15	2								
	> 10 and ≤ 12.5 inch	140	71	11	17	13	9				6						
	> 12.5 and ≤ 15 inch	57	43	5	22	5	7	3			6						
	> 15 and ≤ 17.5 inch	33	12	2	6												
	> 17.5 and ≤ 20 inch	8	6	3	8												
> 2 ≤ 4 ksig	1 inch		15				10										9494
	> 1 and ≤ 2 inch	88	67	5	27	44	28	12									
	> 2 and ≤ 3 inch	97	160	88	31	41	65	137	25	45		30	10				
	> 3 and ≤ 4 inch	345	212	72	56	86	119	275	182	180	2	107					
	> 4 and ≤ 5 inch	59	20	4	1	11	22		1	16							
	> 5 and ≤ 6 inch	371	492	74	73	146	127	336	289	527	25	263	28	6			
	> 6 and ≤ 7 inch	23	23	1	2	1	2	18		38		185					
	> 7 and ≤ 8 inch	340	247	62	68	82	97	117	81	189	20						
	> 8 and ≤ 9 inch	23	38	12	49	16	6	16	22	23		15					
	> 9 and ≤ 10 inch	212	167	53	277	112	64	80	82	155	3	16	73				
	> 10 and ≤ 11 inch	49	19	2	13	14	6	39	5	10							
	> 11 and ≤ 12.5 inch	164	98	42	59	89	25	32		54							
	> 12.5 and ≤ 15 inch	42	10	7	27		2	3									
	> 15 and ≤ 17.5 inch	4		5	12												
	> 17.5 and ≤ 20 inch																
> 4 ≤ 6 ksig	1 inch																6662
	> 1 and ≤ 2 inch	11	45	2	9		6	1	42	8	11		1				
	> 2 and ≤ 3 inch	61	138	18	23	1	16	10	1	14		6					
	> 3 and ≤ 4 inch	124	152	16	14	14	18	15	9	365	102	38	231	197			
	> 4 and ≤ 5 inch	54	33		13		24	3	26	5	9	5					
	> 5 and ≤ 6 inch	223	254	16	109	27	46	31	47	577	150	78	312	621	18		
	> 6 and ≤ 7 inch	37	33	3	8		14	6	5	38	14	13					
	> 7 and ≤ 8 inch	51	97	16	52	11	32	79	71	344	9	10	168	202			
	> 8 and ≤ 9 inch	15	18	9	54	10	7	13		18							
	> 9 and ≤ 10 inch	74	113	6	100	18	12	41	49	46		16	62	12			
	> 10 and ≤ 11 inch	1	12		20	4	16	6		9	4						
	> 11 and ≤ 12.5 inch	32	21	31	24	9		8		10							
	> 12.5 and ≤ 15 inch	4	9		5	1											
	> 15 and ≤ 17.5 inch		8	6		13	3										
	> 17.5 and ≤ 20 inch																
> 6 ≤ 8 ksig	≥ 1 and ≤ 2.5 inch	14	13	19	5	2	3	1	14	13	1						1058
	> 2.5 and ≤ 5 inch	45	44		3	6	25	14	9	7	4	2	3				
	> 5 and ≤ 7.5 inch	43	60	4	77		9	37	30	74	11	5	118	72	5		
	> 7.5 and ≤ 10 inch	25	67	4	48	3	2	6	6	25	5	18	15				
	> 10 and ≤ 12.5 inch	3	6	10					1	13	9						
	> 12.5 and ≤ 15 inch																
	> 15 and ≤ 17.5 inch																
	> 17.5 and ≤ 20 inch																
> 8 ≤ 12 ksig	≥ 1 and ≤ 2.5 inch	2	29								35	18	5				1001
	> 2.5 and ≤ 5 inch	17	26	3	5		57	24	11	7		1	3	1			
	> 5 and ≤ 7.5 inch	1	7		3	16	25	19	5	61		6	199	370	11	4	
	> 7.5 and ≤ 10 inch			21			2			2			5				
	> 10 and ≤ 12.5 inch																
	> 12.5 and ≤ 15 inch																
	> 15 and ≤ 17.5 inch																
	> 17.5 and ≤ 20 inch																
> 12 ≤ 16 ksig	≥ 1 and ≤ 2.5 inch								13	6			1				40
	> 2.5 and ≤ 5 inch	3		1				1		8	2				1		
	> 5 and ≤ 7.5 inch														4		
	> 7.5 and ≤ 10 inch																
	> 10 and ≤ 12.5 inch																
	> 12.5 and ≤ 15 inch																
	> 15 and ≤ 17.5 inch																
	> 17.5 and ≤ 20 inch																
SUMS	by WD	3518	3288	690	1343	807	924	1419	1068	2890	442	833	1234	1482	39	4	
	ALL	19981															

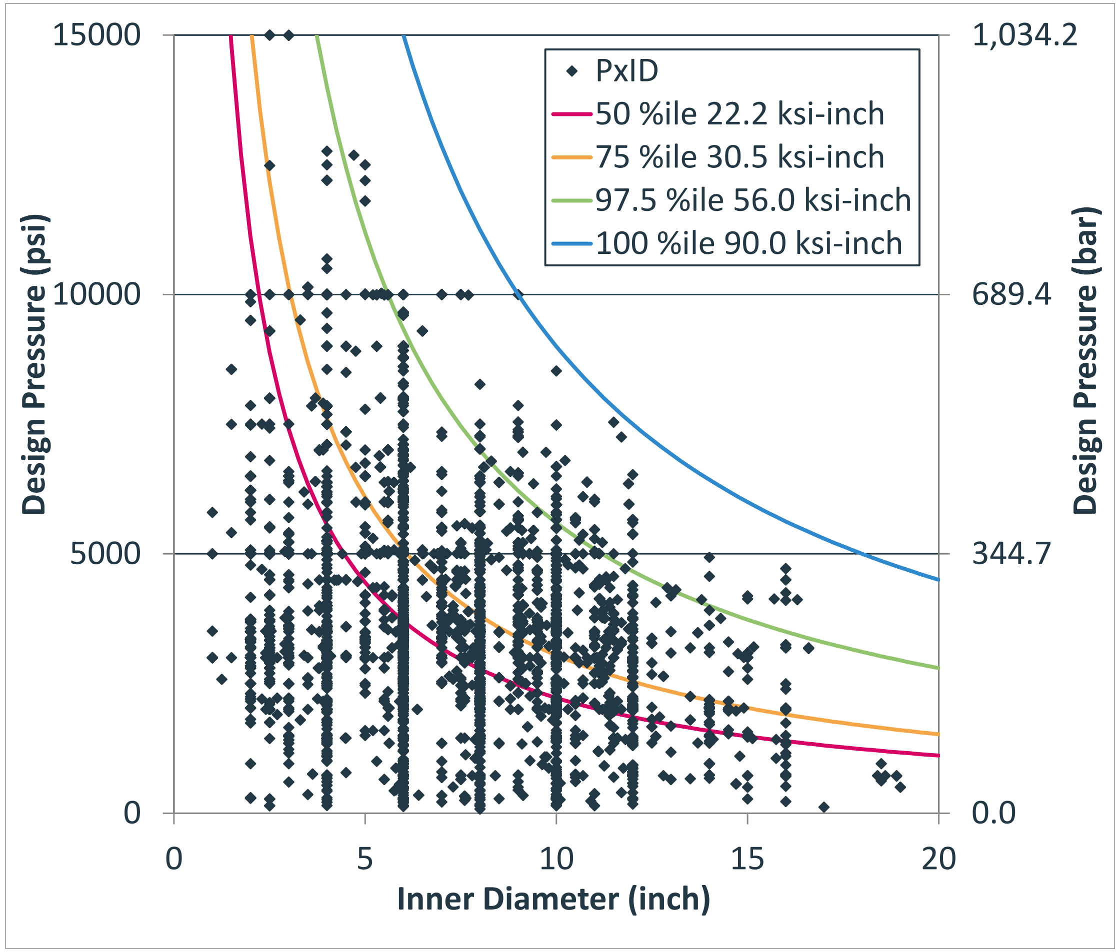
Evolution of Internal Pressure Sheath polymers



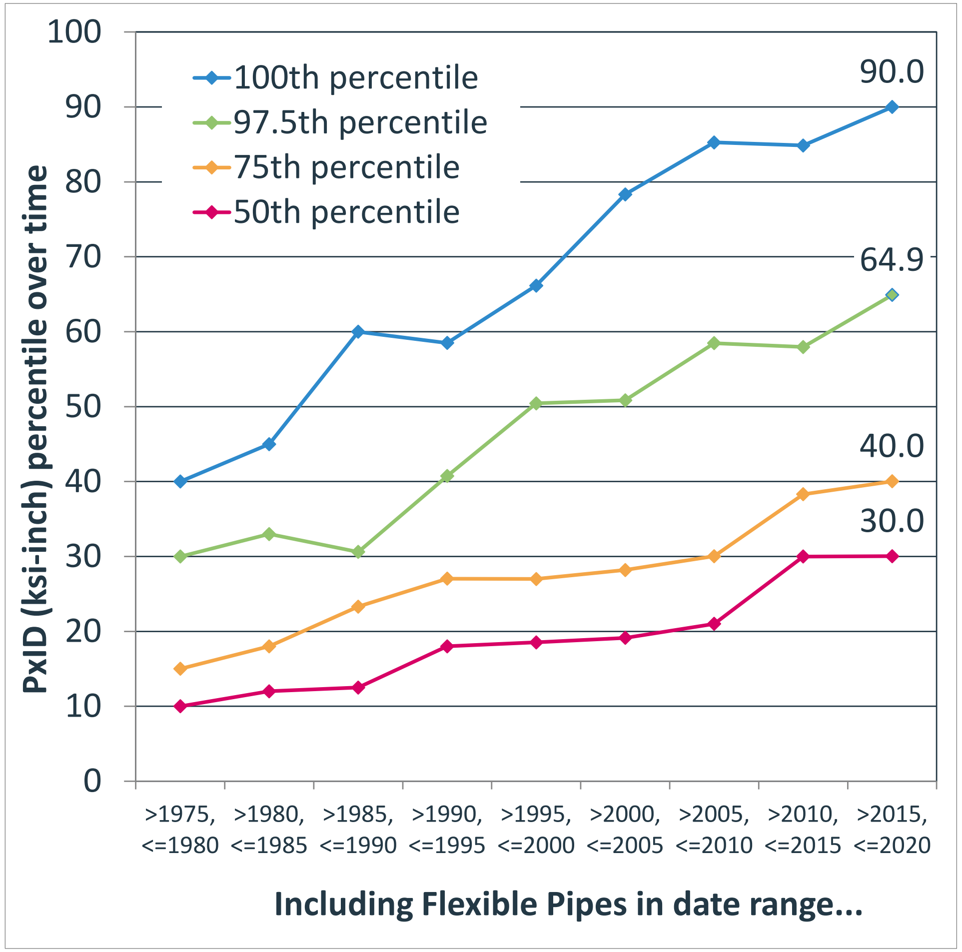
wood.

Design Pressure vs Inner Dia. (internal capacity)

DP vs ID scatter – all pipe, all time

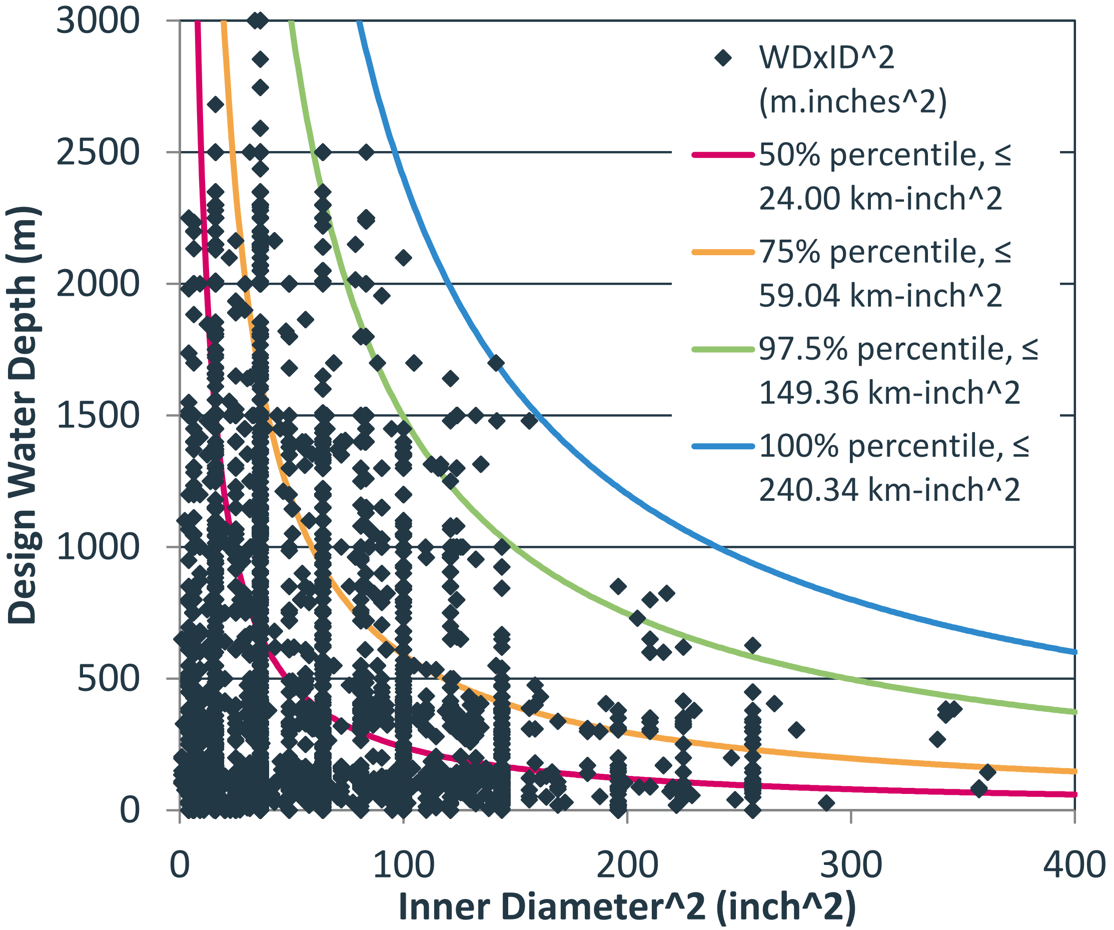


DPxID product percentile evolution over time

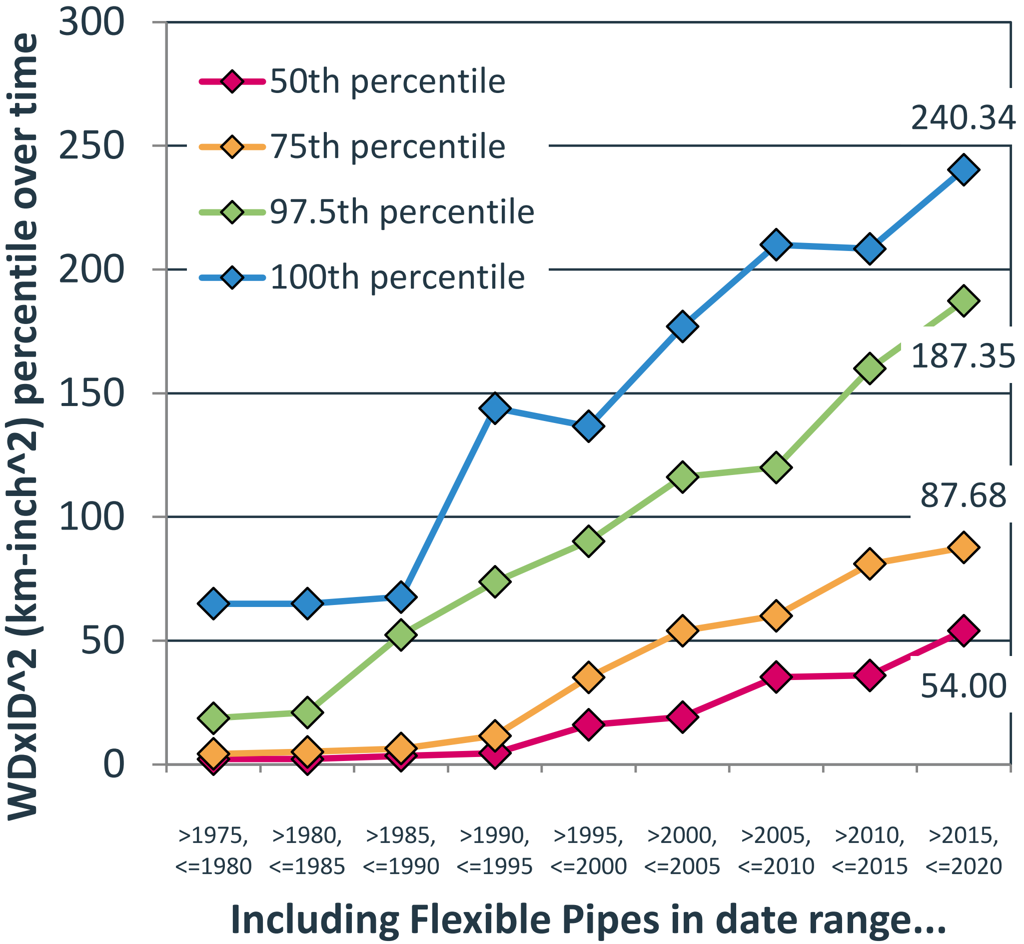


Design Water Depth vs ID^2 (external capacity)

WD vs ID^2 scatter – all pipe, all time



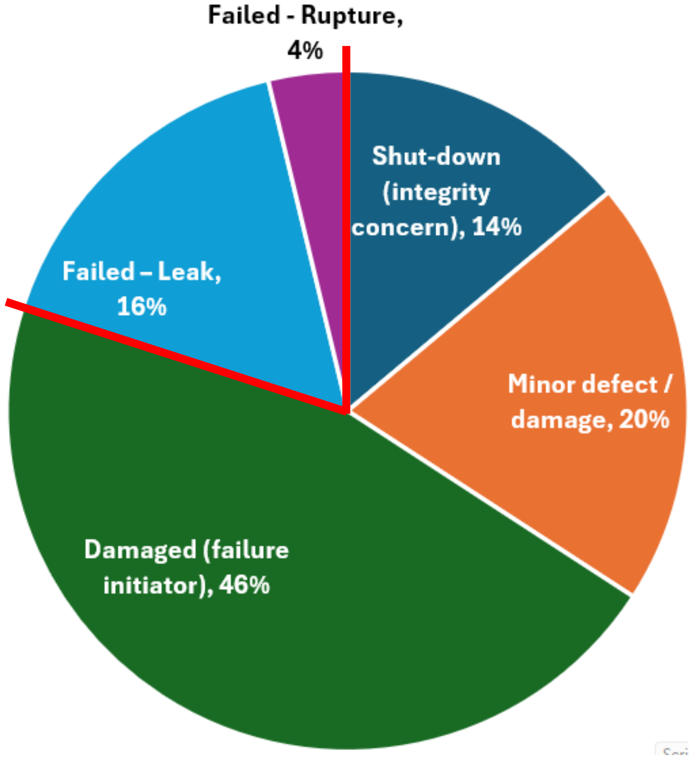
WDxID^2 product percentile evolution over time



wood.

All damage, degradation, and failure experience

Status	Description (brief)	Events (all time)	Loss of Containment	
Shut-down (integrity concern)	Proactive / preventive shutdown (damage not necessarily proven)	126	No	**79.9%**
Minor defect / damage	Not anticipated will lead to failure, unlikely to affect original design life.	184		
Damaged (failure initiator)	Design life may be impacted, but may remain in operation with mitigation	415		
Failed – Leak	Relatively low level leak through sheath	148	Yes	**20.1%**
Failed – Rupture	Failure of bore containment (major)	34		
	All Events	**907**		



wood.

Loss of Containment events, historic vs emergent

Damage / Failure Cause	Failed - leak				Failed - rupture			
	Total Cases	...with dates	Cases since Jul-11	Cases since Jul-16	Total Cases	...with dates	Cases since Jul-11	Cases since Jul-16
Carcass Failure - Fatigue	1	1						
Carcass Failure - Multilayer PVDF Collapse	6	6	1	1				
Carcass Failure - Tearing / Pullout	5	5	1					
Internal Pressure Sheath - Ageing	21	19	2					
Internal Pressure Sheath - End Fitting Pull-out	19	19	1					
Internal Pressure Sheath - Fatigue / Fracture / Microleaks	8	7	1					
Internal Pressure Sheath - Smooth Bore Liner Collapse	6	4			3	3		
Tensile Armour Wire Breakage - in / close to end fitting	3				1	1	1	1
Tensile Armour Wire Breakage - in main pipe section	1	1	1		8	8	8	4
Tensile Armours - Birdcaging	12	10	1		1	1		
Corrosion of Armours - Major / Catastrophic	13	9	4		15	15	11	8
End Fitting Leak / Failure	25	24	10	6	3	3		
Ancillary Equipment - Bend Stiffener - other	2	2						
Ancillary Equipment - Hold-down Failure (tethers / clamps / connections)	1							
Ancillary Equipment - Mid Water Arch	1	1						
Ancillary Equipment - Other	2	2						
Global pipe defect - Dropped Object / 3rd Party Interaction / Dragging	1	1	1	1				
Global pipe Defect - Excess Tension					1	1		
Global pipe Defect - Excess Torsion	1	1			1	1	1	1
Global pipe defect - Overbend / Pressure Armour Unlock	14	12	2	1	1	1	1	1
Global pipe defect - Rough Bore Collapse	1	1	1	1				
Global pipe Defect - Upheaval Buckling	4	4	3	2				
Failure Mechanism Disputed	1	1	1					
Total	**148**	**130**	**30**	**12**	**34**	**34**	**22**	**15**
%	**-**	**87.8%**	**23.1%**	**9.2%**	**-**	**100.0%**	**64.7%**	**44.1%**

Failure cause with ≥5 total cases which are **historic** or subject to limited / isolated cases only

Failure cause with ≥5 total cases which are **emergent** (large proportion of events in recent years)

Loss of Containment events, historic vs emergent

<u>Leak</u> events (>60% <u>historic</u>), largest contributors

- Internal Pressure Sheath - Ageing
- Internal Pressure Sheath - End Fitting Pull-out
- Tensile Armours - Birdcaging
- Overbend / Pressure Armour Unlock

Conversely, more severe <u>Rupture</u> events; lower no. of events, but >65% emergent

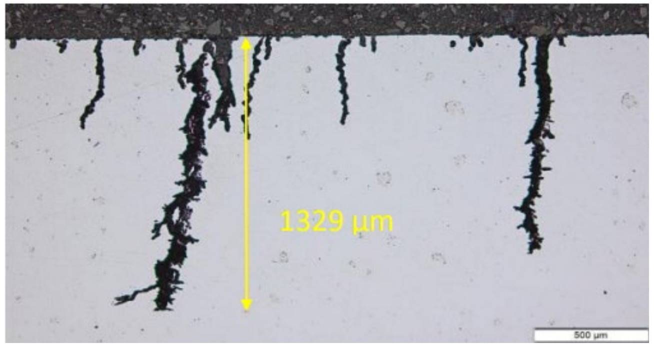
- Fatigue / corrosion-fatigue failures
- Stress corrosion cracking of armours due to CO_2
- Corrosion failures due to atmospheric backflow

Detailed descriptions for all Rupture event

- Applicability to other pipes, and mitigations

Fatigue

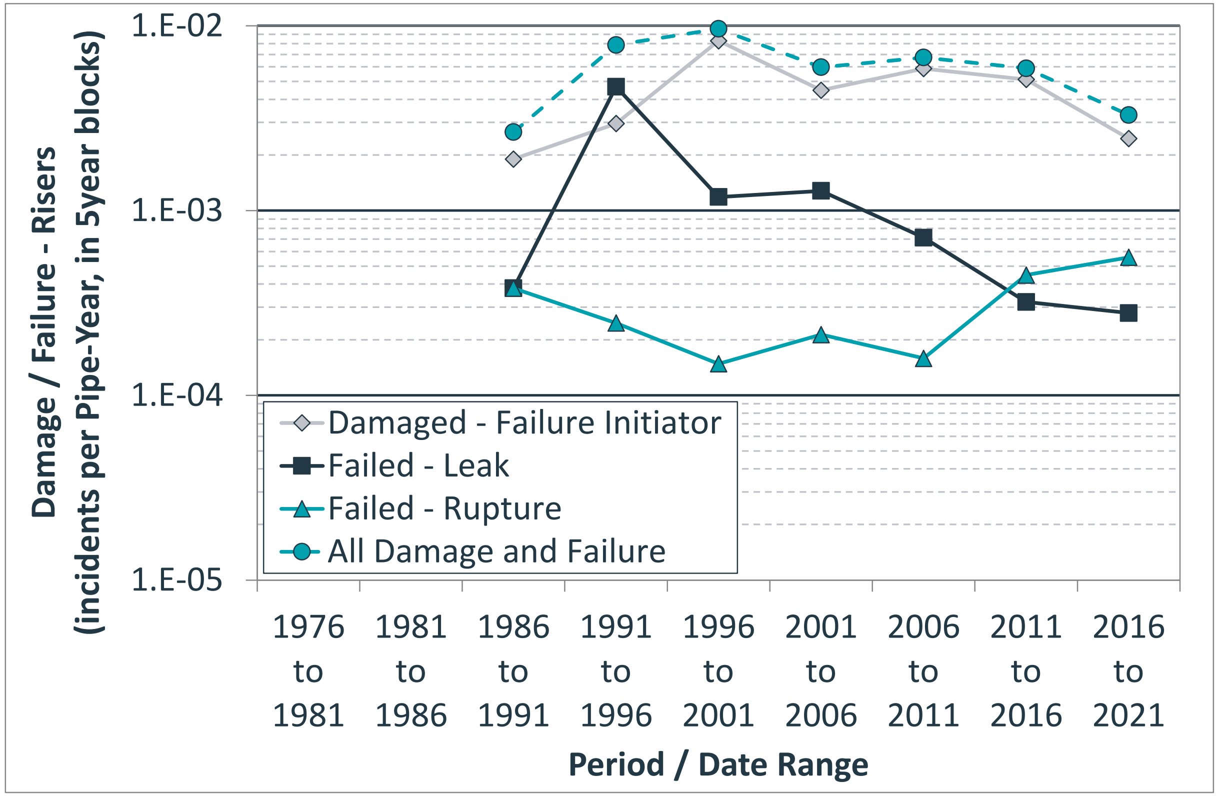
SCC-CO2 (industry research ongoing)

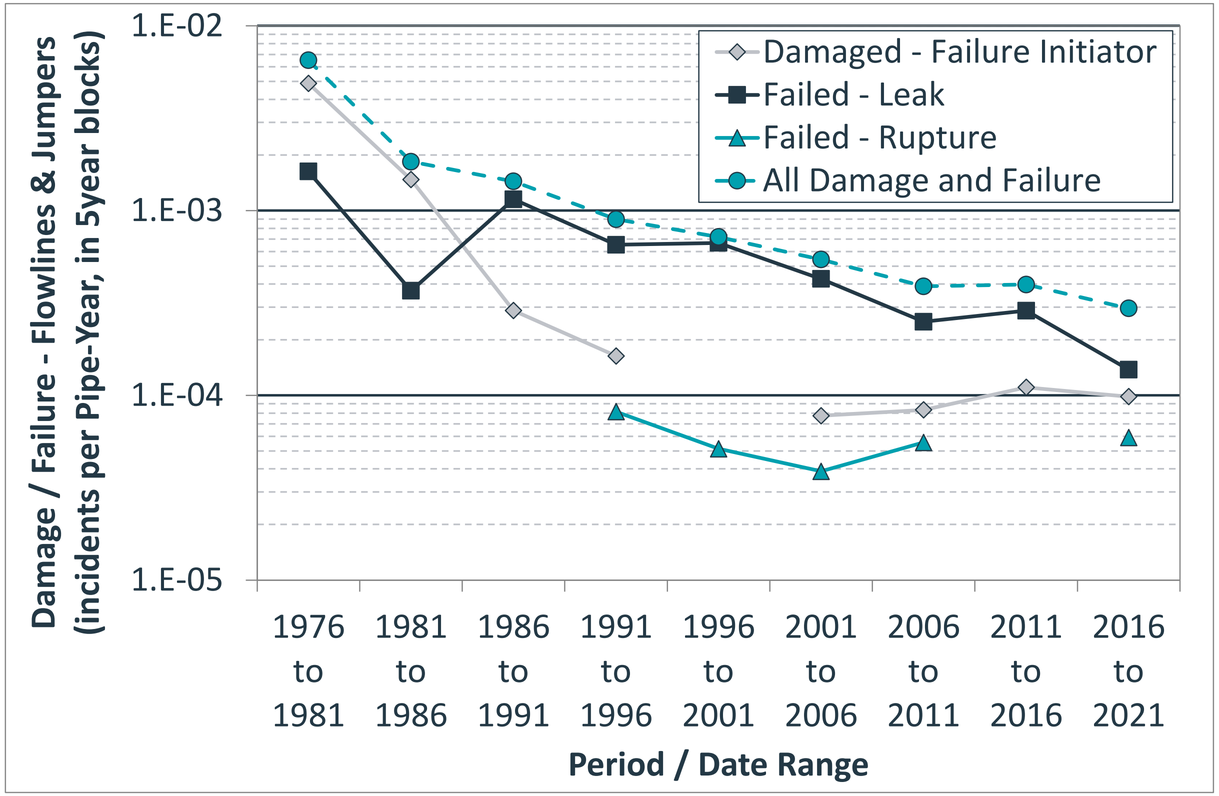


Corrosion (poor venting, annulus backflow)

wood.

Incident rates, Damage and Failure





RISERS

FLOWLINES & JUMPERS

- general reduction in the overall incident rates over time including those relating to all Damage and Leak events
- marked increase in Riser Rupture rates in the last 10-year period, directly attributable to the emergent mechanisms

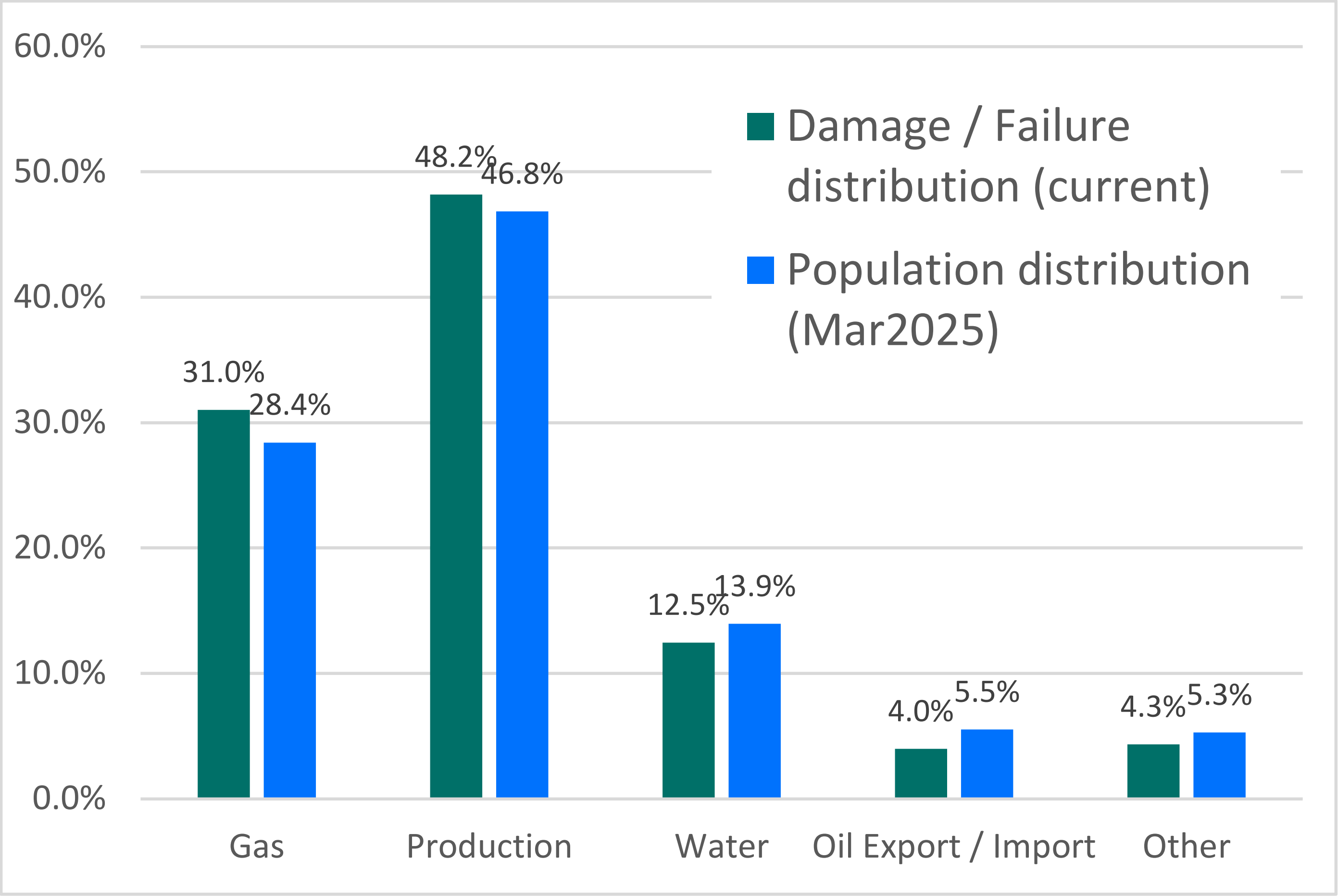
wood.

Pipe Service, Population vs Damage / Failure

Does product service / application impact the likelihood of damage / failure?

- Data suggests this is not the case
  - Contributors to individual groups, though result is general alignment in overall sense

- An ***Unknown Known***…
  - Things we don’t realise we know
  - i.e. the data existed (so theoretically known), but it’s only now being compiled and assessed to expand how we use it, and learn from it…



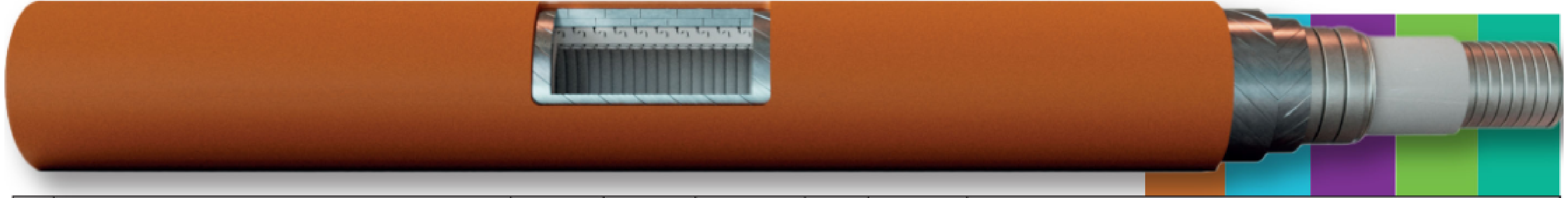
Inspection, Monitoring, Maintenance, and Repair

Risk-based integrity management programs

- Selection of specific measures to mitigate relevant threats
- Basic monitoring vs detective vs predictive techniques depending on risk

Sureflex captures and shares vendor experience

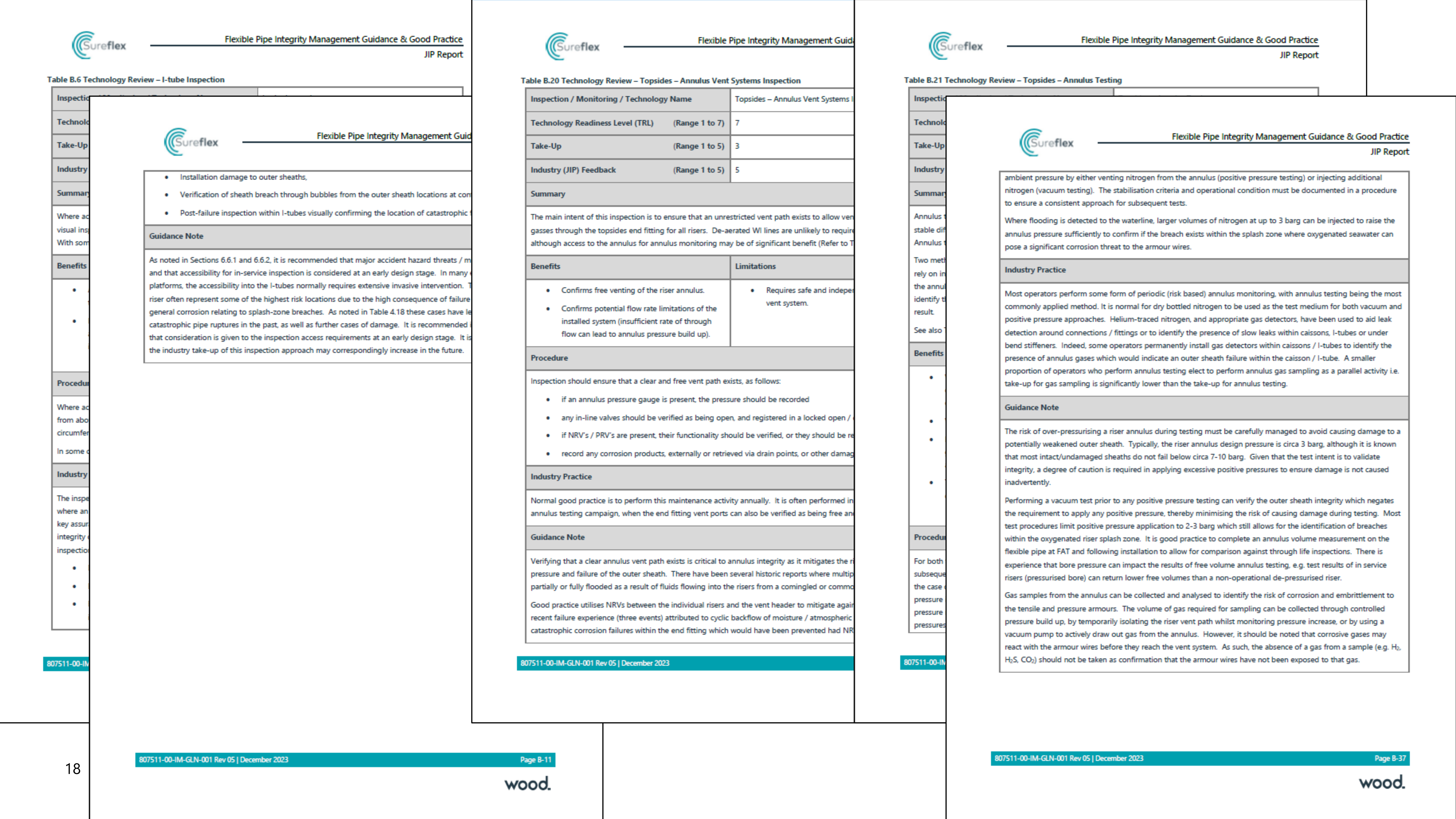
- Series of vendor workshops with JIP members, including scoring of:
  - Industry take-up / use
  - JIP member feedback on application
  - TRL (based on pipe layer / area application)
- Output includes summary table (following) and detailed tables per technique
  - Summary, Benefits, Limitations, Procedure, Industry Practice, Guidance Notes



Sureflex

App B Ref	Inspection / Monitoring / Technology	Monitoring	Inspection / Testing	Maintenance / Repair	Take Up (1-5)	JIP Member Feedback (1-5)	Technology Readiness Level (1-7)						
							Global Riser	Ancillary Equipment	Outer Sheath	Tensile Armour	Pressure Armour	Pressure Sheath	Carcass
B.1	Visual Inspection ROV		X		5	4	7	7	7				
B.2	Visual Inspection Diver		X		2	4	7	7	7				
B.3	Visual Inspection Micro-ROV		X		2	4	7	7	7				
B.4	Visual Inspection Roped Access		X		2	4	7	7	7				
B.5	Visual Inspection ROAV		X		1	4	7	7	7				
B.6	I-Tube Inspection		X		2	4		7	7				
B.7	Laser Measurement		X		2	5		7	7				
B.8	Marine Growth Removal			X	3	4		6	6				
B.9	Environment Monitoring	X			4	4	7			7			
B.10	Offset and Motion Monitoring	X			5/4	4	7						
B.11	Embedded Curvature Monitoring	X			1	N/A	5			5	5		
B.12	Sonar Monitoring (Bend Stiffeners/Risers)	X			1	4	6	6					
B.13	Integrated Fibre Optic Strain Monitoring	X			2	2	6			6			
B.14	Retrofit Bending Control			X	1	N/A	6/5	6/5					
B.15	Temperature Monitoring Inline	X			5	4			7			7	
B.16	Temperature Monitoring Remote	X			2	4		6/5	6/5			6/5	
B.17	Integrated Fibre Optic Temperature Monitoring	X			2	4			7			7	
B.18	Pressure Monitoring Inline	X			5	4				7	7	7	7
B.19	Pressure Testing (Hydro Testing)		X		5/3	3				7	7	7	
B.20	Topsides Annulus Vent Systems Inspection	X	X	X	3	5		7					
B.21	Topsides Annulus Testing		X		5	4			7			7	
B.22	Topsides Annulus Monitoring	X			3	4			7			7	
B.23	Subsea Annulus Testing / Monitoring	X	X		1	N/A			6				
B.24	Vent Port Unblocking			X	1	N/A			6				
B.25	Ultrasonic Testing	X	X		4	4			7	7			
B.26	Electrical Outer Sheath Breach Detection	X	X		1	N/A			5				
B.27	Fibreoptic Armour Wire Inspection (End Fitting)		X		1	N/A				5			
B.28	Clamped Outer Sheath Repair			X	3	4			7				
B.29	Polymer Coupon Monitoring	X			4	4			7			7	
B.30	Bore Fluid Sampling	X			4	5				7	7	7	7
B.31	X-Ray Computer Tomography		X		1	N/A			7	7	7	7	7
B.32	Eddy Current Inspection		X		2	3				7	5		
B.33	Direct Strain Measurement	X	X		2	3				6			
B.34	Magnetic Stress Measurement	X	X		3	2				6/5	4		
B.35	Microwave Inspection		X		1	N/A				5			
B.36	Radiography		X		2	4/2				7/5	7/5	3	7/5
B.37	Acoustic Emission Monitoring - Tensile Armour	X			1	4				7			
B.38	Acoustic Emission Monitoring - Carcass	X			1	2							6
B.39	Internal Inspection		X		2	4							7/6
B.40	Flexible ILI		X		2	3							7
B.41	Flexible Dissection		X		4/3	5	7	7		7	7	7	7

wood.



Flexible Pipe Integrity Management Guidance & Good Practice
JIP Report

Table B.6 Technology Review – I-tube Inspection

- Installation damage to outer sheaths,
- Verification of sheath breach through bubbles from the outer sheath locations at con
- Post-failure inspection within I-tubes visually confirming the location of catastrophic

Guidance Note

As noted in Sections 6.6.1 and 6.6.2, it is recommended that major accident hazard threats / m and that accessibility for in-service inspection is considered at an early design stage. In many platforms, the accessibility into the I-tubes normally requires extensive invasive intervention. T riser often represent some of the highest risk locations due to the high consequence of failure general corrosion relating to splash-zone breaches. As noted in Table 4.18 these cases have le catastrophic pipe ruptures in the past, as well as further cases of damage. It is recommended i that consideration is given to the inspection access requirements at an early design stage. It is the industry take-up of this inspection approach may correspondingly increase in the future.

807511-00-IM-GLN-001 Rev 05 | December 2023 Page B-11

Table B.20 Technology Review – Topsides – Annulus Vent Systems Inspection

Inspection / Monitoring / Technology Name	Topsides – Annulus Vent Systems I
Technology Readiness Level (TRL) (Range 1 to 7)	7
Take-Up (Range 1 to 5)	3
Industry (JIP) Feedback (Range 1 to 5)	5
Summary	
The main intent of this inspection is to ensure that an unrestricted vent path exists to allow ven gasses through the topsides end fitting for all risers. De-aerated WI lines are unlikely to require although access to the annulus for annulus monitoring may be of significant benefit (Refer to T	
Benefits	**Limitations**
• Confirms free venting of the riser annulus. • Confirms potential flow rate limitations of the installed system (insufficient rate of through flow can lead to annulus pressure build up).	• Requires safe and indepe vent system.
Procedure	
Inspection should ensure that a clear and free vent path exists, as follows: • if an annulus pressure gauge is present, the pressure should be recorded • any in-line valves should be verified as being open, and registered in a locked open / • if NRV's / PRV's are present, their functionality should be verified, or they should be re • record any corrosion products, externally or retrieved via drain points, or other damag	
Industry Practice	
Normal good practice is to perform this maintenance activity annually. It is often performed in annulus testing campaign, when the end fitting vent ports can also be verified as being free an	
Guidance Note	
Verifying that a clear annulus vent path exists is critical to annulus integrity as it mitigates the r pressure and failure of the outer sheath. There have been several historic reports where multip partially or fully flooded as a result of fluids flowing into the risers from a comingled or comm Good practice utilises NRVs between the individual risers and the vent header to mitigate agai recent failure experience (three events) attributed to cyclic backflow of moisture / atmospheric catastrophic corrosion failures within the end fitting which would have been prevented had NR	

807511-00-IM-GLN-001 Rev 05 | December 2023

Table B.21 Technology Review – Topsides – Annulus Testing

Flexible Pipe Integrity Management Guidance & Good Practice
JIP Report

ambient pressure by either venting nitrogen from the annulus (positive pressure testing) or injecting additional nitrogen (vacuum testing). The stabilisation criteria and operational condition must be documented in a procedure to ensure a consistent approach for subsequent tests. Where flooding is detected to the waterline, larger volumes of nitrogen at up to 3 barg can be injected to raise the annulus pressure sufficiently to confirm if the breach exists within the splash zone where oxygenated seawater can pose a significant corrosion threat to the armour wires.
Industry Practice
Most operators perform some form of periodic (risk based) annulus monitoring, with annulus testing being the most commonly applied method. It is normal for dry bottled nitrogen to be used as the test medium for both vacuum and positive pressure approaches. Helium-traced nitrogen, and appropriate gas detectors, have been used to aid leak detection around connections / fittings or to identify the presence of slow leaks within caissons, I-tubes or under bend stiffeners. Indeed, some operators permanently install gas detectors within caissons / I-tubes to identify the presence of annulus gases which would indicate an outer sheath failure within the caisson / I-tube. A smaller proportion of operators who perform annulus testing elect to perform annulus gas sampling as a parallel activity i.e. take-up for gas sampling is significantly lower than the take-up for annulus testing.
Guidance Note
The risk of over-pressurising a riser annulus during testing must be carefully managed to avoid causing damage to a potentially weakened outer sheath. Typically, the riser annulus design pressure is circa 3 barg, although it is known that most intact/undamaged sheaths do not fail below circa 7-10 barg. Given that the test intent is to validate integrity, a degree of caution is required in applying excessive positive pressures to ensure damage is not caused inadvertently. Performing a vacuum test prior to any positive pressure testing can verify the outer sheath integrity which negates the requirement to apply any positive pressure, thereby minimising the risk of causing damage during testing. Most test procedures limit positive pressure application to 2-3 barg which still allows for the identification of breaches within the oxygenated riser splash zone. It is good practice to complete an annulus volume measurement on the flexible pipe at FAT and following installation to allow for comparison against through life inspections. There is experience that bore pressure can impact the results of free volume annulus testing, e.g. test results of in service risers (pressurised bore) can return lower free volumes than a non-operational de-pressurised riser. Gas samples from the annulus can be collected and analysed to identify the risk of corrosion and embrittlement to the tensile and pressure armours. The volume of gas required for sampling can be collected through controlled pressure build up, by temporarily isolating the riser vent path whilst monitoring pressure increase, or by using a vacuum pump to actively draw out gas from the annulus. However, it should be noted that corrosive gases may react with the armour wires before they reach the vent system. As such, the absence of a gas from a sample (e.g. H_2, H_2S, CO_2) should not be taken as confirmation that the armour wires have not been exposed to that gas.

807511-00-IM-GLN-001 Rev 05 | December 2023 Page B-37

Sharing of desensitised industry datasets

Sureflex

Developing and sharing guidance and good practice for integrity management of flexible pipe systems

- Gathering input from member and non-member orgs.
- Final JIP report (Rev05) published (free) Dec 2023
  - https://www.woodplc.com/sureflex-report-dec2023-flexiblepipeintegrity (237 pages)
- OTC-35355-MS: Latest Industry Data and Flexible Pipe IM Lessons from the Sureflex JIP OnePetro link (15 pages)
- SPE Journal Petroleum Technology SPE JPT, Lessons from Sureflex (full pdf article 7 pages)
- Member additional deliverables, data and dashboards

OTC-35355-MS

Latest Industry Data and Flexible Pipe Integrity Management Lessons from the Sureflex JIP

I. MacLeod, J. Picksley, M. Birmingham, and A. Moir, Wood, United Kingdom

This paper was prepared for presentation at the Offshore Technology Conference held in Houston, TX, USA, 6 – 9 May, 2024.

Abstract

The 5th phase of the Sureflex Joint Industry Project (JIP) provides the latest data-driven industry guidance relating to unbonded flexible pipe population and damage / failure statistics, integrity management guidance and good practice. To maximise knowledge and experience sharing, the full deliverable report has been made freely available through an open industry publication. This paper shares the key findings of the JIP.

The JIP gathered data from the industry, with wide global member support from flexible pipe suppliers, operators, and regulators, and a wide range of non-member stakeholder organisations. The data is gathered, assessed, desensitised and presented to provide the best possible integrity management guidance to pipe users. The JIP also included a series of workshops: assessing vendor inspection, monitoring, and repair technologies; evaluating other key flexible pipe challenges, and sharing of operational experiences, with the key findings presented in the main JIP report. An ongoing network continues and expands the sharing of data and lessons learned.

Whilst flexible pipe technology may be considered as mature, being commercialised in the 1970s, there has been an almost 1/5th increase in the volume of pipes delivered in the latest five-year period. This indicates an increasing volume of use, and the JIP data demonstrates the pace of technology acceleration of design parameters, as users of the technology seek to stretch the operational envelope.

The manufacturers continue to perform product research, development and qualification to meet this demand, though this has not prevented the emergence of a limited number of new failure modes. Reported **Leak** and **Damage** rates have shown a decreasing trend over the last 20 years, however the incident rate for rarer **Rupture** events has increased for **Riser** applications since 2011. These rupture events have been attributed to a relatively small number of failure mechanisms in specific applications, some of which have emerged in the last 5 years.

Important developments of existing and new inspection and monitoring technologies have continued, though further work to improve the reliability, ease of deployment and usability is required. Knowledge and experience sharing of successes and failures is key to ensuring that appropriate and relevant guidance is maintained and made available to the wider industry.

Building on the knowledge shared through the preceding JIP phases dating back 25 years, this initiative has compiled and shared the most comprehensive industry dataset of unbonded flexible pipe supply

wood.

Questions?

?

wood.

Additional data supporting questions from the session

wood.

Time to Failure (TtF)

Sureflex

Leaks

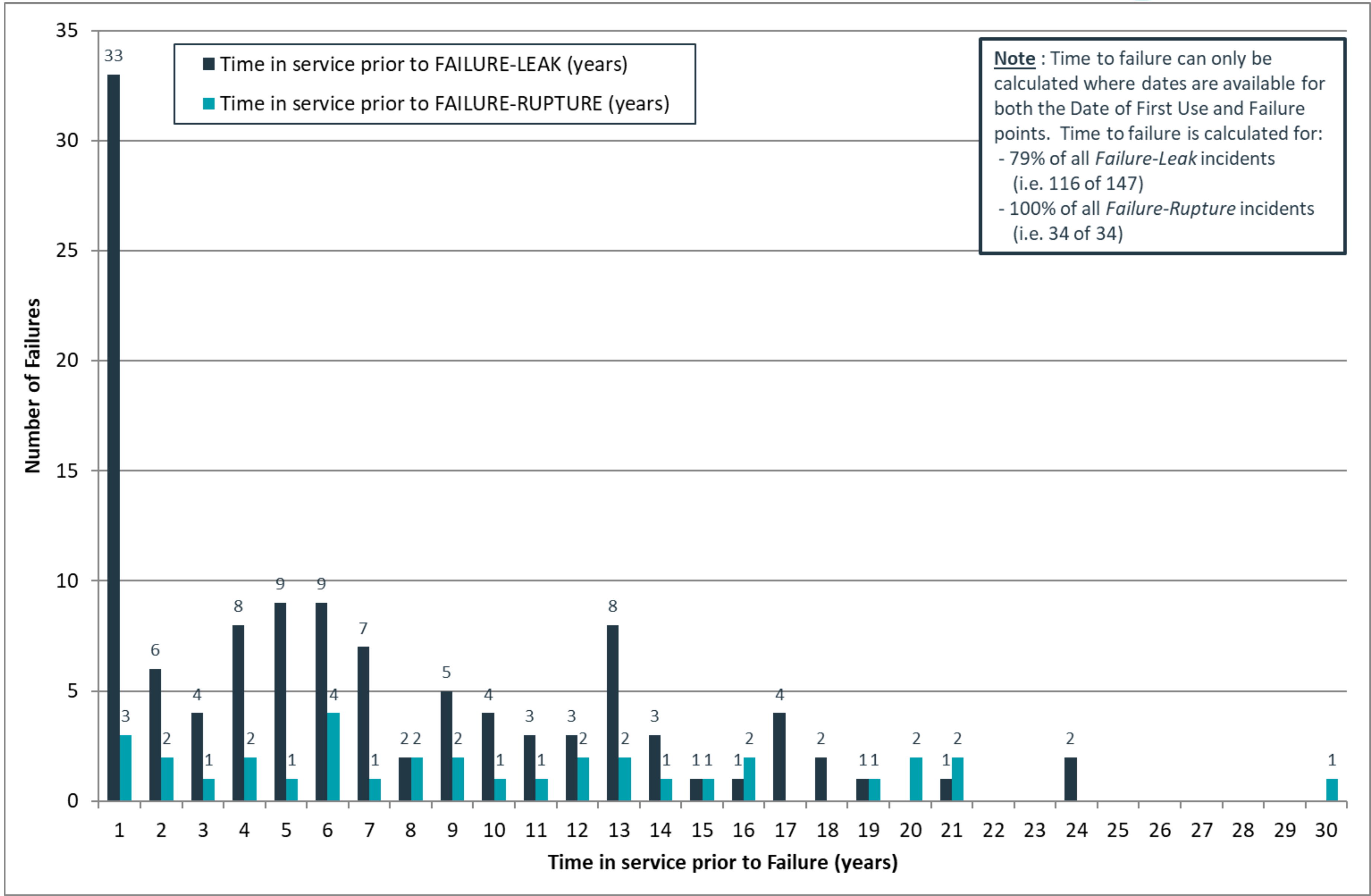
- TtF available for 79% of cases (116 of 147)
- Large peak in Year1
- No late-life bathtub up-tick apparent yet

Ruptures

- TtF available for 100% of cases (34 of 34)

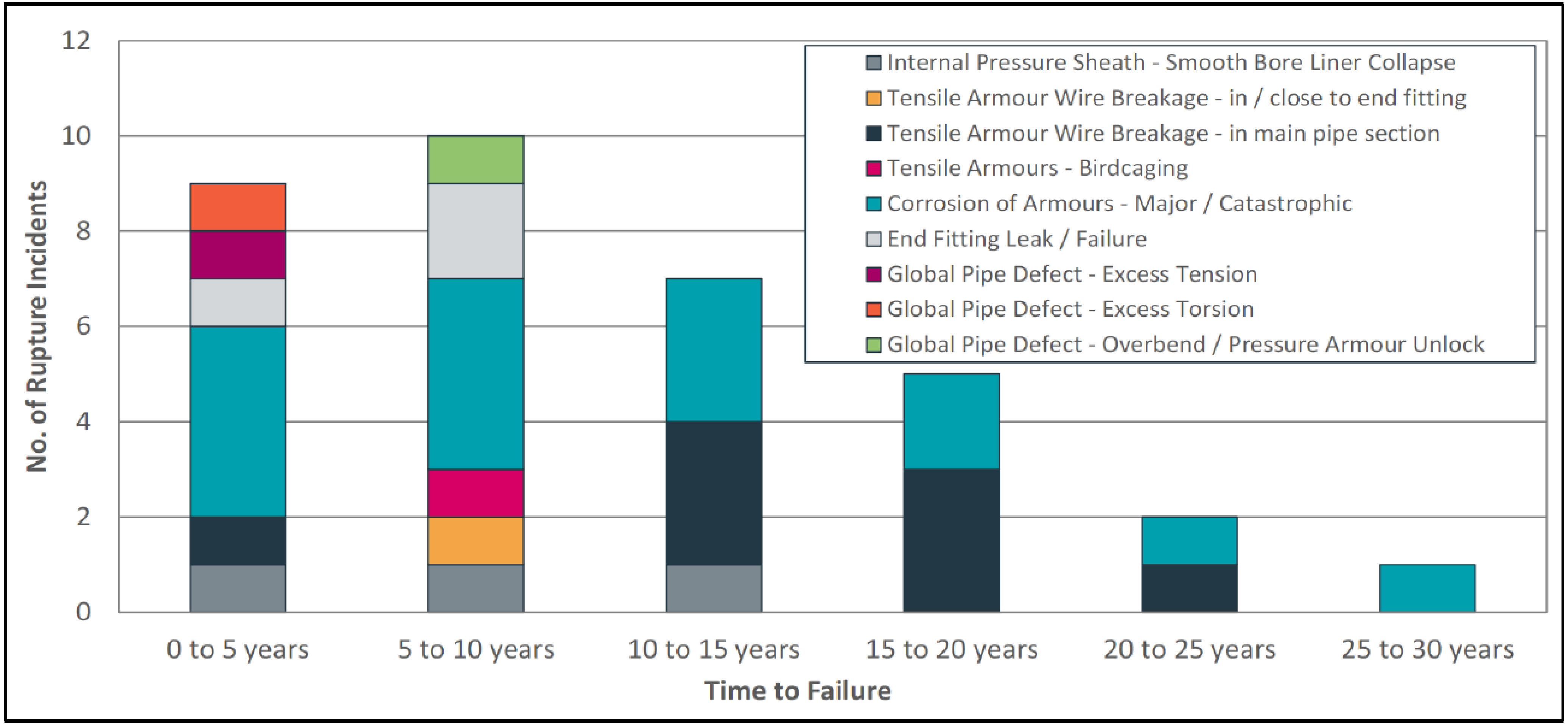
Ref. [Dec-23 report/data]

- Section 4.3.4, Page 80, including further details / descriptions



Time to Failure – All Rupture events

Largest group, corrosion failures, includes both early life corrosion / cracking mechanisms as well as longer term corrosion mechanisms



TtF / Timeline (corrosion mechanisms)

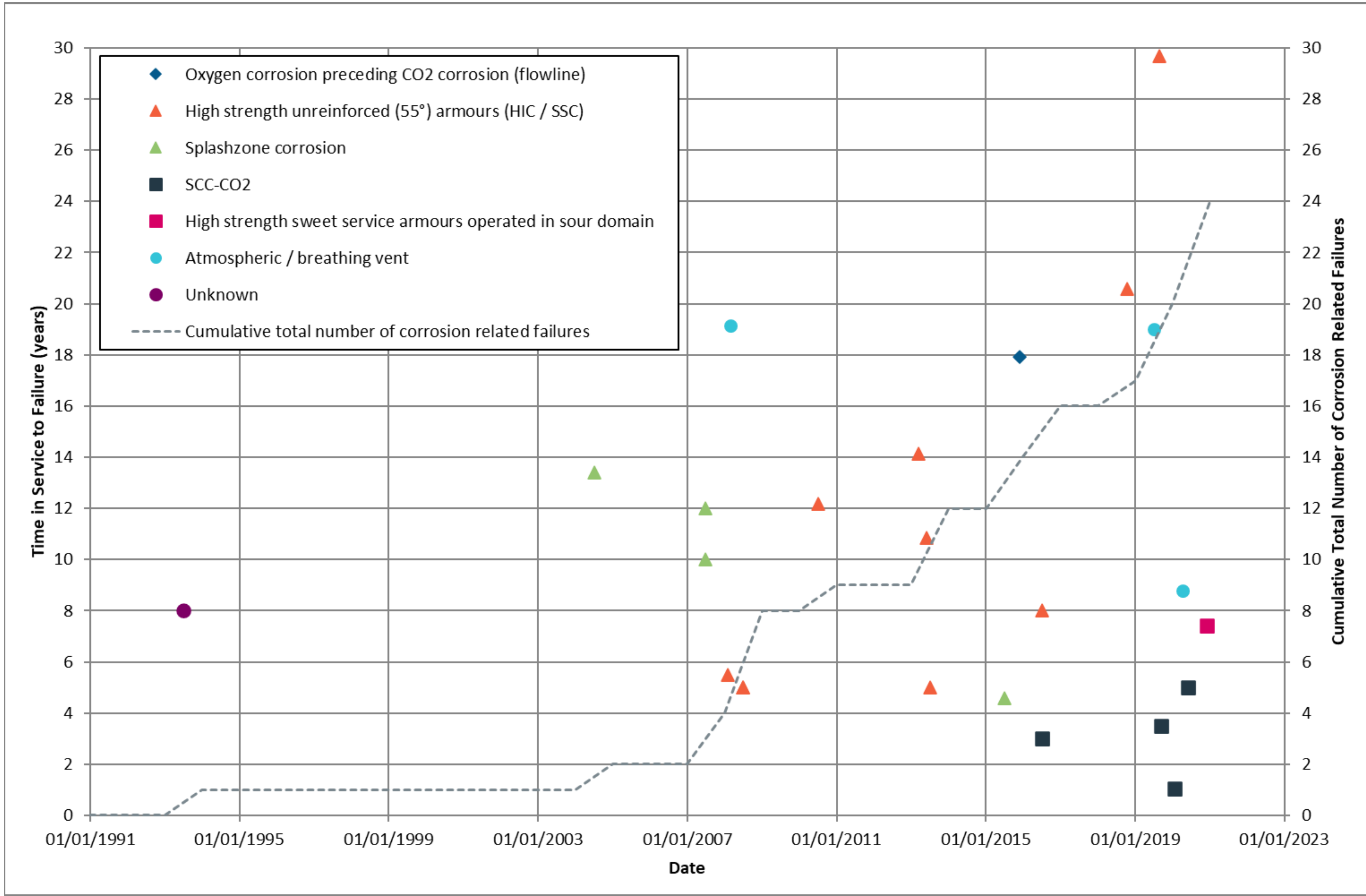
Sureflex

Time to Failure and Timeline i.e. experience

- HIC/SSC 55° armour failures: ~4 to 30years
- splashzone corrosion: ~4 to 14years
- air breathing vents: ~8 to 20years
- SCC-CO2: less than ~5years

Ref. [Dec-23 report/data]

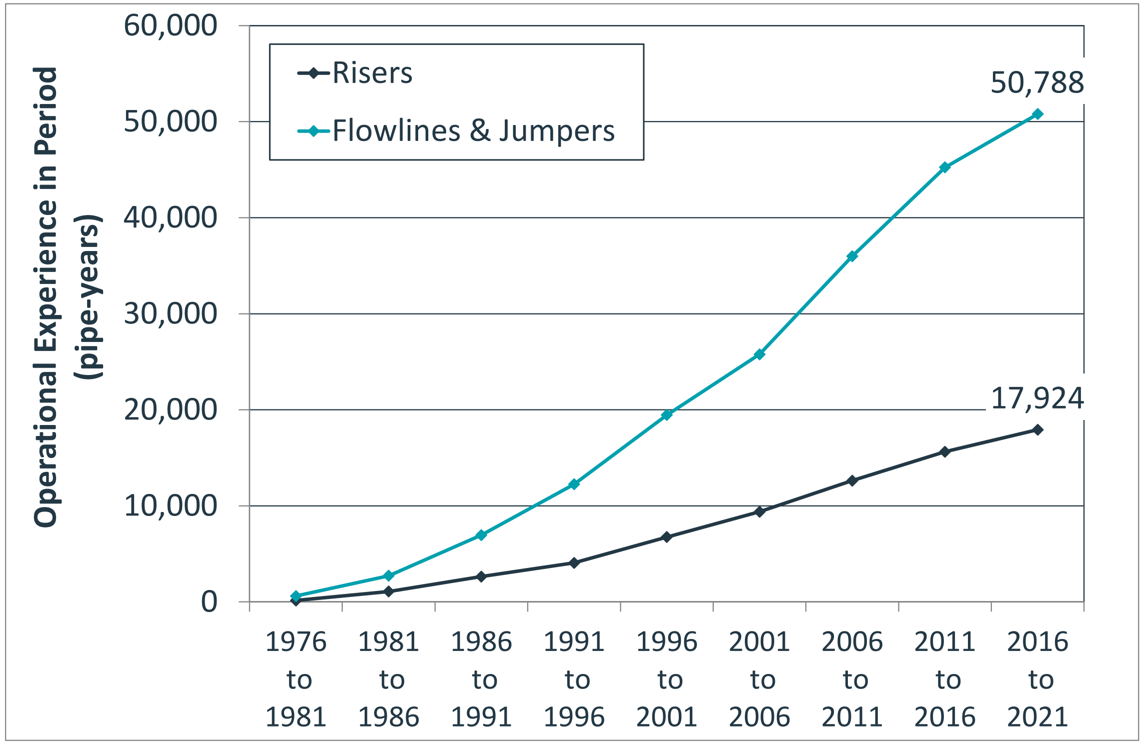
- Section 4.4.3, Pages 91-95, including further details / descriptions



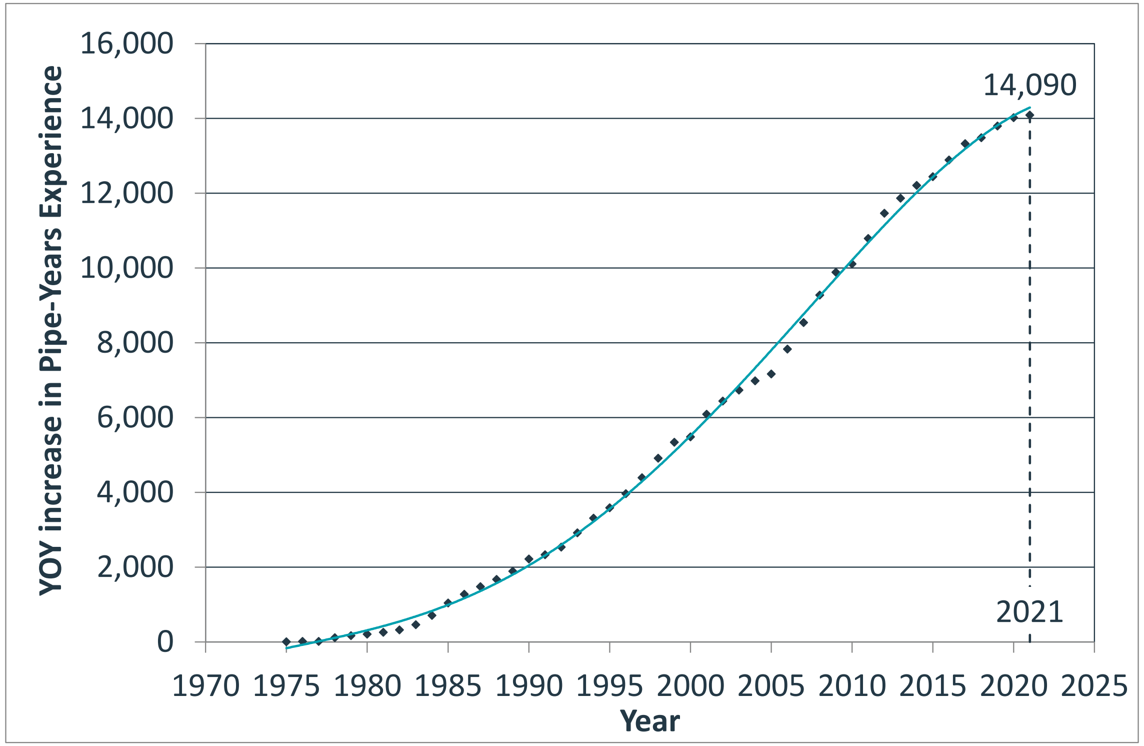
Additional supporting / backup data

Operational Experience (pipe-years)

Experience per 5year block / period



Experience; year-on-year increase (all pipe)



Degradation statistics, all pipe, all time

Damage / Failure Cause	Number of cases, by status					Total	%
	Minor defect / damage	Shut-down (integrity concern)	Damaged (failure initiator)	Failed - leak	Failed - rupture		
Line Recovered Proactively - No significant damage / defect identified		43				**43**	**4.7%**
Carcass Failure - Fatigue				1		**1**	**0.1%**
Carcass Failure - Multilayer PVDF Collapse		10	24	6		**40**	**4.4%**
Carcass Failure - Tearing / Pullout	1	5	6	5		**17**	**1.9%**
Internal Damage - Pigging			2			**2**	**0.2%**
Internal Pressure Sheath - Ageing		26	2	21		**49**	**5.4%**
Internal Pressure Sheath - End Fitting Pull-out	2	15	8	19		**44**	**4.9%**
Internal Pressure Sheath - Fatigue / Fracture / Microleaks	2	1	3	8		**14**	**1.5%**
Internal Pressure Sheath - Smooth Bore Liner Collapse	3			6	3	**12**	**1.3%**
Tensile Armour Wire Breakage - in / close to end fitting				3	1	**4**	**0.4%**
Tensile Armour Wire Breakage - in main pipe section		3	12	1	8	**24**	**2.6%**
Tensile Armours - Birdcaging			6	12	1	**19**	**2.1%**
Corrosion of Armours - Major / Catastrophic			5	13	15	**33**	**3.6%**
Corrosion of Armours - Moderate	5	2	11			**18**	**2.0%**
Annulus Flooding - Cause Unknown	26	4	90			**120**	**13.2%**
Annulus Flooding - Defective Annulus Vent System	14		9			**23**	**2.5%**
Annulus Flooding - Outer Sheath Damage - Ageing / Fracture	1		4			**5**	**0.6%**
Annulus Flooding - Outer Sheath Damage - Mechanical / Impact / Wear	43	5	112			**160**	**17.6%**
Annulus Flooding - Permeated Liquids	2					**2**	**0.2%**
Outer Sheath Damage - Annulus NOT flooded - Ageing / Fracture	4					**4**	**0.4%**
Outer Sheath Damage - Annulus NOT flooded - Mechanical / Impact / Wear	19		6			**25**	**2.8%**
End Fitting Leak / Failure	1		1	25	3	**30**	**3.3%**
Ancillary Equipment - Bend Stiffener - Connection / Interface	9	2	40			**51**	**5.6%**
Ancillary Equipment - Bend Stiffener - 2 part failure			11			**11**	**1.2%**
Ancillary Equipment - Bend Stiffener - other	4		2	2		**8**	**0.9%**
Ancillary Equipment - Buoyancy Modules	3	1				**4**	**0.4%**
Ancillary Equipment - Hang-off Failure			1			**1**	**0.1%**
Ancillary Equipment - Hold-down Failure (tethers / clamps / connections)	3		7	1		**11**	**1.2%**
Ancillary Equipment - Mid Water Arch	3		7	1		**11**	**1.2%**
Ancillary Equipment - Vent System Anomalies / Blockage	21	3	18			**42**	**4.6%**
Ancillary Equipment - Other				2		**2**	**0.2%**
Global Pipe Defect - Dropped Object / 3rd Party Interaction / Dragging	7	2	7	1		**17**	**1.9%**
Global Pipe Defect - Excess Tension					1	**1**	**0.1%**
Global Pipe Defect - Excess Torsion			2	1	1	**4**	**0.4%**
Global Pipe Defect - Flow Induced Pulsation (FLIP) causing wider system effect	2	3				**5**	**0.6%**
Global Pipe Defect - Ovalisation			2			**2**	**0.2%**
Global Pipe Defect - Overbend / Pressure Armour Unlock		1	4	14	1	**20**	**2.2%**
Global Pipe Defect - Rough Bore Collapse			2	1		**3**	**0.3%**
Global Pipe Defect - Upheaval Buckling	4		1	4		**9**	**1.0%**
Global Pipe Defect - Pipe Blockage (wax/hydrates/other)	4		9			**13**	**1.4%**
Global Pipe Defect - Excess Marine Growth			1			**1**	**0.1%**
Failure Mechanism Disputed	1			1		**2**	**0.2%**
Total	**184**	**126**	**415**	**148**	**34**	**907**	**100.0%**
%	**20.3%**	**13.9%**	**45.8%**	**16.3%**	**3.7%**	**100.0%**	