

4subsea investigates used risers

- 28 860 m investigated in detail
- Intact and damaged
- PVDF, PA11, X-link PE pressure sheaths
- Norway, West Africa, Netherlands, UK
- Excellent cooperation with
 - Marintek Sintef DNV
 - IFE NorSea Base
 - Operators Vendors
- 32 engineers full time on flexibles
- Over 400 years flex-riser experience
- Over 1500 offshore annulus tests & vent gas samples

It's so much more on flexibles to learn

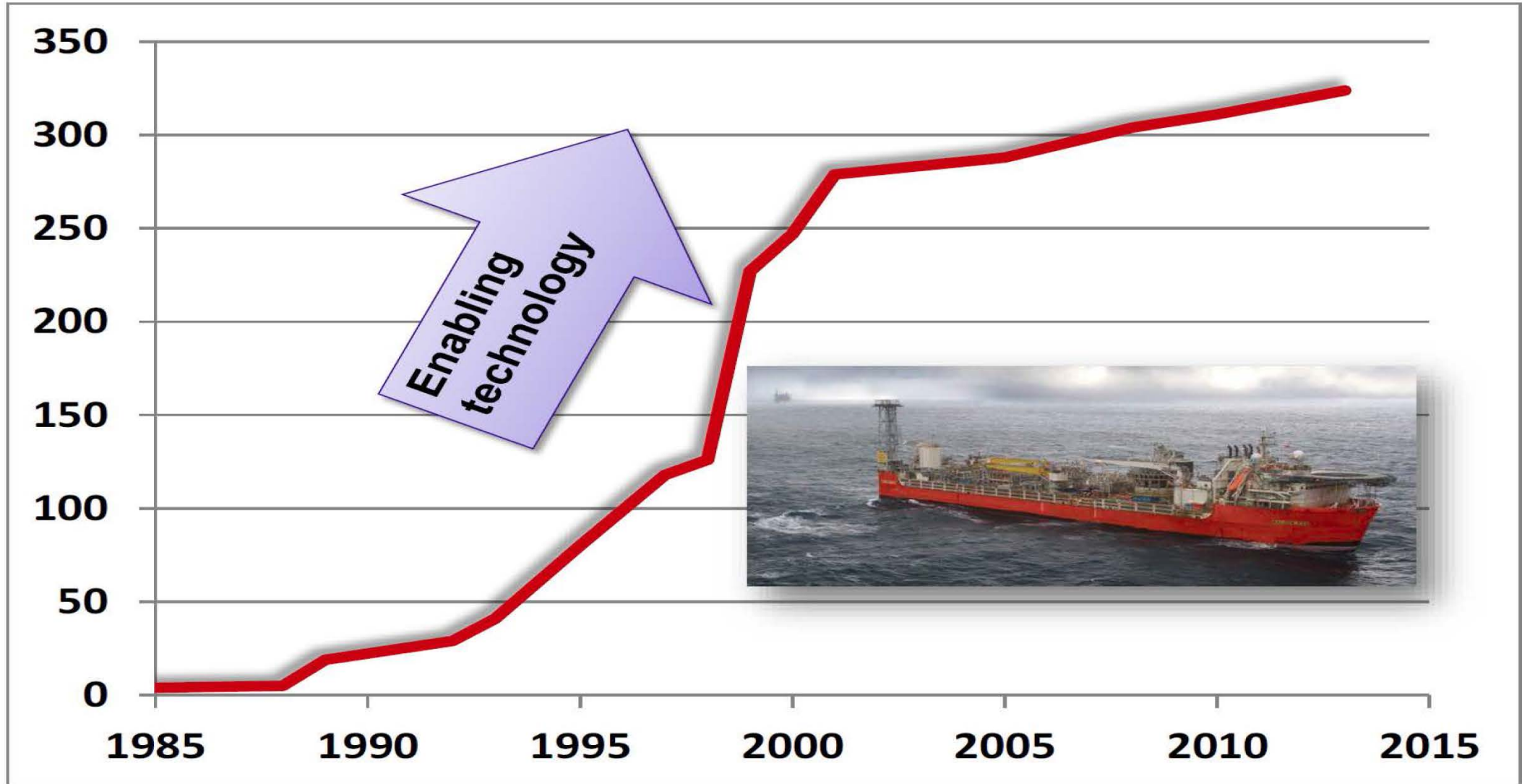


JIPs

- Guidelines for Qualification of Polyamides & Revision of API 17TR2
- Safe and cost effective operation of flexible pipes

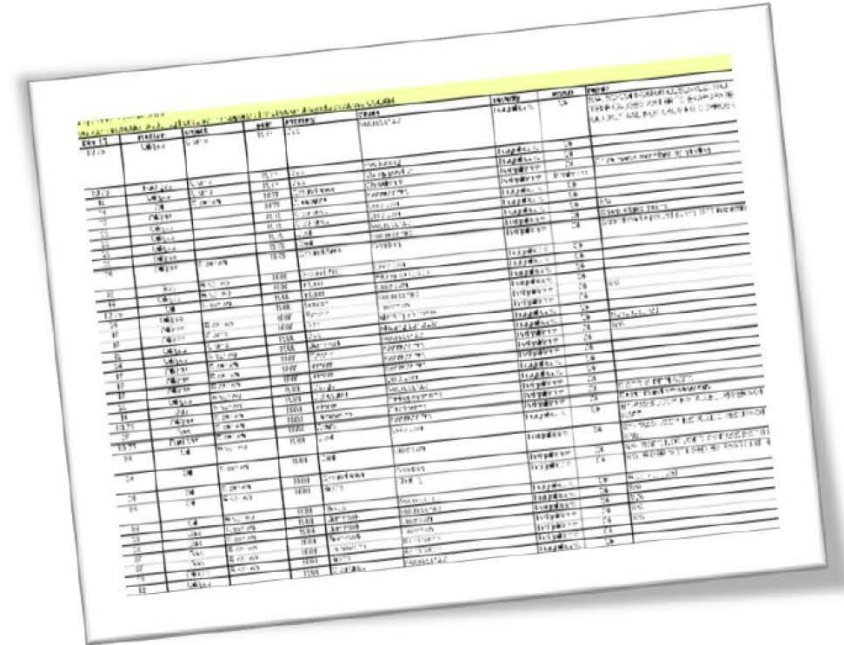


Flexible risers - Norwegian Continental Shelf



What is CODAM database?

- Database managed by PSA
- Data as reported from operators
- Data from mid – 1970's
- Flexible riser data structured from 1995
- Damages and incidents on structures and pipeline systems
- Focus on personnel risk



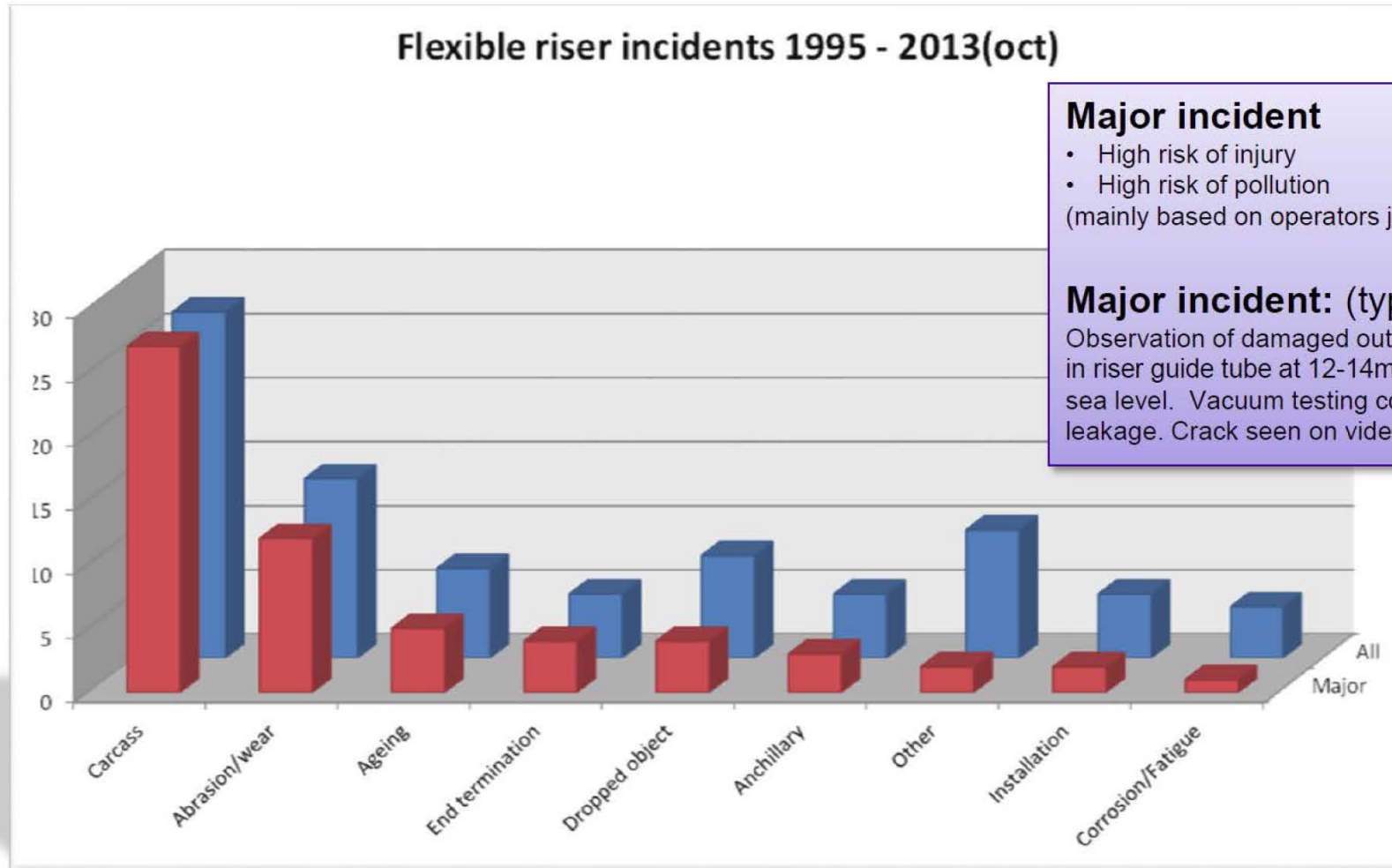
Year	Month	Day	Time	Location	Incident Type	Severity	Personnel Risk	Other
1975	01	15	14:30	North Sea	Riser failure	High	1	
1976	03	22	09:15	North Sea	Structural damage	Medium	0	
1977	05	10	16:45	North Sea	Leakage	Low	0	
1978	07	28	11:20	North Sea	Structural damage	High	2	
1979	09	05	08:00	North Sea	Riser failure	Medium	1	
1980	11	18	13:50	North Sea	Structural damage	Low	0	
1981	01	03	10:10	North Sea	Riser failure	High	1	
1982	02	14	15:30	North Sea	Structural damage	Medium	0	
1983	04	25	12:00	North Sea	Riser failure	Low	0	
1984	06	08	09:45	North Sea	Structural damage	High	1	
1985	08	19	14:15	North Sea	Riser failure	Medium	0	
1986	10	01	11:00	North Sea	Structural damage	Low	0	
1987	12	12	16:30	North Sea	Riser failure	High	1	
1988	01	23	08:45	North Sea	Structural damage	Medium	0	
1989	03	04	13:20	North Sea	Riser failure	Low	0	
1990	05	15	10:00	North Sea	Structural damage	High	1	
1991	07	26	15:45	North Sea	Riser failure	Medium	0	
1992	09	06	12:30	North Sea	Structural damage	Low	0	
1993	11	17	09:15	North Sea	Riser failure	High	1	
1994	01	28	14:00	North Sea	Structural damage	Medium	0	
1995	03	08	11:45	North Sea	Riser failure	Low	0	
1996	05	19	16:30	North Sea	Structural damage	High	1	
1997	07	29	08:15	North Sea	Riser failure	Medium	0	
1998	09	09	13:00	North Sea	Structural damage	Low	0	
1999	11	20	10:45	North Sea	Riser failure	High	1	
2000	01	31	15:30	North Sea	Structural damage	Medium	0	
2001	03	11	12:15	North Sea	Riser failure	Low	0	
2002	05	22	09:00	North Sea	Structural damage	High	1	
2003	07	01	13:45	North Sea	Riser failure	Medium	0	
2004	09	12	10:30	North Sea	Structural damage	Low	0	
2005	11	23	16:15	North Sea	Riser failure	High	1	
2006	01	03	08:00	North Sea	Structural damage	Medium	0	
2007	03	14	12:45	North Sea	Riser failure	Low	0	
2008	05	25	09:30	North Sea	Structural damage	High	1	
2009	07	04	14:15	North Sea	Riser failure	Medium	0	
2010	09	15	11:00	North Sea	Structural damage	Low	0	
2011	11	26	16:45	North Sea	Riser failure	High	1	
2012	01	06	08:30	North Sea	Structural damage	Medium	0	
2013	03	17	13:15	North Sea	Riser failure	Low	0	
2014	05	28	10:00	North Sea	Structural damage	High	1	
2015	07	08	14:45	North Sea	Riser failure	Medium	0	
2016	09	19	11:30	North Sea	Structural damage	Low	0	
2017	11	30	17:15	North Sea	Riser failure	High	1	
2018	01	10	09:00	North Sea	Structural damage	Medium	0	
2019	03	21	13:45	North Sea	Riser failure	Low	0	
2020	05	31	10:30	North Sea	Structural damage	High	1	
2021	07	11	15:15	North Sea	Riser failure	Medium	0	
2022	09	22	12:00	North Sea	Structural damage	Low	0	

Potential for improvements

<http://www.ptil.no/getfile.php/1.10.13Stigeroersskader.pdf>



Flexible riser incidents reported to PSA



Major incident

- High risk of injury
 - High risk of pollution
- (mainly based on operators judgement)

Major incident: (typical)

Observation of damaged outer coating in riser guide tube at 12-14m below sea level. Vacuum testing confirmed leakage. Crack seen on video.



Most frequent riser incidents in Norway



Carcass incidents

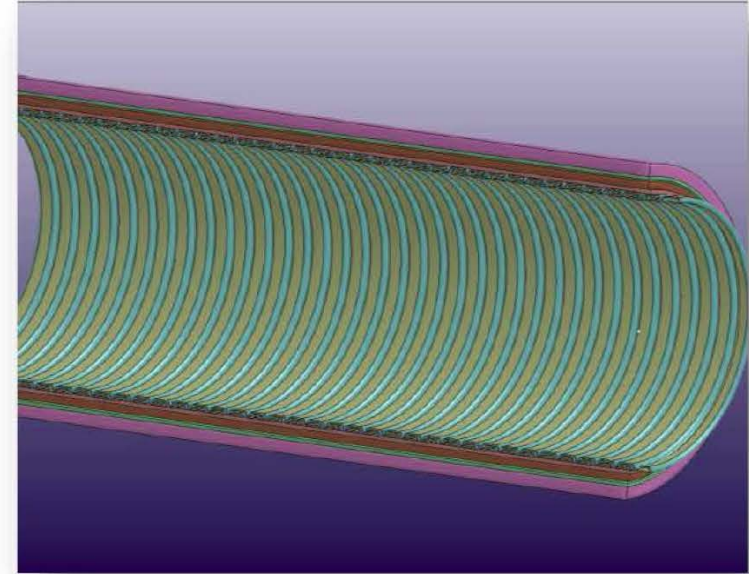
- Collapse
- Pull-out – PVDF interaction
- Axial failure - hydrate blocking
- Sand Erosion
- Fatigue

Abrasion / Wear

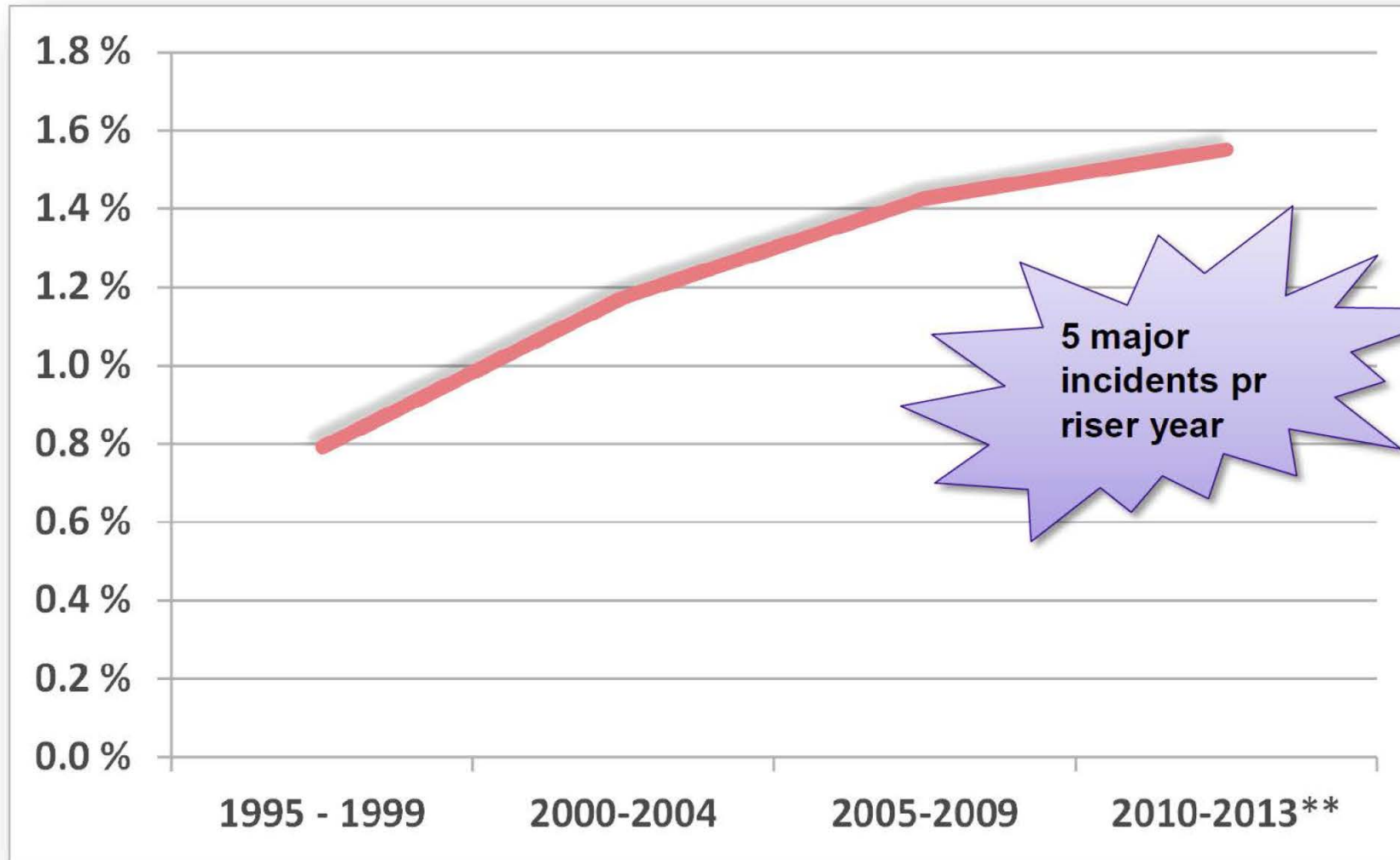
- Bell Mouth / Guide Tube
- Interfacing Structures / Ancillaries
- Seabed At Riser Touch Down
- Internal Wear

Ageing

- Hydrolysis (External Sheath, Tape Layers, Pressure Sheath)
- High temperature (shielding/insulation)



Incident rate development



** data to Oct 2013



- In total 80-100 risers replaced
 - 30-50 risers replaced due to risk assessment
 - 25-30% of the 324 risers in operation have been replaced or re-terminated
- 60 reported major incidents in CODAM (1995-2013)
 - 49 risers reported to be replaced
 - 11 risers repaired (later replaced?)
- Other replacements (flexibles)
 - Flowlines
 - Topside jumpers



Operators checklist – Growing old gracefully

- ❑ Acknowledge the complexity and uncertainties related to flexible risers (design, fabrication, installation, operation)
- ❑ Map internal and external competence – fill the gaps !
- ❑ Facilitate communication, learning and knowledge management
- ❑ Focus on continuity (don't redo the mistakes)
- ❑ Initiate and support research and development (much to gain by knowing more)
- ❑ Improve tools and methods
- ❑ Share experiences & best practices
- ❑ Develop and implement strategies



What is really needed to maintain a failure probability below 10^{-4} ?



PSA checklist – Growing old gracefully

- ❑ Ask the difficult questions
- ❑ Facilitate efficient & consistent reporting of all flexible pipe anomalies
- ❑ Follow up reports to CODAM
 - ❑ What was the end result ?
 - ❑ Replacement or repair ?
 - ❑ Additional info (retrospect)
- ❑ Facilitate experience sharing
- ❑ Provide rules and regulation courses to management personnel

