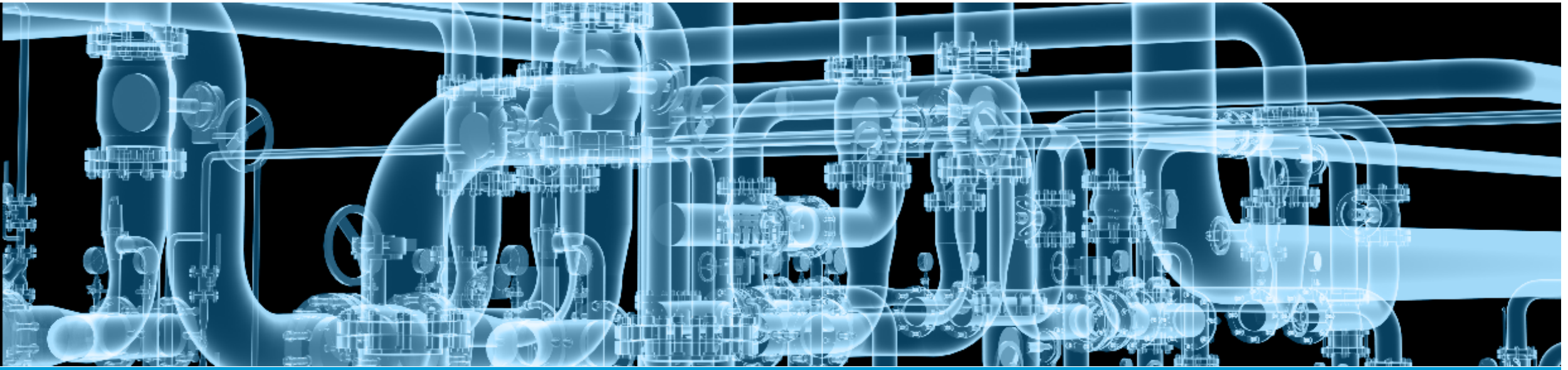


OIL & GAS

Managing the significant threat of corrosion under insulation

DNV GL CUI Manager

Frode Wiggen

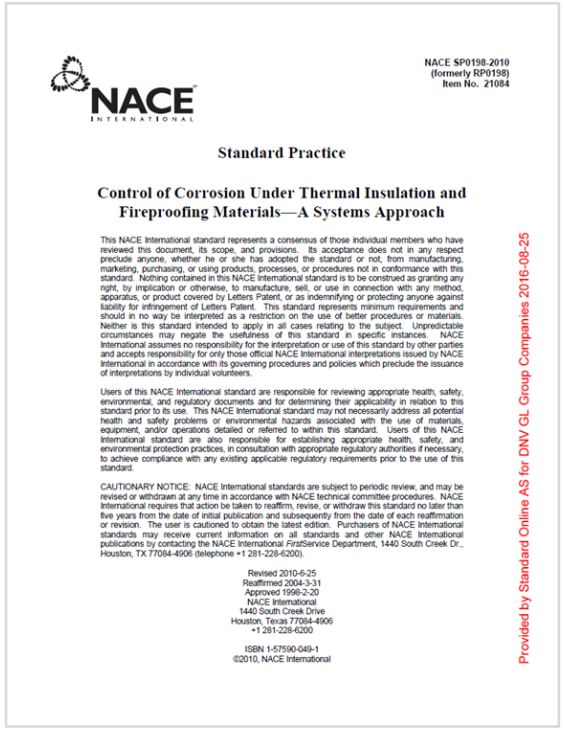
Agenda

DNV·GL

A hidden killer

- Corrosion Under Insulation is difficult to detect.
- Lack of cost effective non-intrusive inspection methods.
- The oil and gas industry has never operated under a standard methodology.
- There is no decision-making tool for managing the threat of CUI.

New industry standard driven by industry collaboration


NACE

NACE SP0198-2010
(formerly RP0198)
Item No. 21084

Standard Practice

Control of Corrosion Under Thermal Insulation and Fireproofing Materials—A Systems Approach

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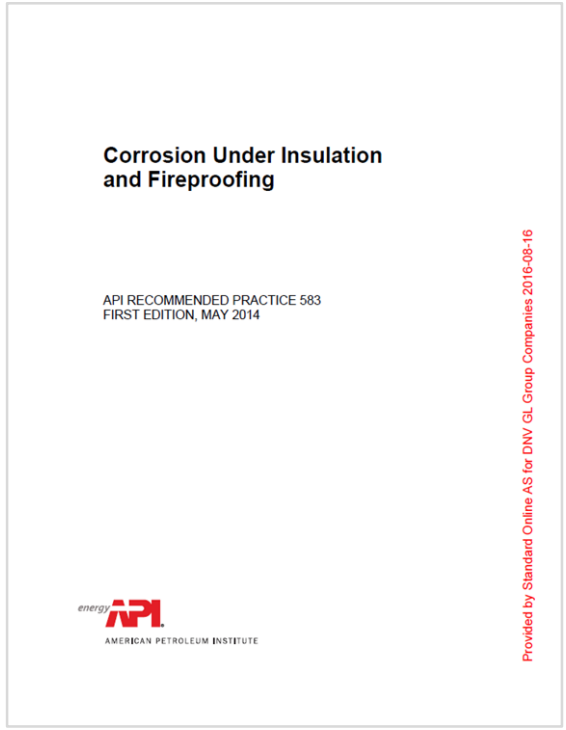
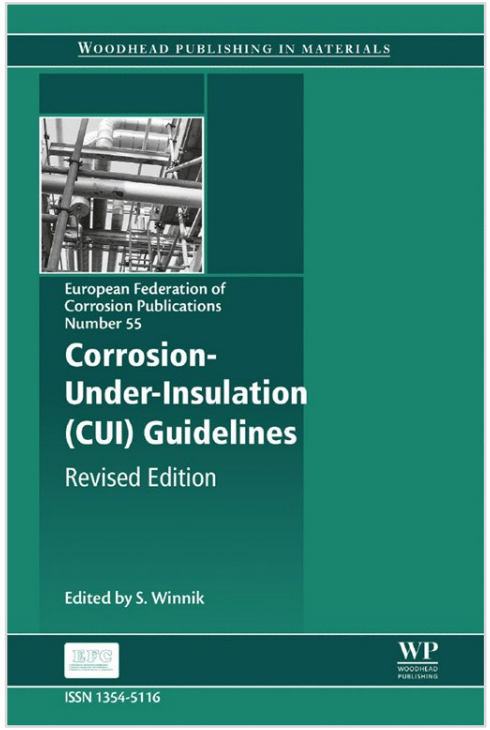
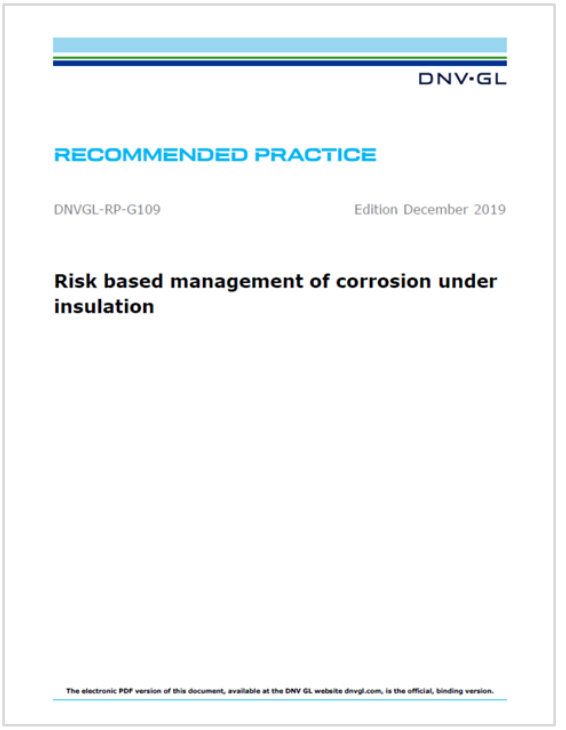

Corrosion Under Insulation and Fireproofing

API RECOMMENDED PRACTICE 583
FIRST EDITION, MAY 2014

energy API
AMERICAN PETROLEUM INSTITUTE

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DNVGL-RP-G109 Edition December 2019

Risk based management of corrosion under insulation

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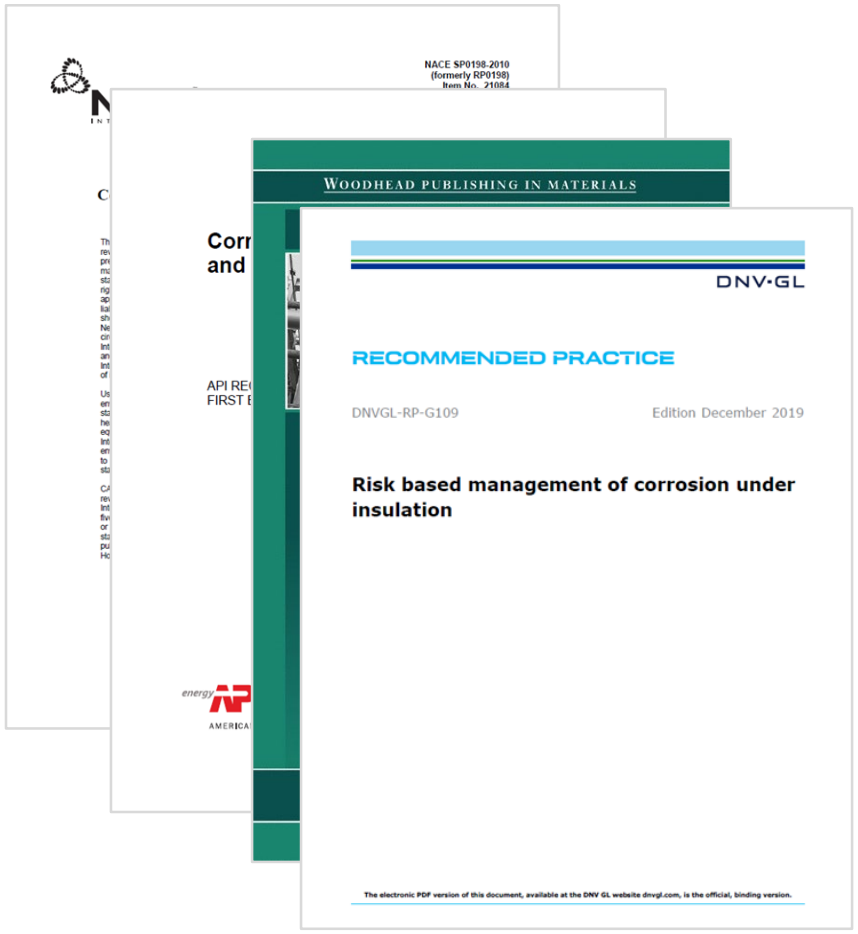
New industry standard driven by industry collaboration



AkerBP | DNV·GL | ConocoPhillips Norway

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GASSCO | NEPTUNE ENERGY

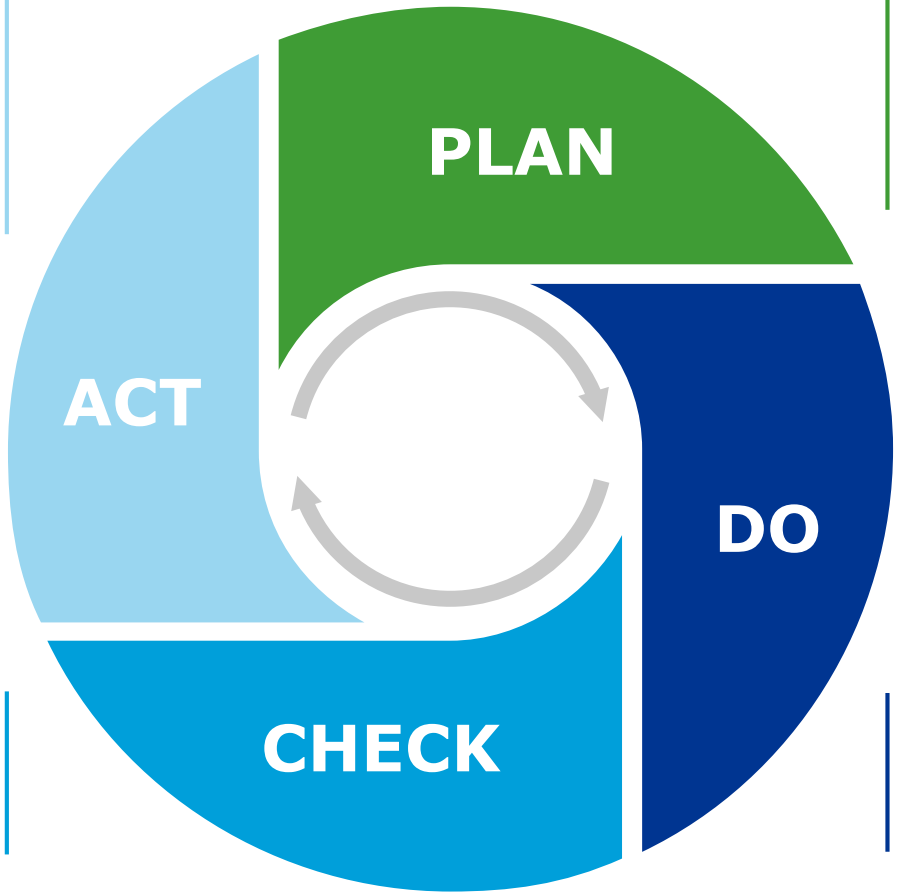
Risk - based management of corrosion under insulation

DNVGL-RP-G109 – methodology description

CUI process as described in DNVGL-RP-G109

Continuous Improvement

- Use achieved results to update CUI strategy
- Standardisation and Procedure development
- Experience transfer



Risk Assessment

- Identify challenge
- Assess risk
- Establish or update plan for risk management of CUI

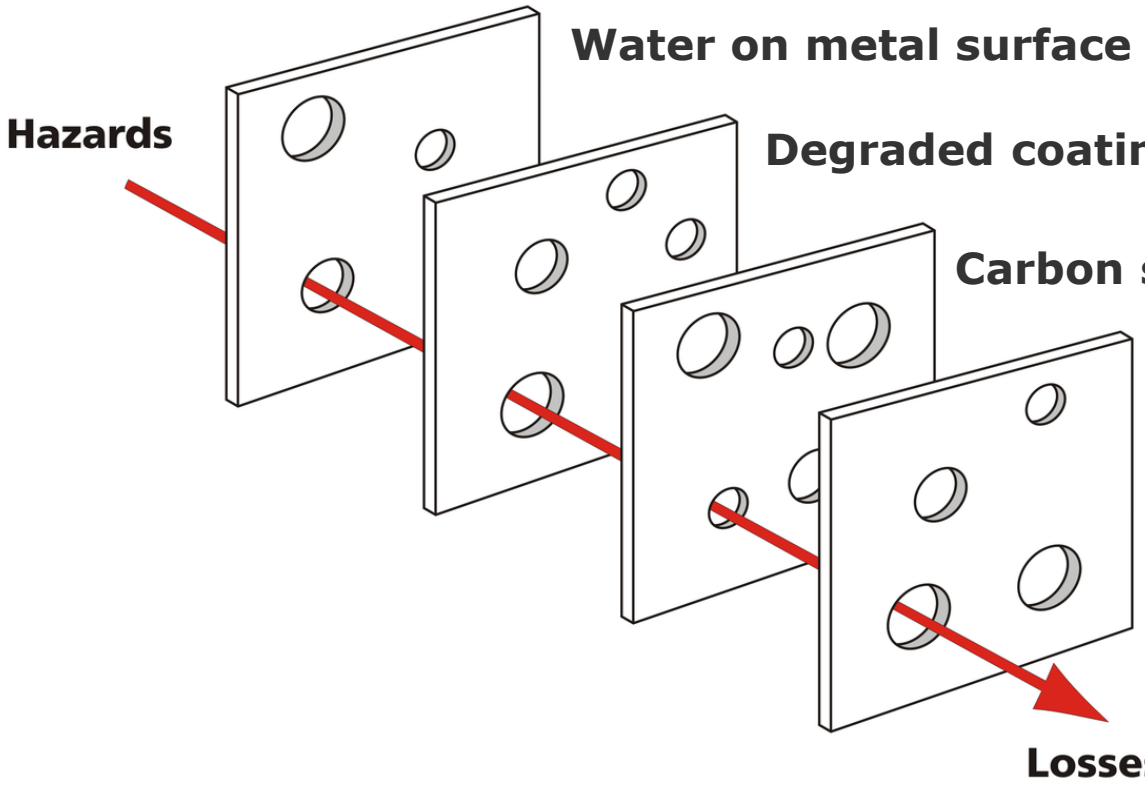
Risk Update

- Ensure and document that the risk mitigation effect are sufficient

Risk Mitigation

- Execute the risk mitigating activity

CUI barriers



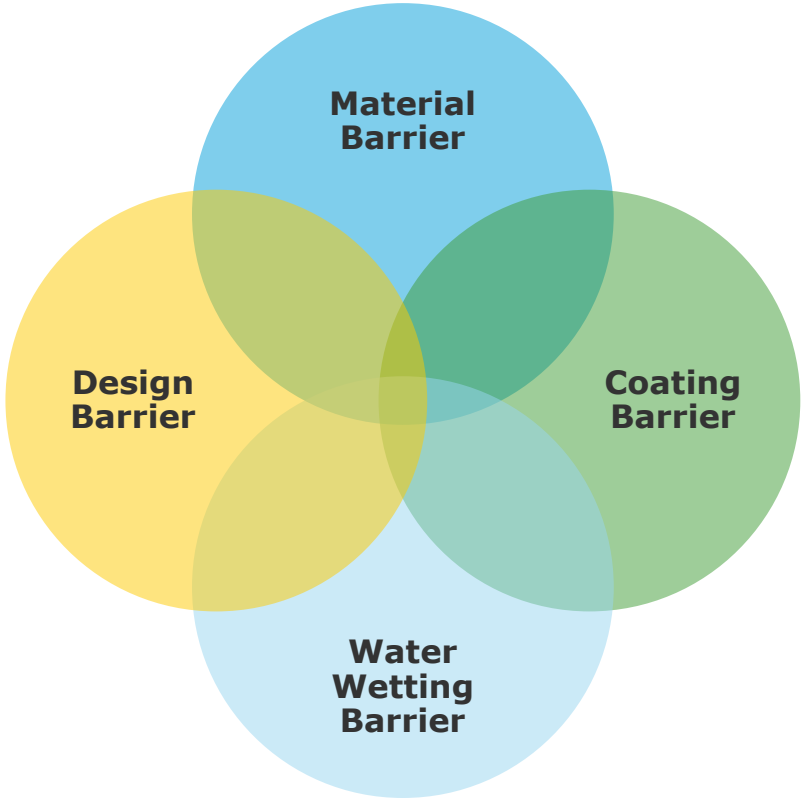
Water on metal surface – Water wetting barrier

Degraded coating – Coating barrier

Carbon steel with high corrosion rate – Material barrier

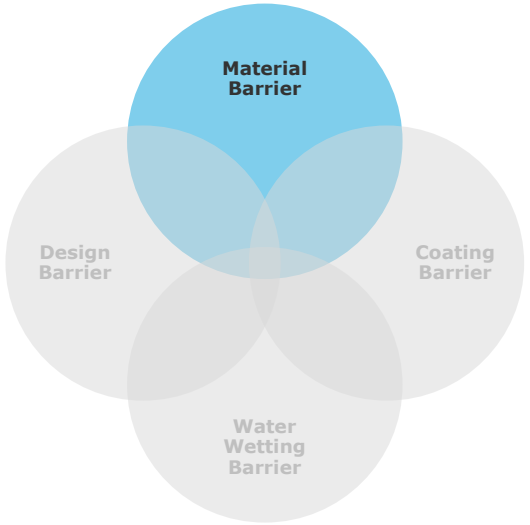
Insufficient design, thin walls – Design barrier

Barrier assessment

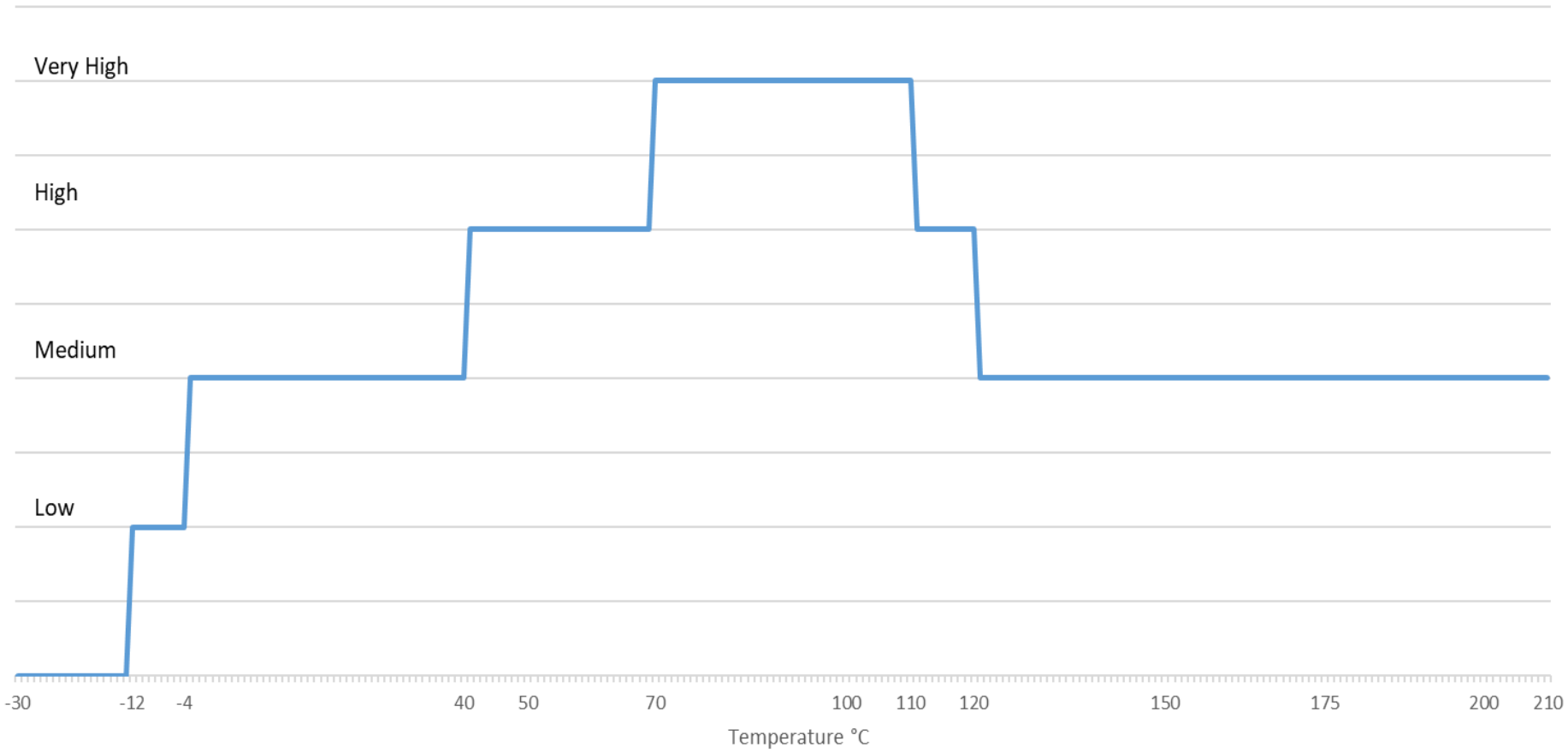


$$PoF_{CUI} = f(PoF_{material}, PoF_{coating}, PoF_{water\ wetting}, PoF_{design})$$

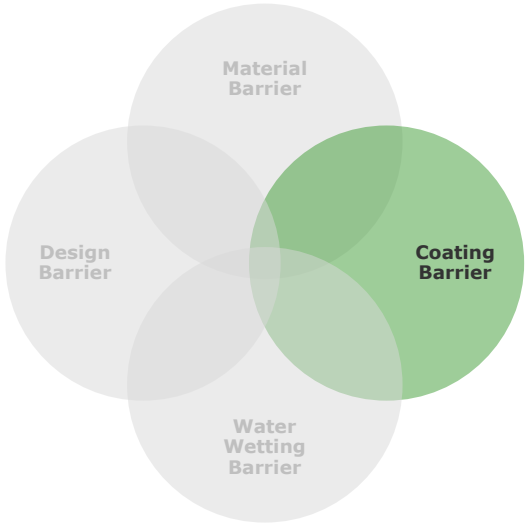
Barrier assessment, material



PoF as Function of Temp.

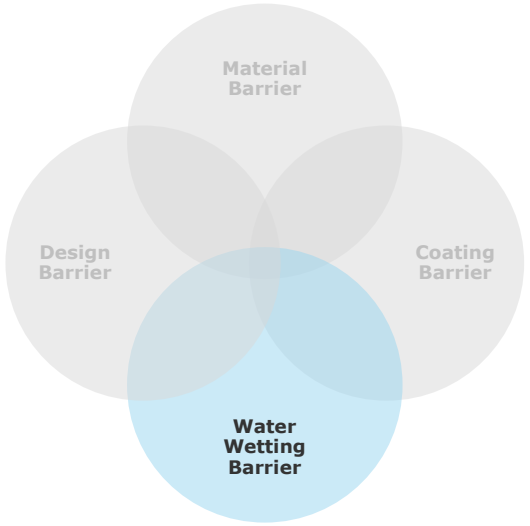


Barrier assessment, coating



Description	NORSOK M-501 system ref	NACE SP0198-2010 syst. ref.	Temp. area	Age of the coating								Comment
				0-5	6-10	11-15	16-20	21-25	26-30	31-35	>35	
Primer (<50 µm)	NA	NA	<60ºC	VH	VH	VH	VH	VH	VH	VH	VH	Not intended to be used as a protective layer under insulation.
Hot Dip Galvanizing (HDG)	NA	NA	<200ºC	L	M	H	VH	VH	VH	VH	VH	Ref ISO 14713-1.
Zinc Silicate with top sealer	NA	NA	<105ºC	L	M	H	VH	VH	VH	VH	VH	Not to be used under insulation according to NORSOK M-501.
2 layer with zinc rich primer as first layer (vinyl,	System 1	NA	<80ºC	M	H	VH	VH	VH	VH	VH	VH	Not to be used under insulation according to NORSOK M-501.
3 layer with zinc rich primer as first layer (epoxy,	System 1	NA	<80ºC	VL	L	M	H	VH	VH	VH	VH	Not to be used under insulation according to NORSOK M-501.
Two component epoxy or polyester based coating	System 7A	NA	<80ºC	VL	VL	L	M	H	VH	VH	VH	Not to be used under insulation according to NORSOK M-501. Need prequalification.
3 layer on epoxy primer (zinc free)	System 6 (A/B) (SS)	NA	<80ºC	L	M	H	VH	VH	VH	VH	VH	Not to be used under insulation according to NORSOK M-501.
2 layer epoxy coating (>350 µm)	System 7 (B/C)	SS-1/CS-1	-45 to 60ºC	VL	L	M	H	VH	VH	VH	VH	Not to be used under insulation according to NORSOK M-501. Need prequalification
2 layer epoxy Phenolic / Novolac	System 6C (SS) System 9 (CS)	SS-2/3 / CS-3/4	-45 to 120ºC/150	VL	VL	L	M	H	VH	VH	VH	Ref NORSOK 501.
Fusion Bond Epoxy (FBE)	NA	CS-2	-45 to 60ºC	L	M	H	VH	VH	VH	VH	VH	Ref NACE SP0198. Shop application only. Potential for cracking.
Thermal Spray Aluminum (TSA) with top sealer	System 2A	SS-6/CS-5	-45 to 595ºC	VL	VL	VL	VL	L	M	H	VH	Normative ref NORSOK M-501.
Air dried silicone or Modified silicone	NA	SS-4	-45 to 540ºC	M	H	VH	VH	VH	VH	VH	VH	Ref NACE SP0198. Limited information for this system available. Testing and prequalification needed.
Inorganic copolymer or coatings with an inert multipolymeric matrix	NA	SS-5 / CS-6	>100°C to 650ºC	L	M	H	VH	VH	VH	VH	VH	Ref NACE SP0198. Evaluation based on testing of 2. generation products, limited practical experience. Further testing and prequalification needed.

Barrier assessment, water wetting

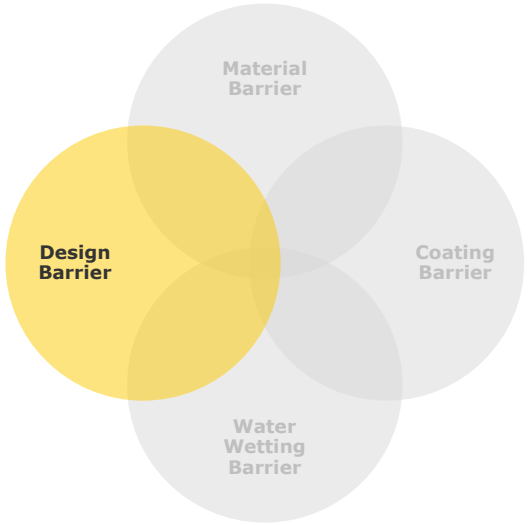


- Climate
- Location
- Cladding
- Insulation type
- Drainage

Water exposure	Probability of breach due to workmanship		
Very High	High	High	Very High
High	Medium	High	Very High
Medium	Low	Medium	High
Low	Very Low	Low	Medium
Very Low	Very Low	Low	Low
	Low	Medium	High

- Workmanship
- Inspection & Maintenance
- Age

Barrier assessment, design



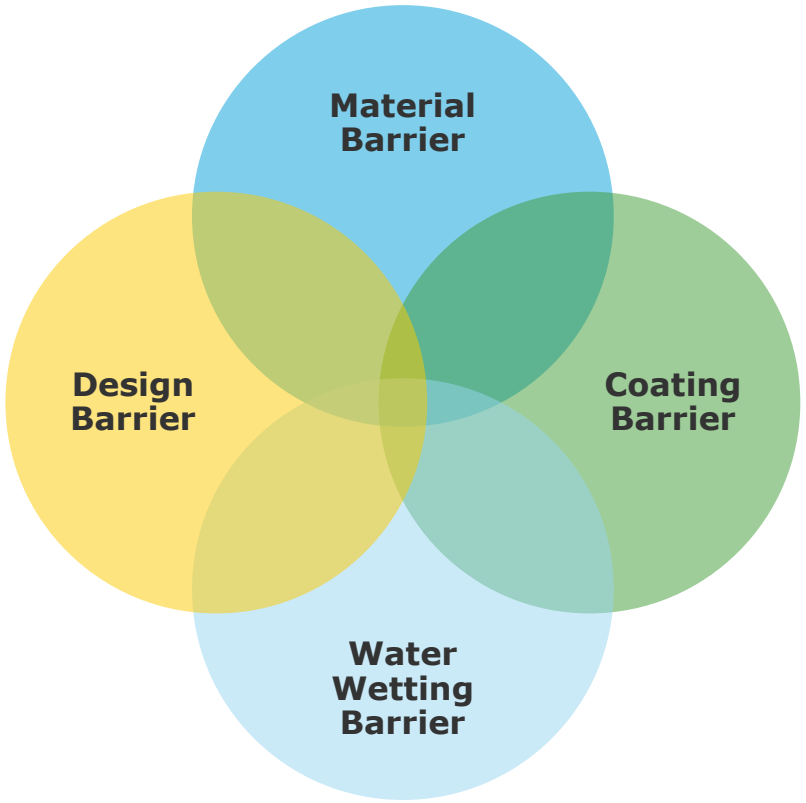
Nominal pipe size mm/inch		OD mm	20	30	STD	40	60	XS	80	100	120	140	160	XXS
15	½	21.3			2.77	2.77		3.73	3.73				4.78	7.47
20	¾	26.7			2.87	2.87		3.91	3.91				5.56	7.82
25	1	33.4			3.38	3.38		4.55	4.55				6.35	9.09
32	1¼	42.2			3.56	3.56		4.85	4.85				6.35	9.70
40	1½	48.3			3.68	3.68		5.08	5.08				7.14	10.15
50	2	60.3			3.91	3.91		5.54	5.54				8.74	11.07
65	2½	73.0			5.16	5.16		7.01	7.01				9.53	14.02
80	3	88.9			5.49	5.49		7.62	7.62				11.13	15.24
90	3½	101.6			5.74	5.74		8.08	8.08				-	-
100	4	114.3			6.02	6.02		8.56	8.56		11.13		13.49	17.12
125	5	151.3			6.55	6.55		9.53	9.53		12.70		15.58	19.05
150	6	168.3			7.11	7.11		10.97	10.97		14.27		18.26	21.95
200	8	219.1	6.35	7.04	8.18	8.18	10.31	12.70	12.70	15.09	18.26	20.62	22.01	22.23
250	10	273.1	6.35	7.80	9.27	9.27	12.70	12.70	15.09	18.26	21.44	25.40	28.58	25.40
300	12	322.9	6.35	8.38	9.53	10.31	14.27	12.70	17.48	21.44	25.40	28.58	33.32	25.40
350	14	355.6	7.92	9.53	9.53	11.13	15.09	12.70	19.05	23.83	27.79	31.75	35.71	
400	16	406.4	7.92	9.53	9.53	12.70	16.66	12.70	21.44	26.19	30.96	36.53	40.49	
450	18	457.2	7.92	11.13	9.53	14.27	19.05	12.70	23.88	29.36	34.93	39.67	45.24	
500	20	508.0	9.53	12.70	9.53	15.09	20.62	12.70	26.19	32.54	38.10	44.45	50.01	
550	22	558.0	9.53	12.70	9.53	-	22.23	12.70	28.58	34.93	41.26	47.63	53.98	
600	24	609.6	9.53	14.27	9.53	17.48	24.61	12.70	30.96	38.89	46.02	52.37	59.54	
650	26	660.4	12.70	-	9.53	-		12.70						
700	28	711.2	12.70	15.88	9.53			12.70						
750	30	762.0	12.70	15.88	9.53	-		12.70						
800	32	812.8	12.70	15.88	9.53	17.48		12.70						
850	34	862.6	12.70	15.88	9.53	17.48		12.70						
900	36	914.4	12.70	15.88	9.53	19.05		12.70						
950	38	965.2			9.53			12.70						
1000	40	1016.0			9.53			12.70						
1050	42	1066.8			9.53			12.70						
1100	44	1117.8			9.53			12.70						
1150	46	1168.4			9.53			12.70						
1200	48	1219.2			9.53			12.70						

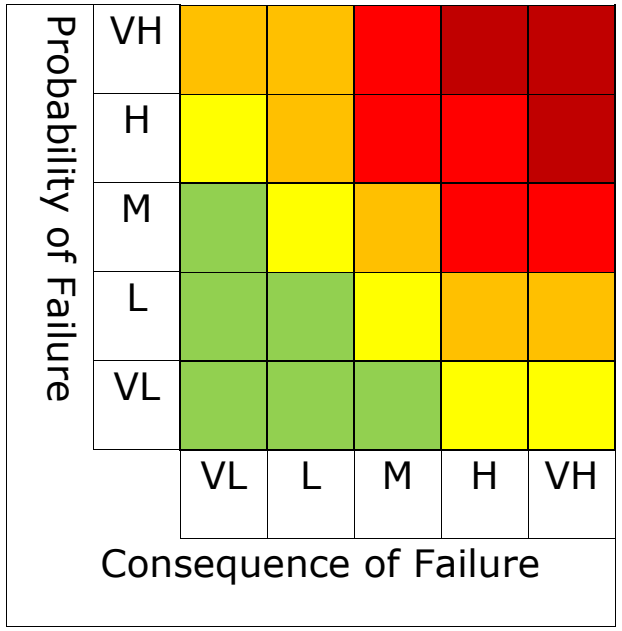
High PoF with respect to Design / Schedule

Low PoF with respect to Design / Schedule

Ref ASME B36 10

From PoF to risk assessment





QRA/TRA or CoF from existing RBI

Risk mitigation

Change parameters that cause the risk

- Modifications, maintenance, repair

Increase knowledge of the parameters causing the risk (remove uncertainty)

- Analysis, new data, new technology and knowhow, inspection and monitoring

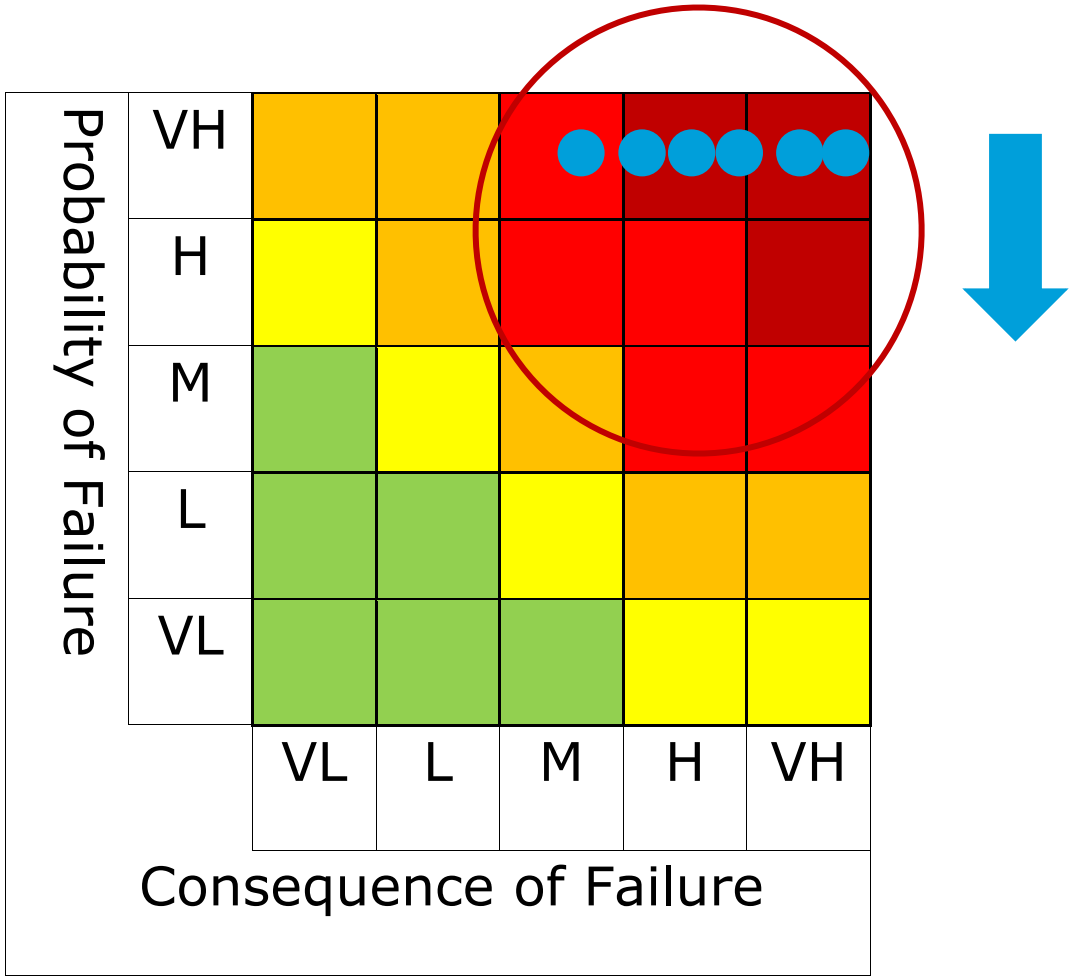
Risk reducing effect of mitigation, examples

Mitigation	Material	Coating	Water wetting	Design	Comment
GVI			Limited effect		
CVI external cladding			Short term effect		
CVI under insulation		Good effect	Good effect	Good effect	
Refurbishment of coating		Very good effect	Good effect	Very good effect	Assumed controlled conditions and QA
Coating local repair		Short term effect			Often reduced quality
Repair of insulation damage			Good local effect		Assumed that dry condition is confirmed and assured
NDT-RT				Short term effect	
Permanent removal of insulation	Very good effect	Very good effect	Very good effect	Very good effect	

Update of risk based on mitigation

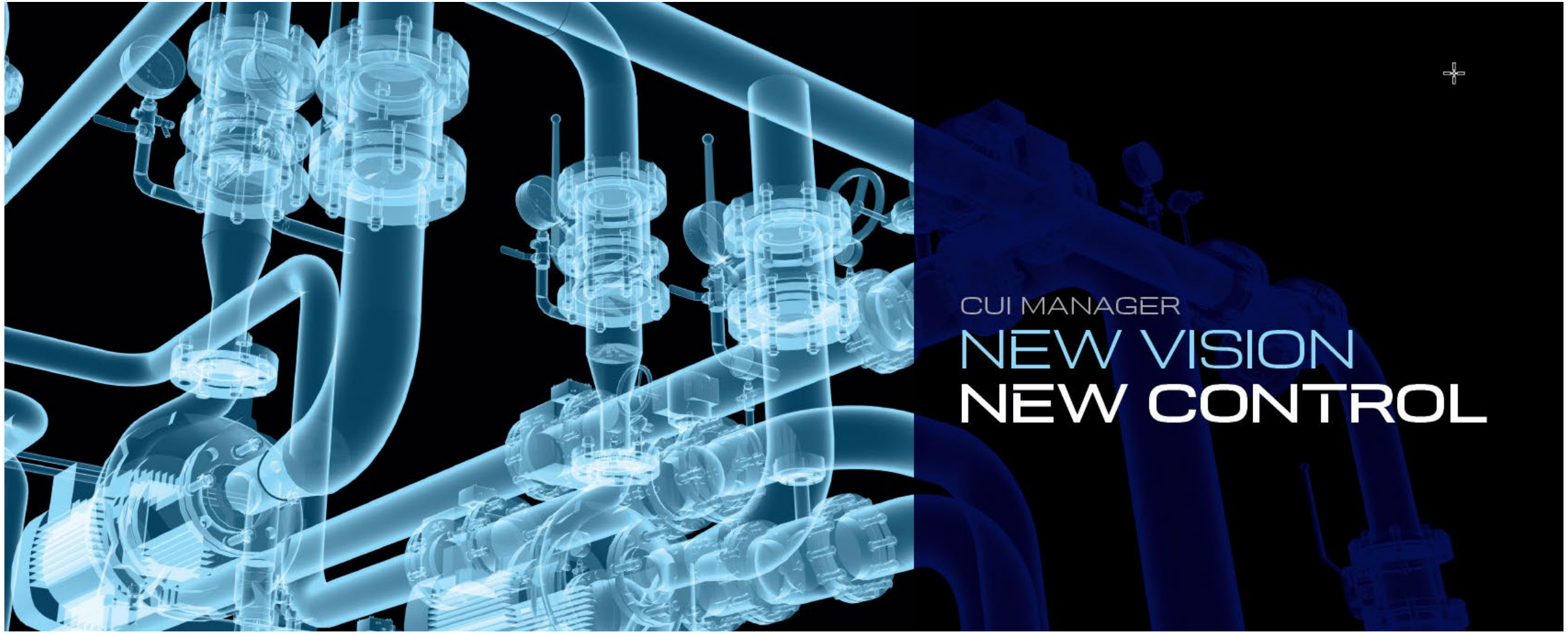
Examples of mitigation:

- Permanent removal of insulation
- CVI after removal of insulation, reinstall insulation afterwards
- RT-NDT of 50% hot spots
- General visual inspection
- Coating repair, spot
- Coating repair, full refurbishment



Implementation – Digital tool

CUI Manager



A systematic approach

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RECOMMENDED PRACTICE

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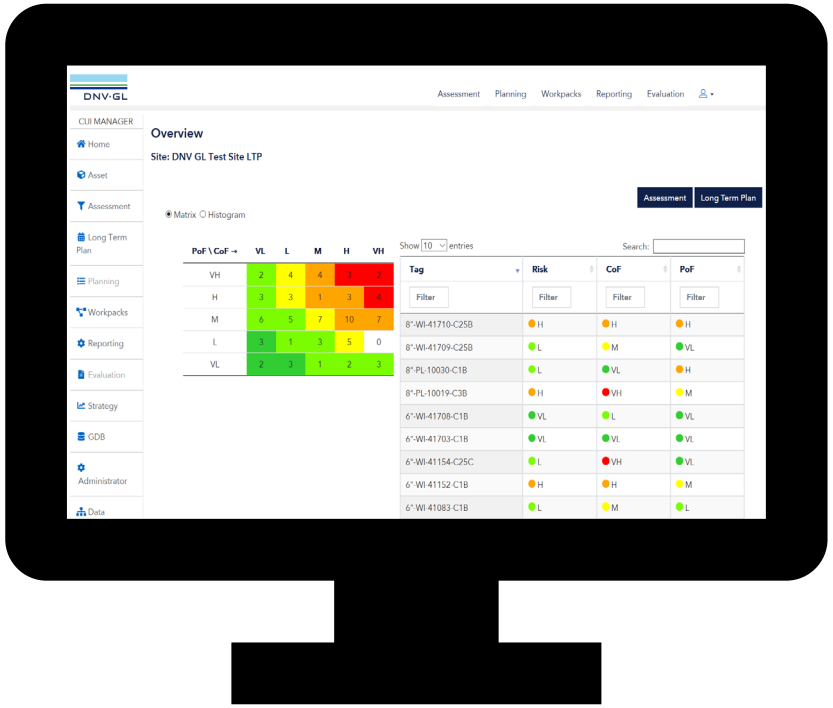

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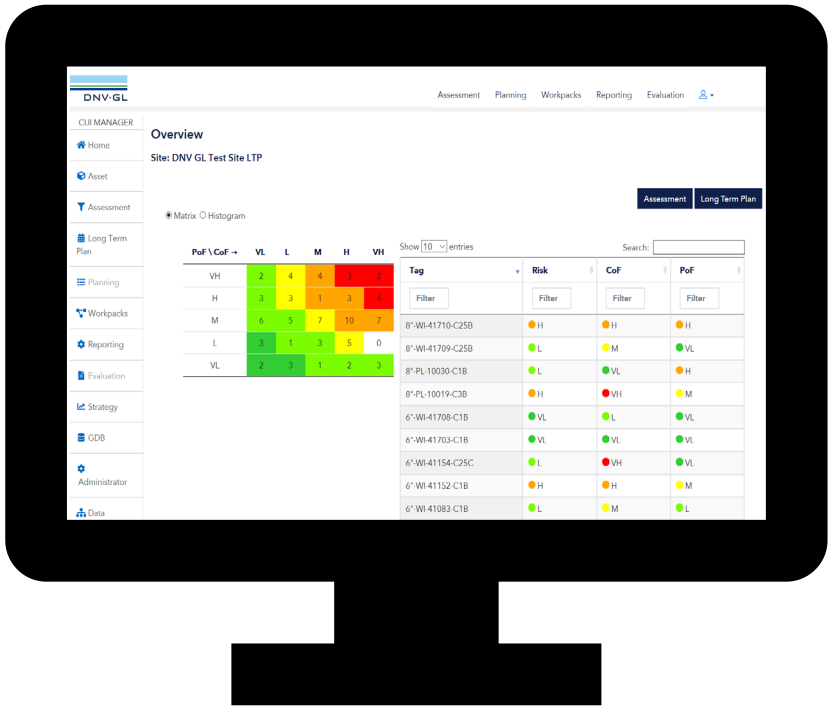
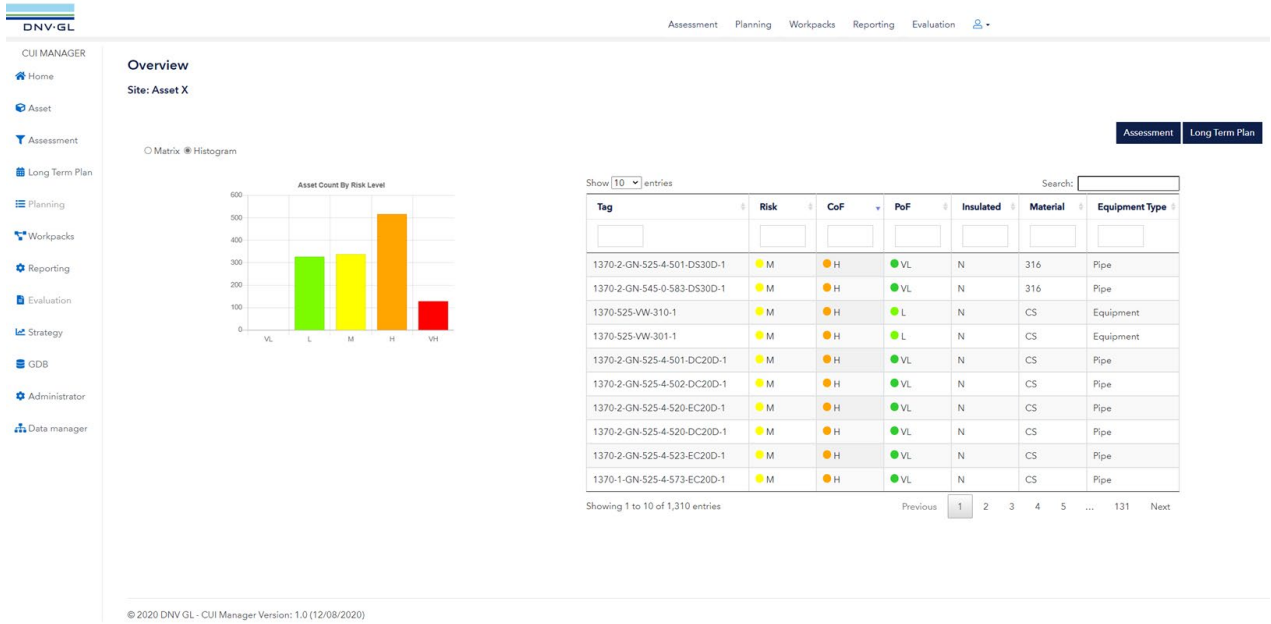
A systematic approach – with many features

VERACITY
by DNV GL



CUI Manager functionalities

- Implements the **methodology** and CUI experiences data from **the Recommended Practice**



CUI Manager functionalities

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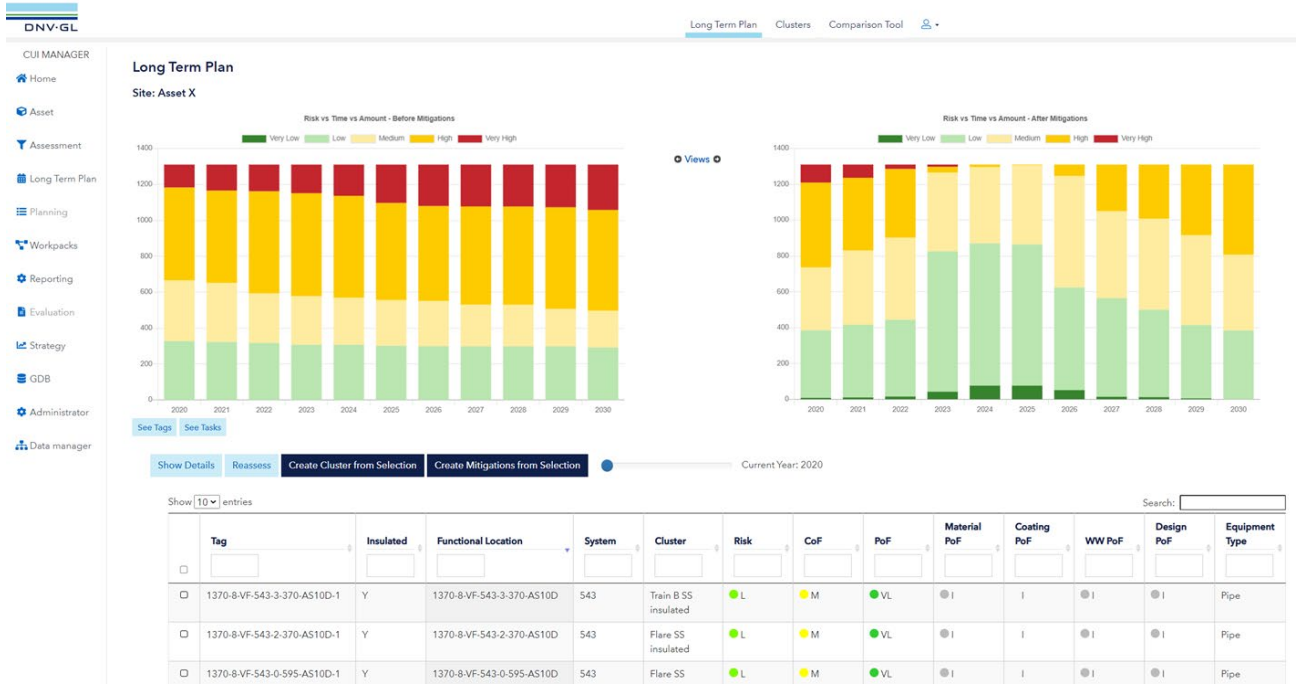
- Facilitates structured continuous assessment and documentation of present and **future** CUI risk



CUI Manager functionalities

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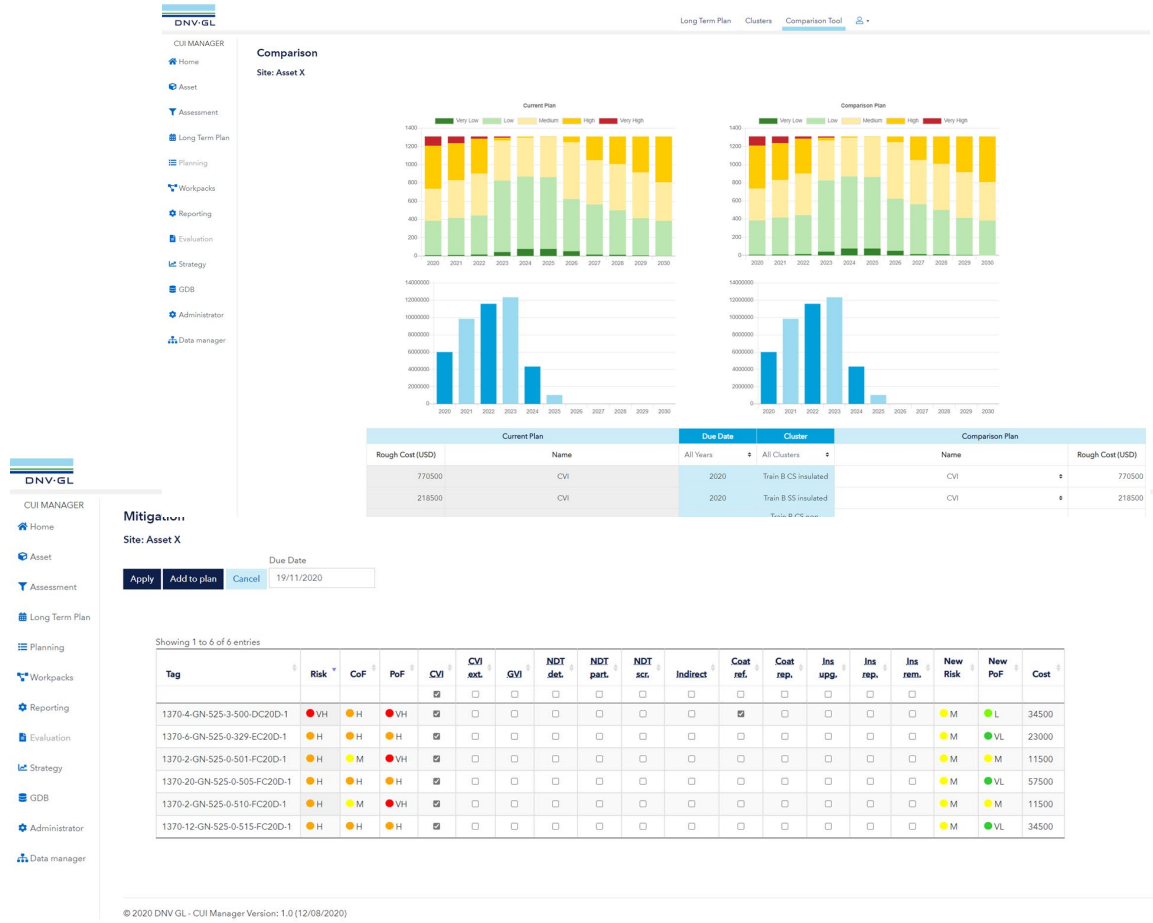
- Facilitates prioritisation of **most cost and risk efficient** mitigation



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- Facilitates prioritisation of **most cost and risk efficient** mitigation
- **Integrate** with existing ERP systems and enables machine learning

CUI Manager functionalities

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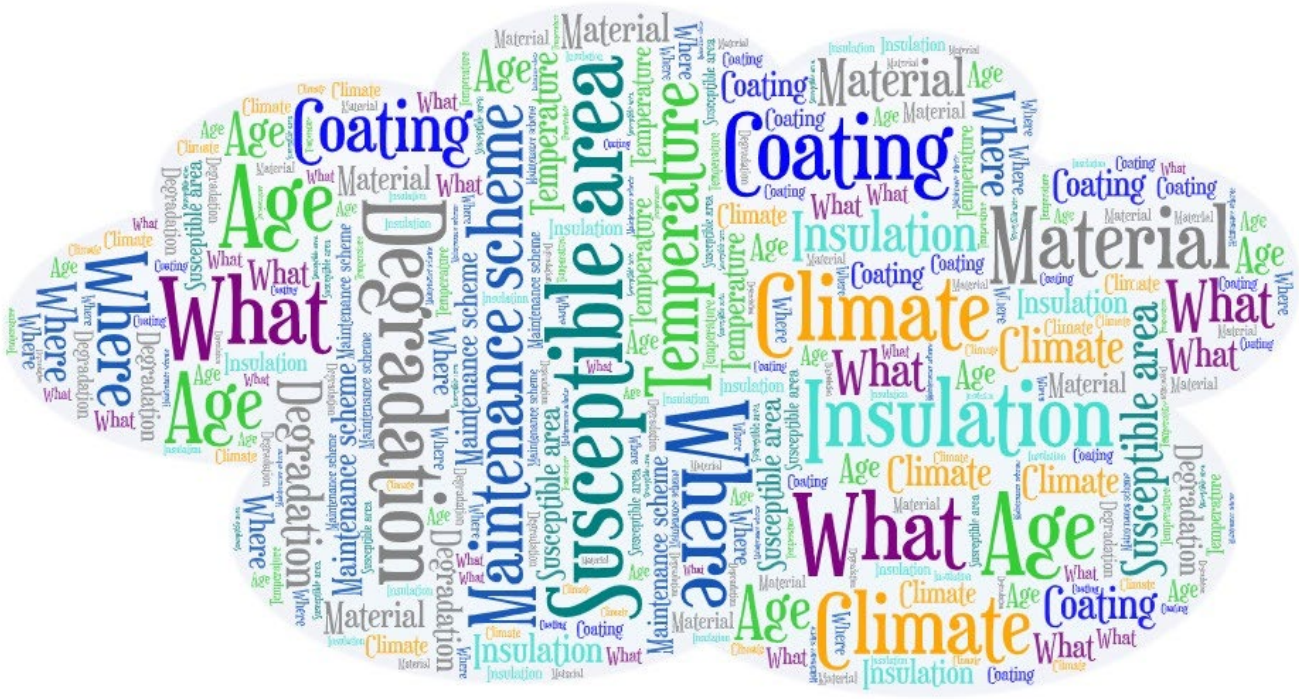
- Facilitates prioritisation of **most cost and risk efficient** mitigation
- **Integrate** with existing ERP systems and enables machine learning
- Build a global data base for shared **experience transfer** and improvements



Experience transfer

CUI is a common challenge across geographies and industries

Information sharing and learning across companies and industries are poor

The CUI Manager will build a global shared database to enable learning across industries

DNV GL will issue annual CUI learning reports to CUI manager users

Increase safety and reduce cost

Allows easy implementation of industry experience and methodology

Facilitates assessment and documentation of present and future CUI risk

Enables comparison of mitigation cost with risk mitigation effect

Developes CUI knowledge and gives insights for improved CUI management

Increase safety and reduce cost

Q&A

Thank You!

For more information visit dnvgl.com/CUI or please contact us.

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