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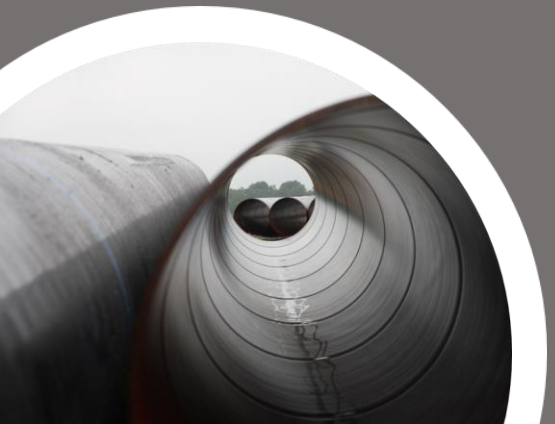
Risk assessments

best practices (what / if)

Hoe we industriële vooruitgang borgen

&

prestaties monitoren



"Aim for the best"

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Achtergrond

-> 2004 **E&P equipment engineering**

-> 2008 - heden **Transportleiding industrie**

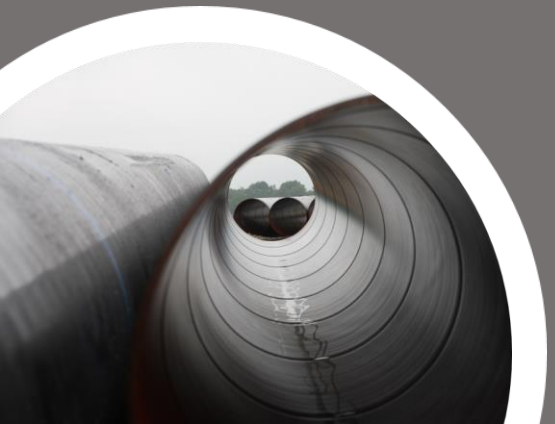
- Operationeel beheer & risk management
- Consultant
- Project manager EPC

-> 2020 – heden Shell pipeline Systems

-> 2006 – heden **Zelfstandige**
- Pipeline management (integrity / beheer & onderhoud)

-> 2019 – heden **Docent Pipeliner Msc**

- Operationeel beheer buisleidingen
- Onderhoudsstrategie buisleidingen



Disciplines

Chemie, tankopslag, processing, raffinage, water & warmte
Upstream / midstream / downstream
Nationale & internationale standaards / codes / normen

Branche vertegenwoordiging

- Velin / Fetrapi / Klip-Klim / Deltalinqs

Norm commissie

- NEN3655 werkgroep II integriteit

Werkgroepen & energie transitie

- AOMD “modal shift buisleidingen” (RWS / I&W / EZ / RIVM & CBS)
- Porthos / Aramis
- Holland Hydrogen I electrolyzer
- Klankbordgroep buisleiding vervoer (multiphase)

“Aim for the best”

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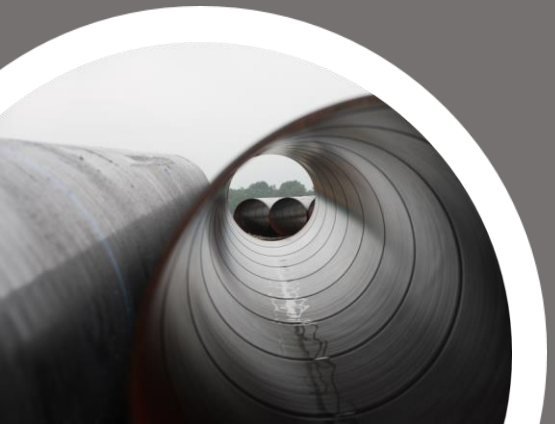
RIE
best practices

Aandachtsgebieden

- RIE in BevB & normen
- RIE methodieken & complexiteit
- Combineren van kwantitatieve data vs. kwalitatieve SME’s
- ILI vs. Non-piggables
- Borging & herhaling
- RIE in de praktijk
- Presenteren van resultaten
- State of Art
- Open discussie



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RIE in BevB & normen

BevB

- Bijlage 4 lid 3

(levensfase conform 5.2.1 NEN 3655)

NEN

- NEN3656 hfst 6.3
- NEN3655 hfst 3.32

ISO

- ISO 14001
- ISO 19345

API

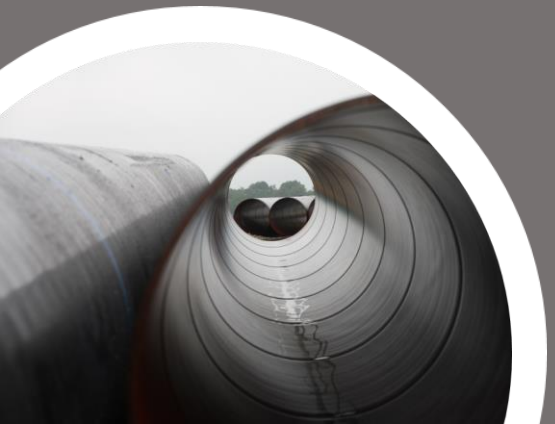
- API 1160
- API 580
- API 1173

EN

- EN 16348

NACE

- Nace SP0502
- NACE SP0208
- NACE SP0206



NACE INTERNATIONAL THE CORROSION SOCIETY

National Association of Corrosion Engineers

AMPP

Association for Materials Protection and Performance

API American Petroleum Institute

nen

ISO

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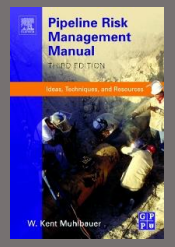
Methodieken en de complexiteit



2003 - 2015

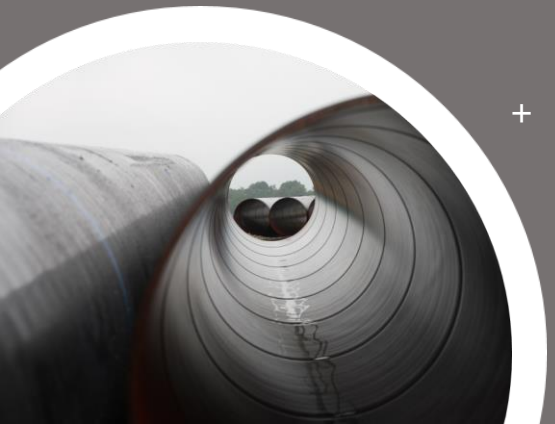
Risk Index factor (SME based)

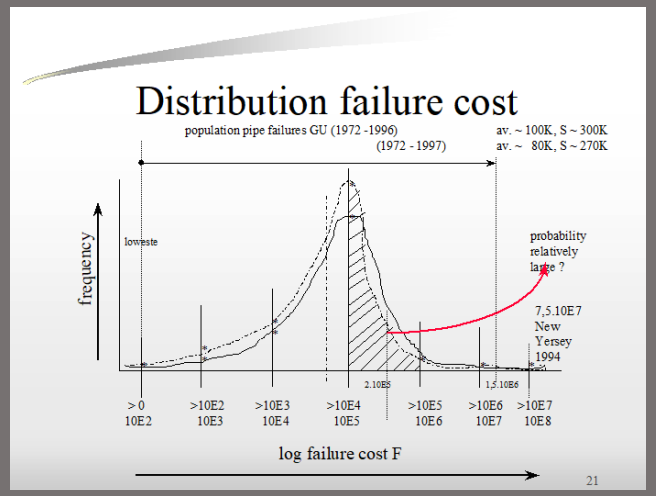
> 2014

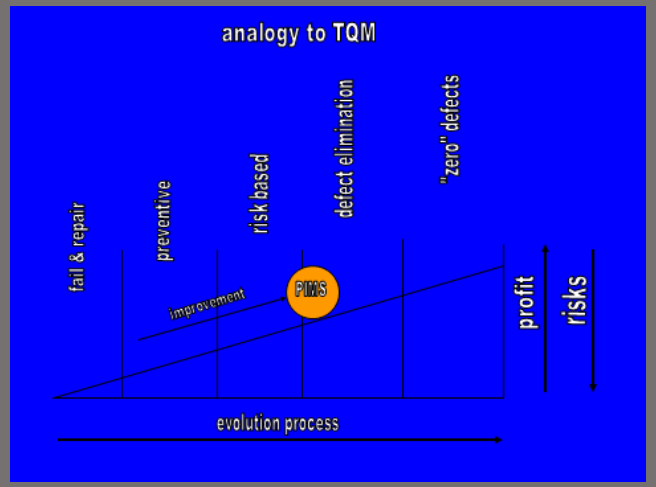
POF = exposure, mitigatie, weerstand (non SME)

+ **RIE simplified**
  - CoF
  - PoF
  - Fine & Kinney (R = K x E)
  - R = PoF x Freq x CoF

+ **Kwalitatief vs. Kwantitatief**
  - Risk index
  - RBI







< 1945

Rundown to failure

>. 1945 – 1960

Preventief onderhoud/TQM

> 1960 - 1970

FMECA (US military & NASA)

> 1970 - 1990

FMECA => RCM
Reliability Centered Maintenance

> 1990 - 2010

Total productive maintenance,
Cost based maintenance
Life cycle Cost analyses,
RBI
Risk Assessment & Method Statement

> 2010

Big Data & Business Intelligence
RIE => future methods

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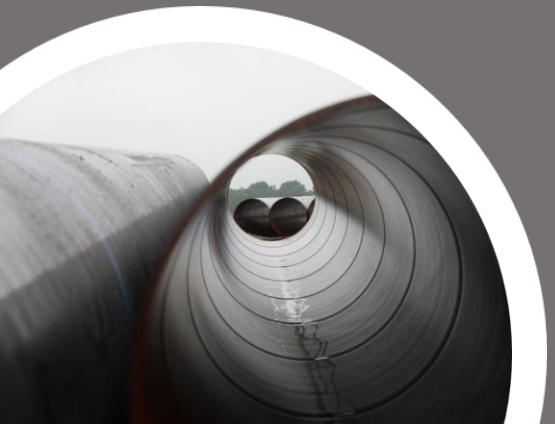
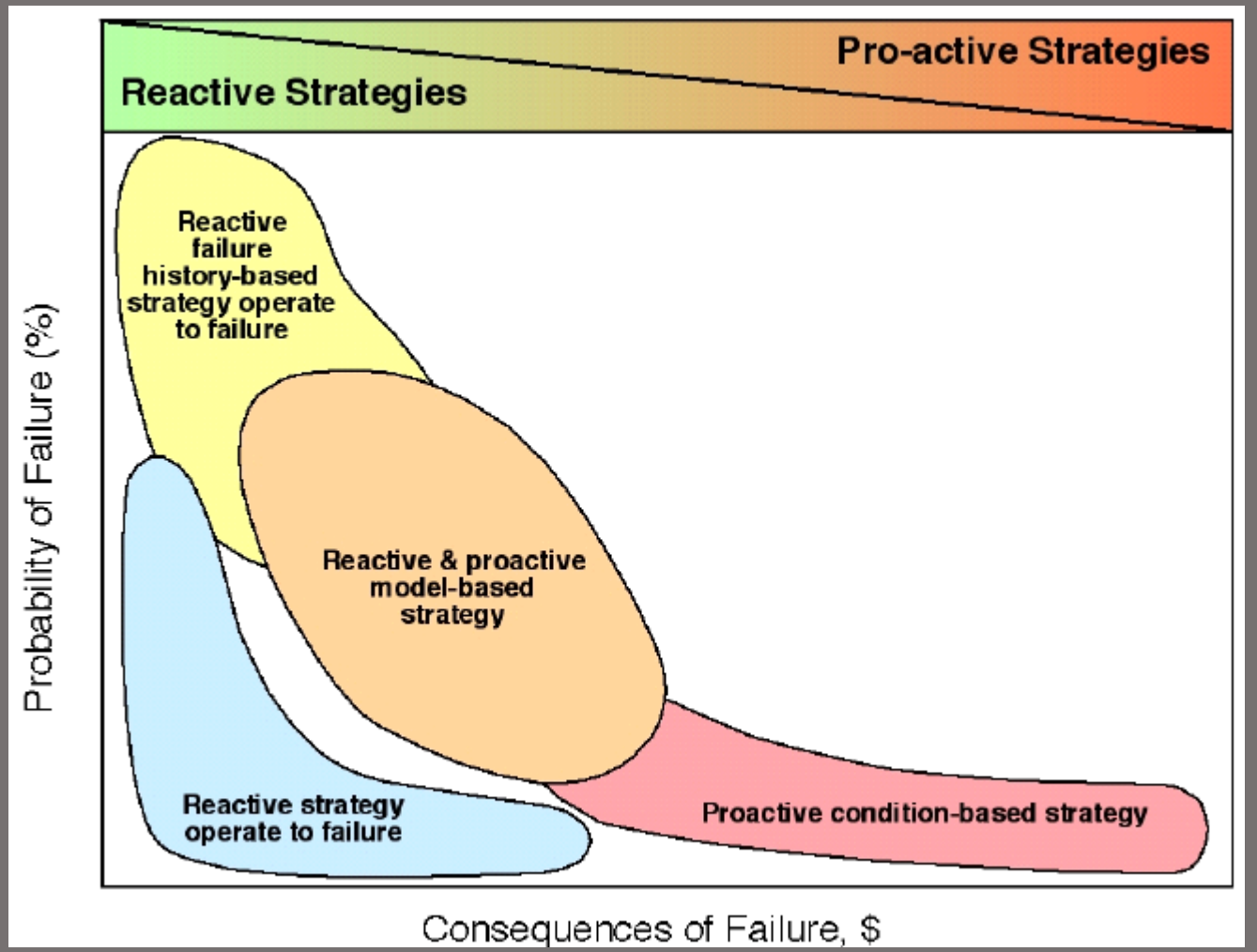
Methodieken en de complexiteit

CoF





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Methodieken en de complexiteit

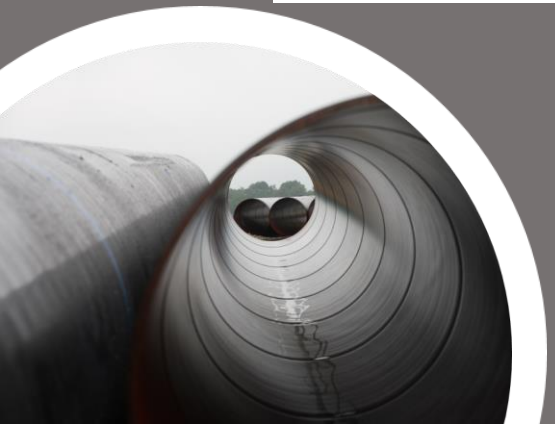
CoF Chemie + O&G

	COF	Very Low	Low	Moderate	High	Very High
LOF		1	2	3	4	5
Very High	5	5	10	15	20	25
High	4	4	8	12	16	20
Moderate	3	3	6	9	12	15
Low	2	2	4	6	8	10
Very Low	1	1	2	3	4	5

Figure 1 Score-Based Risk Matrix

	COF	Very Low	Low	Moderate	High	Very High
LOF		$2,500	$5,000	$15,000	$30,000	$100,000
Very High	80%	$2,000	$4,000	$12,000	$24,000	$80,000
High	45%	$1,125	$2,250	$6,750	$13,500	$45,000
Moderate	15%	$375	$750	$2,250	$4,500	$15,000
Low	5%	$125	$250	$750	$1,500	$5,000
Very Low	1%	$25	$50	$150	$300	$1,000

Figure 2 Monetized Risk Matrix



Severity	Consequences					Frequency						
	People	Environment	Assets	Reputation	Security	F0	F1	F2	F3	F4	F5	F6
						< 10^{-6}/ year	10^{-6}-10^{-5}/ year	10^{-5}-10^{-4}/ year	10^{-4}-10^{-3}/ year	10^{-3}-10-2/year	10^{-2}-10-1/year	>1-10/year
						Extremely unlikely	Very unlikely	Improbable	Remote	Occsional	Probable	Frequent
S5	1external fatality/several fatalities on site	Catastrophic offsite damage	>25 million €	International media attention	International. Attention							
S4	1 fatality / several severe injuries	Offsite release with long term clean-up	<25 million €	National media attention/ official investigation	Fatal assault			ALARP (documented measures)			NOT Acceptable (action required)	
S3	Severe injury	Offsite release or on site release with long clean-up, permit violation	<5 million €	Local media attention/official investigation	Sabotage							
S2	Reportable injury	On site release/ site clean up	<1 million €	External complaint	Burglary		Acceptable, (continuous improvement)					
S1	First aid	Spill	<100k€	None	Trespass							

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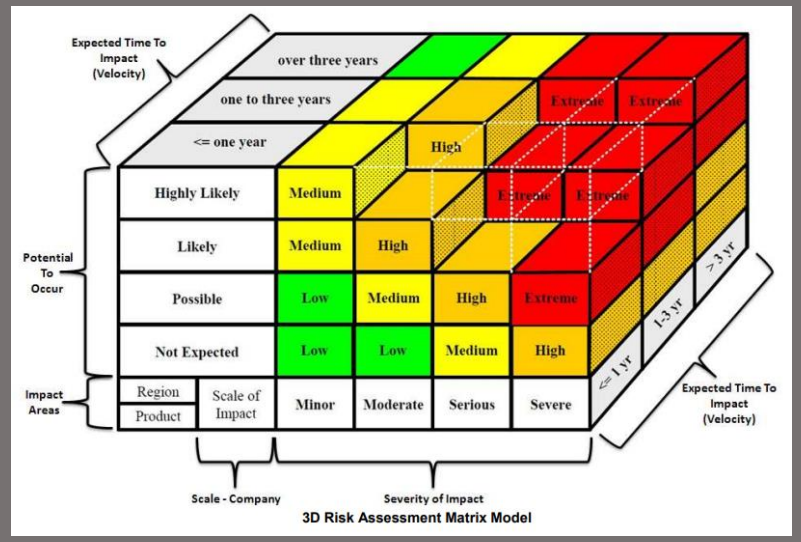
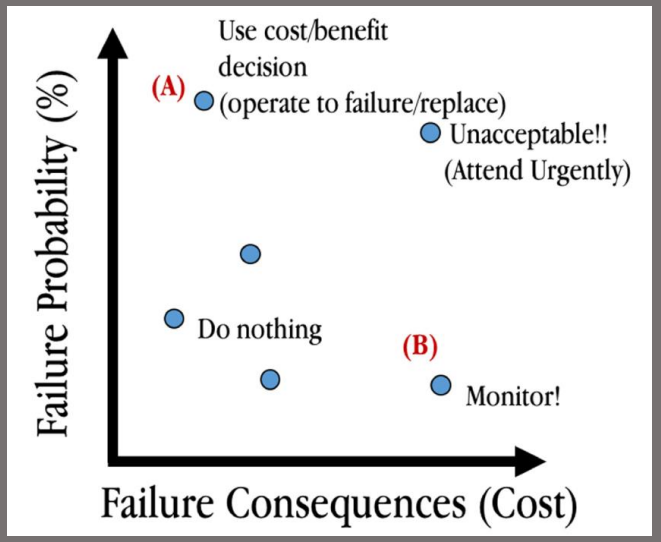
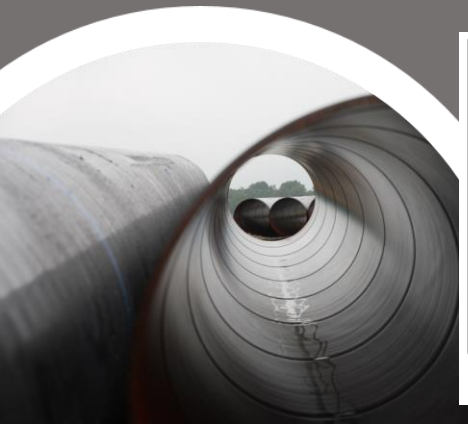
Methodieken en de complexiteit

CoF Non O&G



3D Risk Assessment Matrix Model





Risk Model		PROBABILITY			
		Low	Medium	High	Imminent
IMPACT	Critical				
	Serious				
	Significant				
	Minor				

Risk Legend: Minimal, Moderate, High, Imminent

Waternet - total effect	Risk Matrix Water Quality Frequency of Failure							
	X > 100 years	15 < X < 100 years	10 < X < 15 years	5 < X < 10 years	2 < X < 5 years	1 < X < 2 years	0.25 < X < 1 years	X < 0.25 years
Acute health parameters								
Customer-oriented parameters								
Non-acute health parameters								
Technical parameters								
Non-conform Dutch water act								
No effect								

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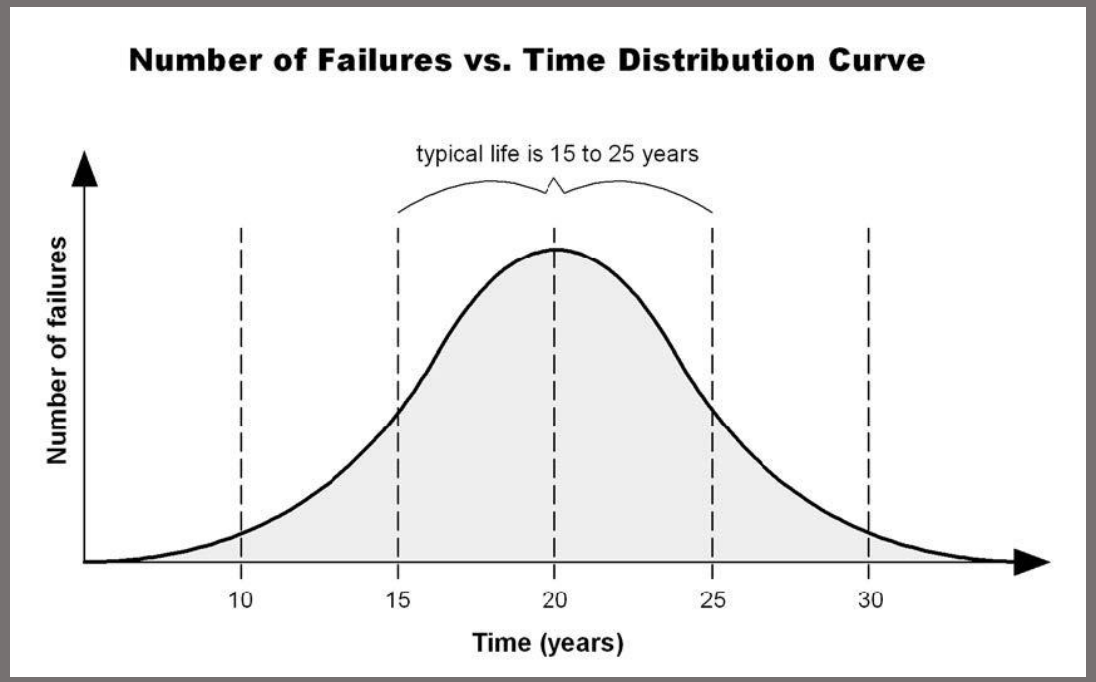
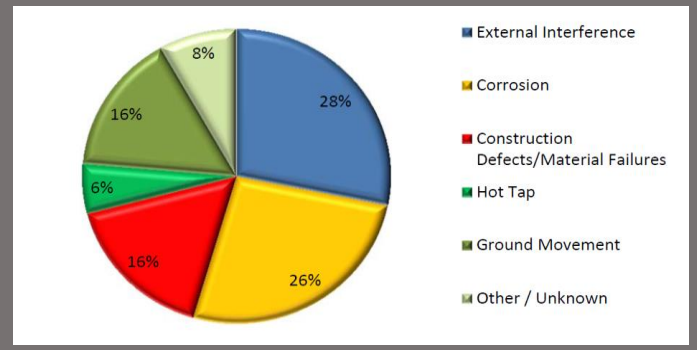
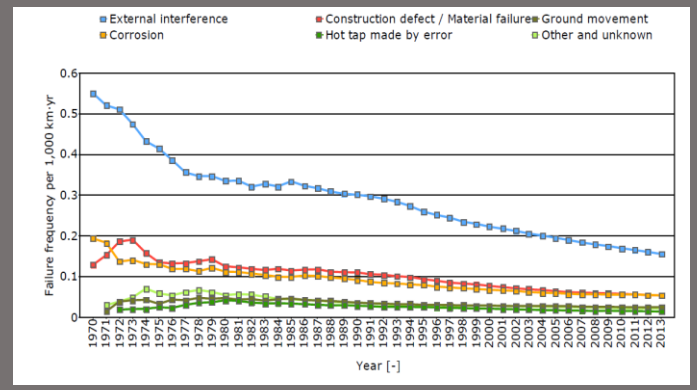
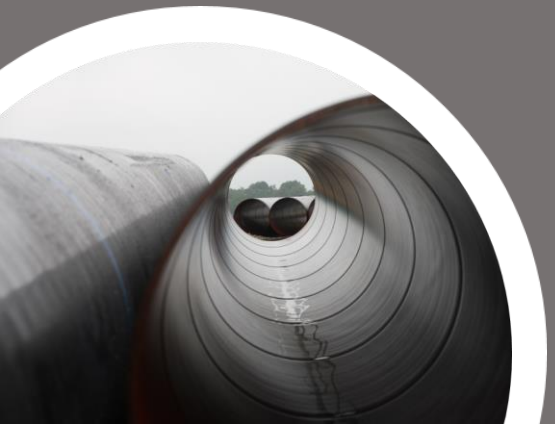
Methodieken en de complexiteit

PoF









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Methodieken en de complexiteit

PoF

Table 44: Steel pipelines – variation of failure frequency by diameter

Diameter (inch)	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
<= 6	32.4	47,051.6	6.88E-04
>6 to 10	32.4	27,913.5	1.16E-03
>10 to 16	20.9	36,004.5	5.82E-04
>16	7.0	108,195.4	6.45E-05
Total/average	92.7	219,165.0	4.23E-04

Bron: Parloc report 6th 2015 (ca. 20.000 km)

Period	Number of Incidents	Total Exposure [km.yr]	Frequency [Incidents per 1000 km.yr]
1952 – 1961	0	3,740	0.000
1962 – 1966	7	12,245	0.572
1967 – 1971	29	40,942	0.708
1972 – 1976	19	65,961	0.288
1977 – 1981	28	80,055	0.350
1982 – 1986	43	88,689	0.485
1987 – 1991	27	93,951	0.287
1992 – 1996	7	100,593	0.070
1997 – 2001	12	103,830	0.116
2002 – 2006	3	110,457	0.027
2007 – 2011	12	111,460	0.108
2012 – 2016	10	115,428	0.087
TOTAL	**197**	**927,351**	**0.212**

Table 3: 5-Year Incident Frequency

Bron: UKOPA report 2018 (ca 22.000 km)

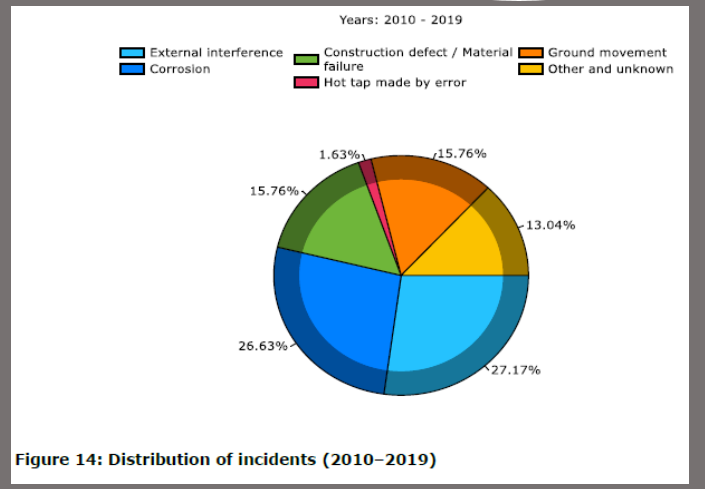


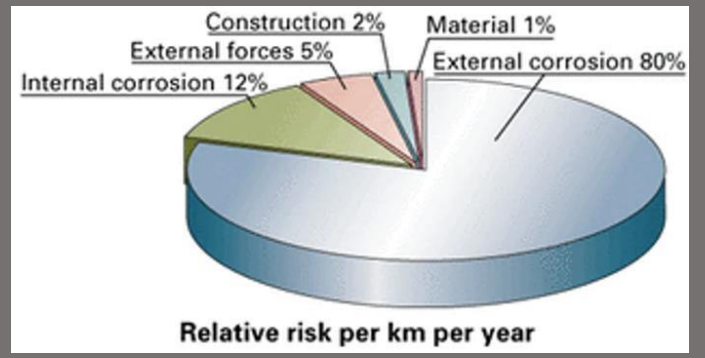
Figure 14: Distribution of incidents (2010–2019)

Bron: EGIG 11th report

Period	Interval	Number of incidents	Total system exposure $\cdot 10^6$ km·yr	Primary failure frequency per 1,000 km·yr
1970 – 2007	7th report, 38 years	1,173	3.15	0.372
1970 – 2010	8th report, 41 years	1,249	3.55	0.351
1970 – 2013	9th report, 44 years	1,309	3.98	0.329
1970 – 2016	10th report, 47 years	1,366	4.41	0.310
1970 – 2019	11th report, 50 years	1,411	4.84	0.292
1980 – 2019	40 years	1,050	4.36	0.241
1990 – 2019	30 years	663	3.63	0.183
2000 – 2019	20 years	388	2.64	0.147
2010 – 2019	10 years	184	1.42	0.129
2015 – 2019	5 years	90	0.71	0.126

Table 1: Primary failure frequencies

Bron: EGIG 11th report (ca. 143.000 km)



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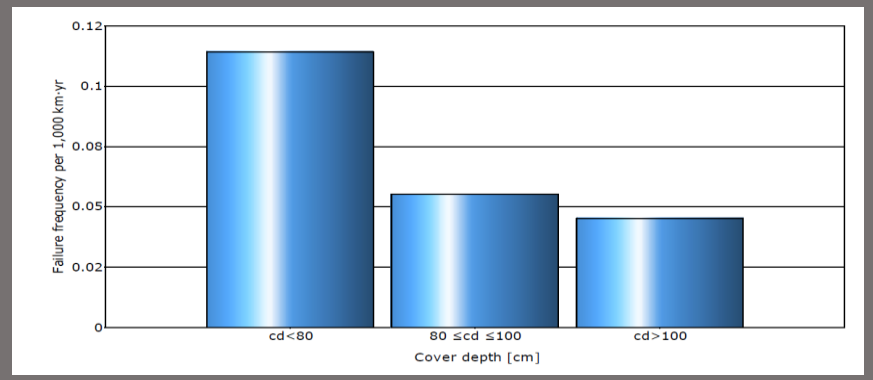
Combineren van kwantitatieve data vs. kwalitatieve SME’s in RIE’s

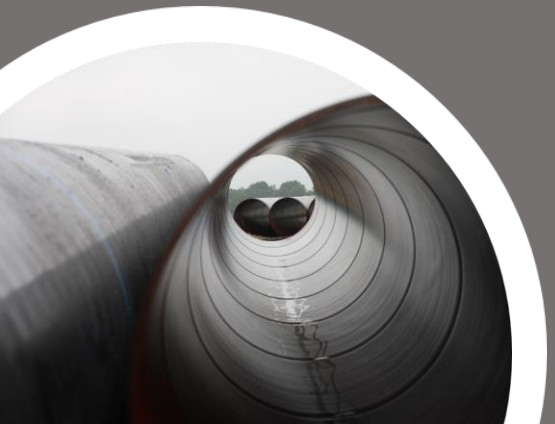
Levensfasen

- Ontwerp / aanleg / Operatie / end of life

NEN3655 (geparafraseerd)

- De RIE omvat de gehele levenscyclus van de leiding en is de basis voor verdere systeemontwikkeling volgens PCDA





Detection	Incident distribution 1970 – 2013 [%]	Incident distribution 2004 – 2013 [%]
Public	36.1	24.9
Patrol + Contractors + Staff	39.6	38.8
Unknown	7.3	1.4
Landowner	5.0	14.4
Distribution company	4.8	4.3
Other	5.5	11.5
In-line inspection	1.8	4.8

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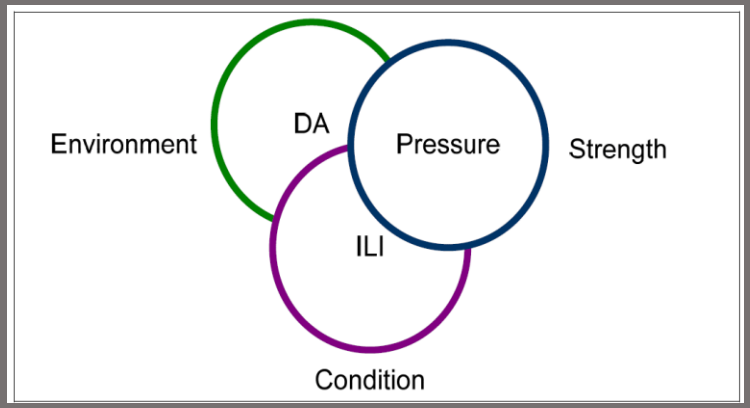
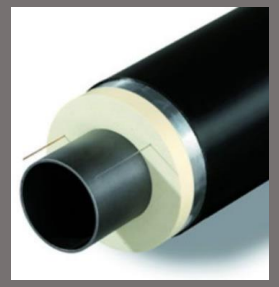
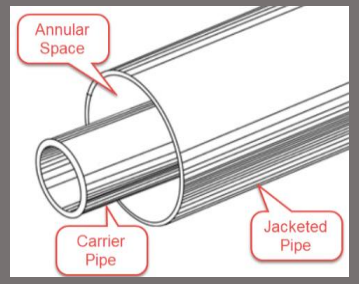
ILI & Non-piggables dynamiek

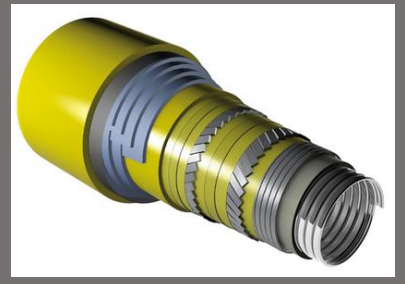
De complexiteit van RIE’s op gediversifieerde asset typen
- Uniformiteit
- Benchmarking in de branche
- Standaardisatie



- Big data vs. few data
- PoF @ big data & PoF @ few data
- Cof vs impact (multiphase / dense phase etc.)
- Digital twin => why / how
  - Bestaat dat wel bij aging assets +40 jr?







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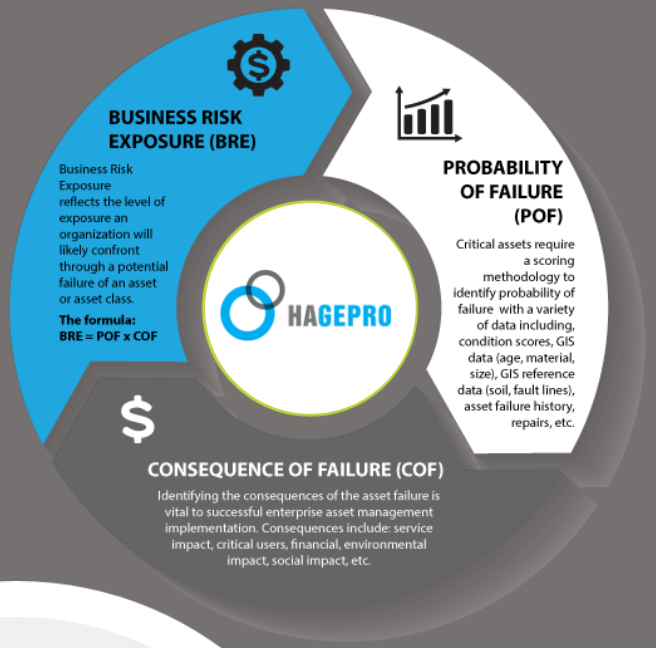
Borging & herhaling



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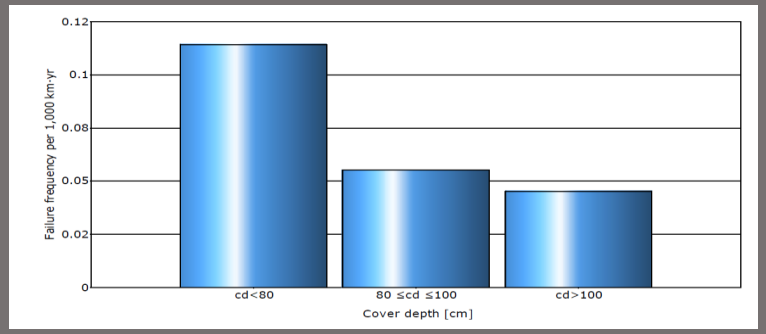
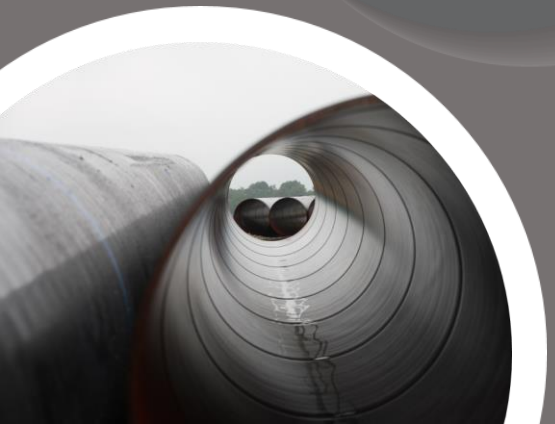


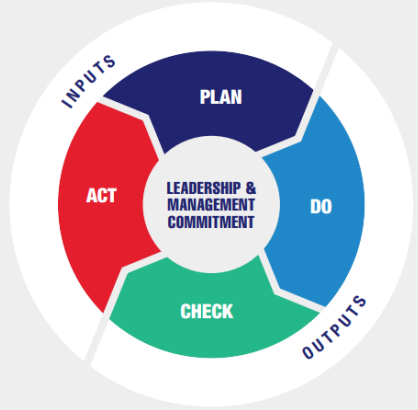


PLAN
- Identify Threats
- Identify Potential Impacts to High Consequence Areas
- Assess Risk and Rank Segments
- Develop or Revise an Integrity Management Plan

DO
- Conduct Inspections, Testing, Examinations
- Collect Integrity Data
- Collect Performance Data

ACT
- Perform Preventative and Mitigative Activities
- Calculate Reassessment Intervals
- Perform Program Improvement Activities
- Perform Remediation Activities

CHECK
- Review Management of Change (MOC)
- Integrate MOC Information with Integrity and Performance Data
- Review Operator, Industry, and Regulator Learnings, Recommendations or Advisories
- Evaluate Integrity Program Performance
- Assess Pipeline Integrity



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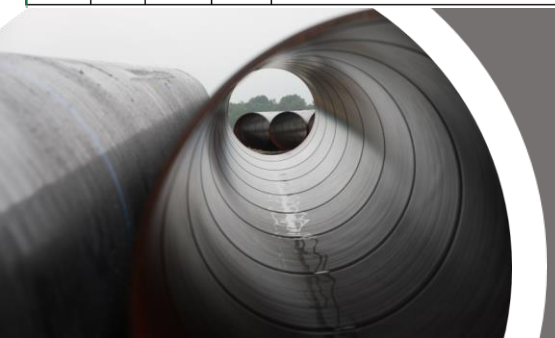
RIE in de praktijk

Pipeline	Route	Pipeline code	Line ID	Regio	Segment nr.	Segment type	Segment ID	Segment lengte (m)	Diameter	Dia (inch)	Materiaal	WT (mm)	Risico score											Risicobeheersing				
													PoF	People (CoF)	Environment	Assets	reputation	Security	SOM (effect)	Effect MAX	RISK	Safety factor	RISK incl. safetyfactor	Beheersmaatregel - voorgesteld	Beheersmaatregel - genomen	Actie-houder	Reduc.Factor (1 - 5)	Risudual Risk
													F0	3	3	3	3	3	*15*	*3*	**3E-06**	1,0	3E-06				1	3E-06
Tronox 1989 (PIP) (Chloor)	Nobian - Tronox	PT113056 (PL) PT113100 (Casing)	2"DCL30-11.3056 (carrier pipe) 6"DCL-30-11-3100 (mantel)	1(Site N)	1.1	Above soil	PT113056 TR1.1	1	60,38	2" + 6" mantel (PIP)	ASTM A333 Gr 6 (3.1 B certificaat)	2" wt 5,54 mm 6" wt 7,92 mm	F0	1	1	1	1	1	*5*	*1*	**1E-06**	1,0	1E-06				1	1E-06
				1(Site N)	1.2	SubS (PH low)	PT113056 TR1.2	127,31				2" wt 5,54 mm 6" wt 7,92 mm	F0	1	1	1	1	1	*5*	*1*	**1E-06**	1,0	1E-06				1	1E-06
				2 (offsite)	1.3	SubS (contam)	PT113056 TR1.3	179,31				2" wt 5,54 mm 6" wt 7,11 mm	F0	1	1	1	1	1	*5*	*1*	**1E-06**	1,0	1E-06				1	1E-06
				2 (offsite)	1.4	SubS Rail Cr	PT113056 TR1.4	10				2" wt 5,54 mm 6" wt 7,11 mm	F1	3	3	3	3	3	*15*	*3*	**3E-05**	1,0	3E-05				1	3E-05
				2 (offsite)	1.5	SubS	PT113056 TR1.5	165,42				2" wt 5,54 mm 6" wt 7,11 mm	F0	1	1	1	1	1	*5*	*1*	**1E-06**	1,0	1E-06				1	1E-06
				2 (offsite)	1.6	Sub S Rail Cr	PT113056 TR1.6	10				2" wt 5,54 mm 6" wt 7,11 mm	F1	3	3	2	3	3	*15*	*3*	**3E-05**	1,0	3E-05				1	3E-05
				2 (offsite)	1.7	SubS (MIC susp)	PT113056 TR1.7	144,77				2" wt 5,54 mm 6" wt 7,11 mm	F2	1	1	1	1	1	*5*	*1*	**0,0001**	1,0	1E-04				1	0,0001
				2 (offsite)	1.8	Sub S Rail Cr	PT113056 TR1.8	10				2" wt 5,54 mm 6" wt 7,11 mm	F3	1	1	1	1	1	*5*	*1*	**0,001**	1,0	0,001				1	0,001
				2 (offsite)	1.9	SubS	PT113056 TR1.9	29,56				2" wt 5,54 mm 6" wt 7,11 mm	F3	1	1	1	1	1	*5*	*1*	**0,001**	1,0	0,001				1	0,001
				2 (offsite)	1.10	Sub S Rail Cr	PT113056 TR1.10	10				2" wt 5,54 mm 6" wt 7,11 mm	F2	3	3	3	3	3	*15*	*3*	**0,0003**	1,0	3E-04				1	0,0003
				2 (offsite)	1.11	SubS	PT113056 TR1.11	302,55				2" wt 5,54 mm 6" wt 7,11 mm	F1	1	1	1	1	1	*5*	*1*	**1E-05**	1,0	1E-05				1	1E-05
				3 (offsite)	1.12	Sub S Water Cr	PT113056 TR1.12	327,79				2" wt 5,54 mm 6" wt 7,92 mm	F1	3	3	3	3	3	*15*	*3*	**3E-05**	1,0	3E-05				1	3E-05
				2 (offsite)	1.13	SubS	PT113056 TR1.13	1392,57				2" wt 5,54 mm 6" wt 7,11 mm	F2	1	1	1	1	1	*5*	*1*	**0,0001**	1,0	1E-04				1	0,0001
				2 (offsite)	1.14	Sub S Rail Cr	PT113056 TR1.14	10				2" wt 5,54 mm 6" wt 7,11 mm	F3	1	1	1	1	1	*5*	*1*	**0,001**	1,0	0,001				1	0,001
				2 (offsite)	1.15	SubS	PT113056 TR1.15	69,9				2" wt 5,54 mm 6" wt 7,11 mm	F5	1	1	1	1	1	*5*	*1*	**0,1**	1,0	0,1				1	0,1
				2 (offsite)	1.16	Sub S Rail Cr	PT113056 TR1.16	25,34				2" wt 5,54 mm 6" wt 7,11 mm	F1	3	3	3	3	3	*15*	*3*	**3E-05**	1,0	3E-05				1	3E-05
				2 (offsite)	1.17	SubS	PT113056 TR1.17	680,22				2" wt 5,54 mm 6" wt 7,11 mm	F1	1	1	1	1	1	*5*	*1*	**1E-05**	1,0	1E-05				1	1E-05
				1(Site K)	1.18	SubS (contam)	PT113056 TR1.18	120				2" wt 5,54 mm 6" wt 7,11 mm	F1	3	3	3	3	3	*15*	*3*	**3E-05**	1,0	3E-05				1	3E-05



AIP 571

Defect/degradatie mechanismen API 571 Leidingen => 24": Natronloog (Vloeistof) 6" / 4" / 3" & 2"								Risico score											Risicobeheersing				
	Nr.	Mechanism	Event	Cause	Effect	Appl.	Client comm	Likelyhood	People	Environment	Assets	Reputation	Security	SOM (effect)	Effect MAX	RISK	Safety factor	RISK incl. safetyfactor	Beheersmaatregel - voorgesteld	Beheersmaatregel - genomen	Actie-houder	Reduc. Factor (1 - 5)	Risudual Risk
API 571 hfdst. 4 Algemene schade mechanismen																							
Materiaal	4.3.2.	Atmosferische corrosie	Corrosie	Corrosie als gevolg van vochtige lucht	Materiaal degradatie	✔	Check	F1	1	1	1	1	1	*5*	*1*	**0,00001**	1,0	1E-05				1	0,00001
	4.3.8.	Microbiologically Induced Corrosion (MIC)	Corrosie	Corrosie veroorzaakt door levende organismen zoals bacteriën, algen of schimmels. Het wordt vaak geassocieerd met de aanwezigheid van	Materiaal degradatie	✔	Zou kunnen bij ASTM 106 Gr B extern	F1	3	3	3	3	3	*15*	*3*	**0,00003**	1,0	3E-05				1	0,00003
	4.3.9.	Bodemcorrosie	Corrosie	Degeneratie van metalen a.g.v. bodemsamenstelling, Incl. zwerfstroom AC/DC	Materiaal degradatie	✔	KB / DCVG	F2	3	3	3	3	3	*15*	*3*	**0,0003**	1,0	3E-04				1	0,0003

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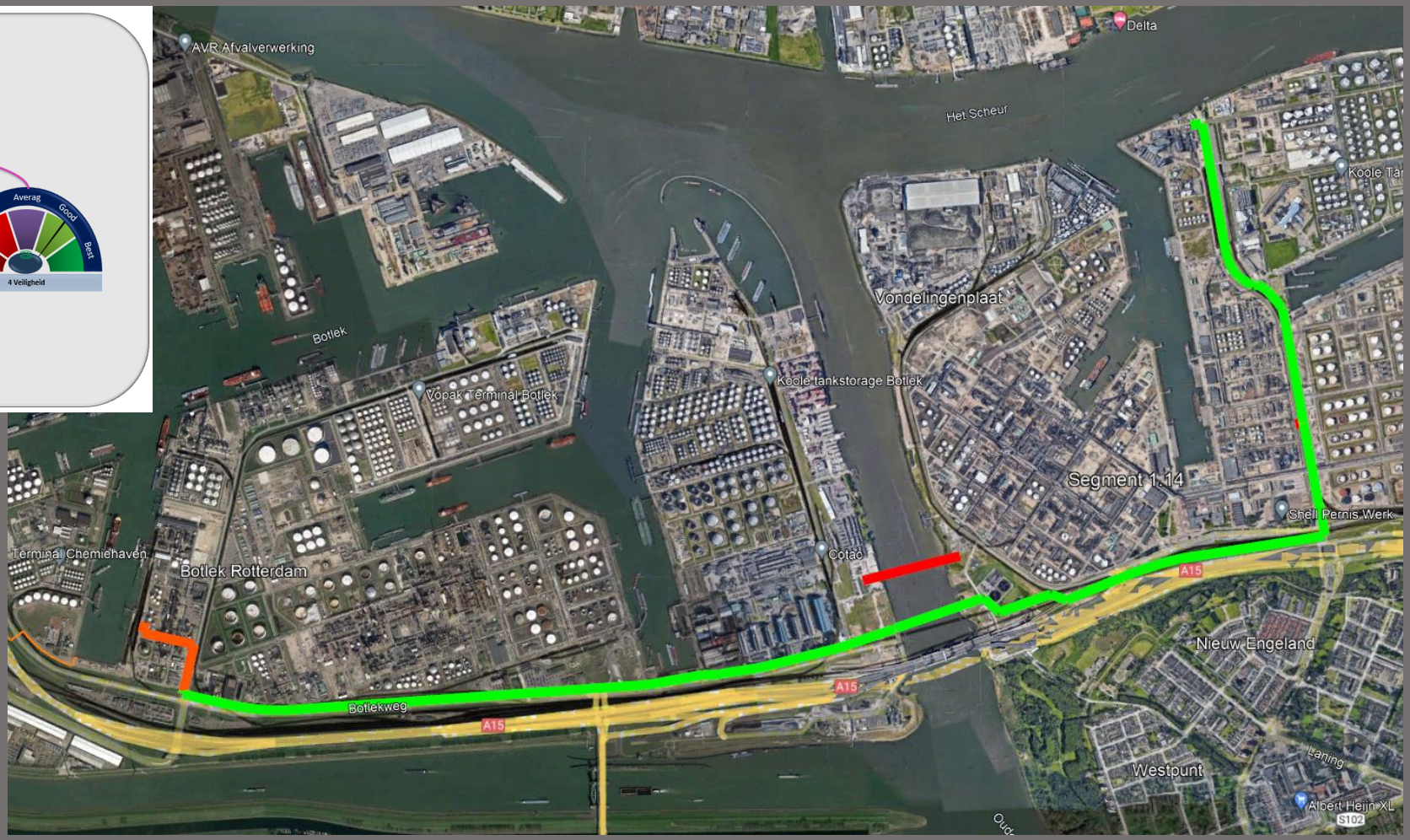
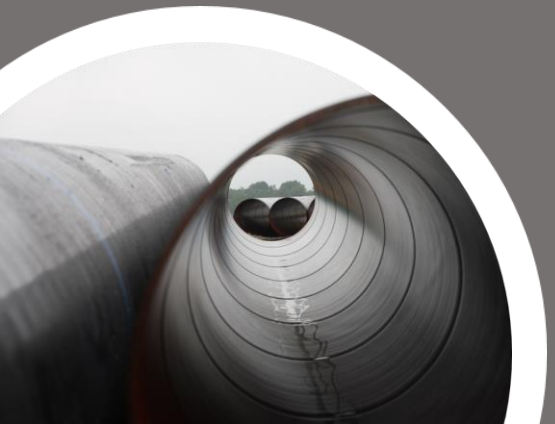
Presenteren van resultaten





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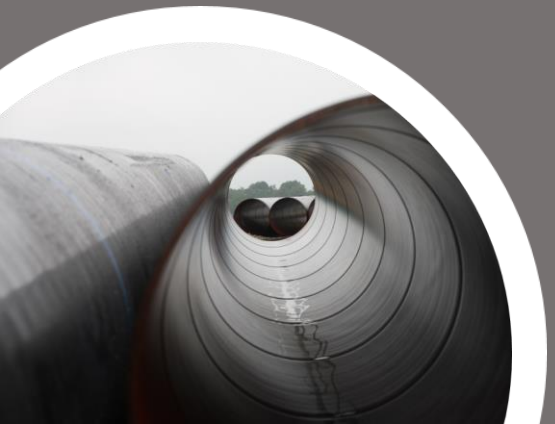
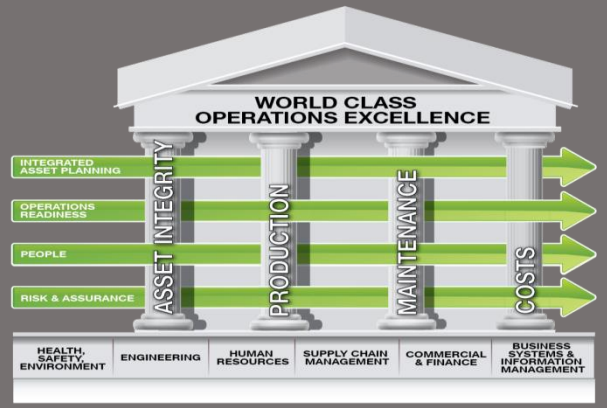
State of the Art

The highest level of general development, as of a device, technique, or scientific field achieved at a particular time (Bron; Wikipedia)

Tabel 3 bijlage 1 BevB

- 3rd party damage
- Mechanical
- Inwendige corrosie
- Uitwendige corrosie
- Natuurlijke oorzaken
- Operationeel en overig





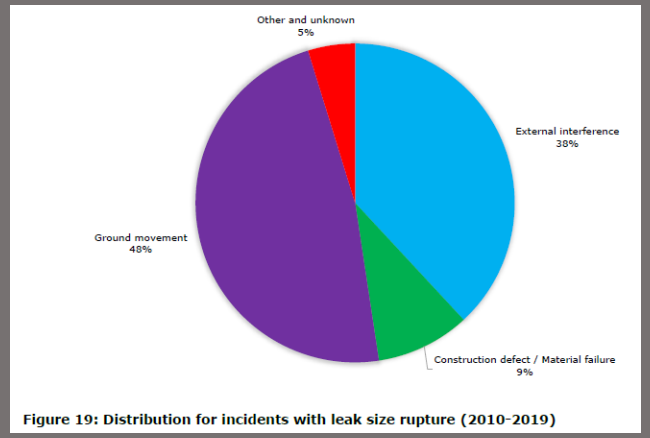


Figure 19: Distribution for incidents with leak size rupture (2010-2019)

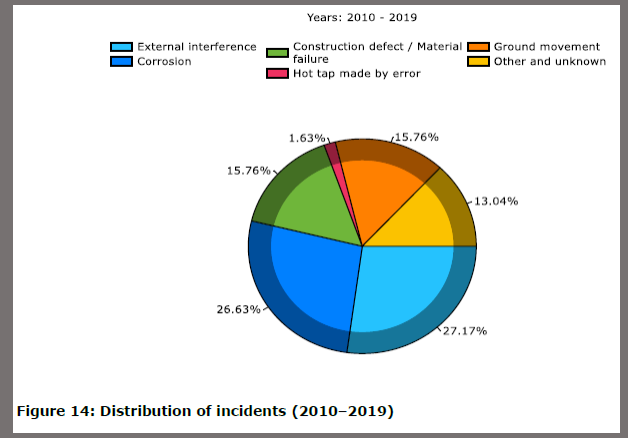


Figure 14: Distribution of incidents (2010–2019)

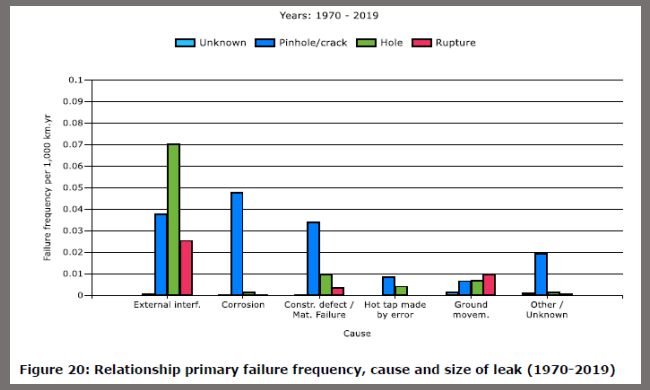
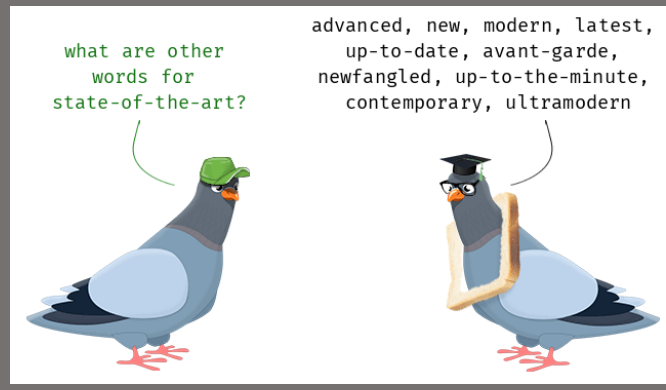


Figure 20: Relationship primary failure frequency, cause and size of leak (1970-2019)



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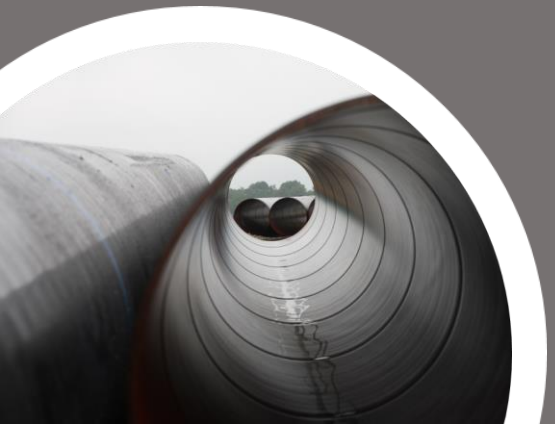
Open discussie



Dank voor uw aandacht