

LÆRING FRA KORROSJON UNDER ISOLASJON (KUI) BASERT PÅ TILSYN OG  
GRANSKNINGER

# Learning from corrosion under insulation (CUI) based on audits and investigations

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#### Objective:

To identify how observations from audits and investigations towards CUI can be presented and distributed to have the greatest effect on learning in the industry, from an individual, organizational and industry perspective. A common approach and cross industry learning may reduce the risk of accidents.

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## 1 EXECUTIVE SUMMARY

DNV has on behalf of the Norwegian Petroleum Safety Authority (PSA) conducted a project to identify how observations from audits and investigations towards Corrosion Under Insulation (CUI) can be presented and distributed to have the greatest effect on learning in the industry, from an individual, organizational and industry perspective. To identify and evaluate the areas for learning or permanent improvement, DNV have attempted to identify the existing arenas for communication and learning, as well as any gaps in “who needs to learn” and “who PSA reach with existing communication”. The work has been performed through a four steps approach where observations in audit and investigation reports, the different target groups, existing and future communication platforms, and theory for learning has been used.

In the categorization of PSA audits and investigation findings it was identified mostly organizational findings, with three (3) technical findings and 18 organizational findings. None of the findings related to CUI could be categorized as human findings.

For the target groups, it was identified seven (7) organizational levels consisting of: projects and design, operational personnel, operational management, expert support, operations management, top management, and external premises. All communication platforms used by PSA were identified and linked to the relevant target groups. For some of the target groups there was identified some communication platform gaps, which led to interviews with industry representatives in the relevant target groups to clarify assumptions and gather input on possible improvements in communication from PSA.

It was observed that not all target groups are well covered by communication platforms. The target groups for “operational personnel” and “operational management” working offshore shifts have few communication platforms towards the PSA, although a substantial number of observations in audit and investigation reports are relevant for them. These groups receive very little information from the PSA and have very few arenas where they can meet others in similar roles and learn.

Measures to improve communication towards these target groups could be to develop a tailored e-mail service where information from the PSA would be distributed based on defined guide words, such as CUI; stronger participation by the PSA on conferences such as and Overflatekonferansen and the Non-Destructive Testing (NDT) Associations yearly conferences; that the PSA request the point of contact from the companies to forward CUI relevant information to certain roles; and, to improve descriptions of observations in audit and investigation reports to better highlight the CUI specific problems and their key causes.

To ensure learning and improvement towards CUI it is important to have in place technology, processes and people. Learning activities for technology, processes and people have been described and linked to the theoretical frameworks for the different target groups by sorting the seven organizational levels into individuals, organizational and external level. Learning processes and recommendations is described for each level.

## 2 BACKGROUND AND OBJECTIVE

The scope of work as described by PSA:

English	Norwegian
<p><b>Background</b></p> <p>The Petroleum Safety Authority works consciously to continuously improve our risk-based follow-up of activities, where follow-up of corrosion under insulation (CUI) in the design and operation of offshore installations and onshore facilities is a priority topic, as KUI is a serious contributor to major accident risk. The PSA has previously investigated leaks from pipes associated with CUI, such as a steam leak in 2012, a hydrogen leak in 2016, and naphtha leaks in 2017 and 2020, as well as cracks in a gas cooler in 2021. The PSA completed projects on CUI in 2021 for ordinary steel and 2022 for corrosion resistant alloys. One study shows that the PSA's investigations have the greatest effect on companies' work on safety and the working environment for the company that has been investigated. Another study has shown that considerable effort is put into failure reporting on different codes for corrective maintenance, but since limited concrete examples have been presented of how this amount of failure codes and history are used, there is reason to question whether the industry extracts value and knowledge from these efforts in order to reduce the major accident risk. On some equipment with a limited number of failure modes, it is relatively easy to follow up with analysis and improvement compared to equipment that is more complex with a larger number of failure modes. CUI can be an example of few failure modes and will be the focus of this assignment. In a report from the Safety Forum, thematic analyses are highlighted as a relevant method where several incidents are analysed and where similarities and differences are examined, thus trying to extract learning across multiple events within a specific area. In this case, CUI can be implemented at several levels, both locally on a facility, at company level and across the companies in the petroleum industry.</p> <p><b>Objective</b></p> <p>Identify ways in which observations from investigations and audits concerning CUI can be designed and disseminated to have the greatest impact on learning in the industry, with an individual, organization, and industry perspective.</p> <p>A common approach and learning across the industry can reduce the risk of accidents.</p>	<p><b>Bakgrunn</b></p> <p>Petroleumstilsynet jobber bevisst med kontinuerlig forbedring av vår risikobasert oppfølging av aktiviteter, der oppfølging av korrosjon under isolasjon (KUI) i prosjektering og drift av offshore installasjoner og landanlegg er et prioritert tema, da KUI er en alvorlig bidragsyter til storulykkerisiko. Ptil har tidligere gransket lekkasjer fra rør forbundet med KUI, som damp lekkasje i 2012, hydrogenlekkasje i 2016, og naftalekkasje i 2017 og 2020, samt sprekker i en gasskjøler i 2021. Ptil fikk gjennomført prosjekter på KUI i 2021 for alminnelig stål og 2022 for rustbestandige materialer.</p> <p>En studie viser at Ptils granskninger har størst effekt på selskapers arbeid med sikkerhet og arbeidsmiljø for selskapet som blir gransket. En annen studie har vist at det legges ned en betydelig innsats i feilrapportering på ulike koder på korrigerende vedlikehold, men ettersom det har blitt presentert begrenset med konkrete eksempler på hvordan hele denne mengden av feilkoder og historikk blir brukt er det grunn til å stille spørsmål om bransjen tar ut verdi og kunnskap av denne innsatsen til å redusere storulykkerisiko. På noe utstyr med et begrenset antall sviktmodi er det relativt sett enklere å følge opp med analyse og forbedring sammenlignet med utstyr som er mer kompleks med et større antall sviktmodi. KUI kan utgjøre eksempel på få sviktmodi og vil være fokus i dette oppdraget.</p> <p>I en rapport fra Sikkerhetsforum trekkes tematiske analyser fram som en relevant metode der en analyser flere hendelser der en ser på likheter og forskjeller, og på den måten prøver å trekke ut læring på tvers av flere hendelser innenfor et spesifikt område. I dette tilfellet KUI og kan gjennomføres på flere nivåer, både lokalt på en innretning, på selskapsnivå og på tvers mellom selskapene i petroleumsindustrien.</p> <p><b>Formål</b></p> <p>Identifisere måter som observasjoner fra granskninger og tilsyn som omhandler KUI kan utformes og formidles for å ha størst effekt på læring i næringen, med et individ, organisasjon og bransje perspektiv.</p> <p>En felles tilnærming og læring på tvers kan gi redusert risiko for ulykker.</p>

### 3 INTRODUCTION

The PSA are responsible for ensuring that the actors in the petroleum industry maintain a high level of health, environment and safety. As part of this work, PSA has received earmarked funds from the government to strengthen and further develop the systems and practice to follow-up serious incidents in the petroleum industry.

To strengthen and further develop follow-up of serious incidents in the petroleum industry, DNV has on behalf of PSA conducted a project to identify how observations from audits and investigations towards CUI can be presented and distributed to have the greatest effect on learning in the industry, from an individual, organizational and industry perspective.

To identify and evaluate areas for learning and permanent improvement, it is important to identify the existing arenas PSA use to communicate observations from incident investigations and audits. It is also important to investigate any gaps in how observations are communicated, to identify potential for improvement in learning both internally in PSA and externally from PSA to the industry in general.

To ensure learning and improvements for the relevant target groups in the industry it is not only important to ensure the availability of the information, but also the success of communicating the relevant information to the correct target groups.

DNV has in this report identified target groups for CUI observations, available communication platforms towards these target groups, gaps in communication platforms, as well as input to approaches for permanent improvement within systems, technology, and organisations,

## 4 METHOD

To identify and evaluate the areas for learning and improvement, DNV have attempted to identify the arenas for communication and sharing learning points; as well as any gaps in “who needs to learn” and “who PSA reach with existing communication”. The problem has been investigated through a four steps approach where the different messages, the different target groups, existing and future communication platforms, and theory for learning has been used.

### 4.1 Step 1: Categorizing of observations in PSA audits and investigations

Initially, categories for sorting and analysing observations in audit and investigation reports were developed. The categories covered human, organizational, and technical factors and were discussed and agreed with the PSA before reviewing relevant reports. The technical categories were based on CUI causes described in DNV-RP-G109 «Risk based management of Corrosion Under Insulation», and the human and organizational categories were based on Performance Shaping Factors (PFSs) commonly used in the industry, such as the Energy Institute’s Guidance on Human Factors Safety Critical Task Analysis ref. /9/.

The organisational factors covered aspects such as design and work processes, procedures, team composition, work distribution, roles and responsibilities, information, culture, management, KPIs, frame conditions etc. The human factors covered aspects such as knowledge and skills for the individual workers, as well physical and psychosocial working environment, physical abilities, human machine interface, stress, workload, human machine interface etc.

In collaboration with PSA, eight (8) CUI relevant audits and incident investigation reports were selected based on CUI relevance. Observations in these reports were then sorted according to the above mentioned pre-defined categories for human, organizational and technical factors. One observation could have several categories, sub-categories, and target groups.

### 4.2 Step 2: Target groups

Based on the breakdown of findings in different categories, as described in step one, a list of target groups and potential future target groups were identified. The list was presented to PSA in a workshop held in Stavanger the 27<sup>th</sup> of June 2023, and updated based on comments given in the workshop.

### 4.3 Step 3: Communication platforms

The third step was to identify all communication platforms used by PSA. Since the focus of this report is CUI, the platforms identified were all related to CUI or general communication platforms also expected to capture CUI relevant information.

#### 4.3.1 Workshop with PSA

DNV did a desktop review of communication platforms and presented the results to PSA in a workshop the 27<sup>th</sup> of June 2023. The list was both reviewed and supplemented by PSA. When the list was completed the different target groups and communication platforms were combined to reflect which communication platform that is expected to reach each target group.

#### 4.3.2 Interviews

Based on the findings in step one, two and three it was decided that more in-depth information was needed for some target groups. The target groups were selected based on the number of relevant findings in investigations and audits, as well as the lack of identified communication channels for these particular target groups. The selected target groups were from the operational level, with both operational personnel and operational management represented. There was one additional



interview planned based on feedback given in the first interviews, this interview was with a person representing expert support.

The interviews were conducted on Teams based on a predefined interview guide. The interview guide consisted of these 8 questions:

1. Can you describe your role?
2. What is your relationship with PSA, and the information they send out?
  - a. In general ?
  - b. Within CUI?
3. What is on the top of your list of risk?
4. What is your relationship with CUI?
  - a. How important is CUI in your role?
  - b. Who do you consider the owner of CUI?
5. What are the communication platforms you know of that PSA use to reach people in your role?
  - a. Does your organization have any internal methods for distributing information from PSA to all relevant parties?
6. In what way do you use the information you receive from PSA in your work?
  - a. Do you forward the information from PSA to other relevant parties?
  - b. Are there any other personnel on your installation/in your organization you should forward the information from PSA to?
7. Are there any summits, conferences, or other arenas for people in your role, where information about progress and learning within areas such as risks, maintenance and efficient operations can be shared?
8. How could PSA provide you with better information? Directly or within your organization?

Each interview lasted approximately 30 minutes. The informants have all been anonymized for both identity and company, and only their position is given in the report.

## 4.4 Step 4: Learning theory

To be able to identify learning and improvements from PSA audits and investigations for different target groups it is important to understand some basic theory towards learning both on an individual level but also on an organisation level. This step describes relevant theory, and how this theory is relevant for the PSA.

DNV has previously supported PSA with several studies related to incidents, learning, maintenance, and CUI:

- PSA- Corrosion under isolation for corrosion resistant alloys, 2022, ref. /7/
- Ptils granskning av alvorlige hendelser- evaluering av effekt, 2022, ref. /8/
- PSA- The effect of maintenance, 2022, ref. /6/

- PSA - Maintenance management - corrosion under insulation (CUI), 2021, ref. /3/

## 5 RESULTS

### 5.1 Categorizing of PSA audit and investigation findings

A systematic review of the selected incident investigation and audit reports resulted in 19 deviations and recommendations relevant for CUI, hereafter called findings. Most of the findings were organisational, with three (3) technical findings and 18 organizational findings. Two (2) of the findings were combinations of technical and organizational issues, and these are therefore categorized as both technical and organizational. None of the findings related to CUI could be categorized as human findings.

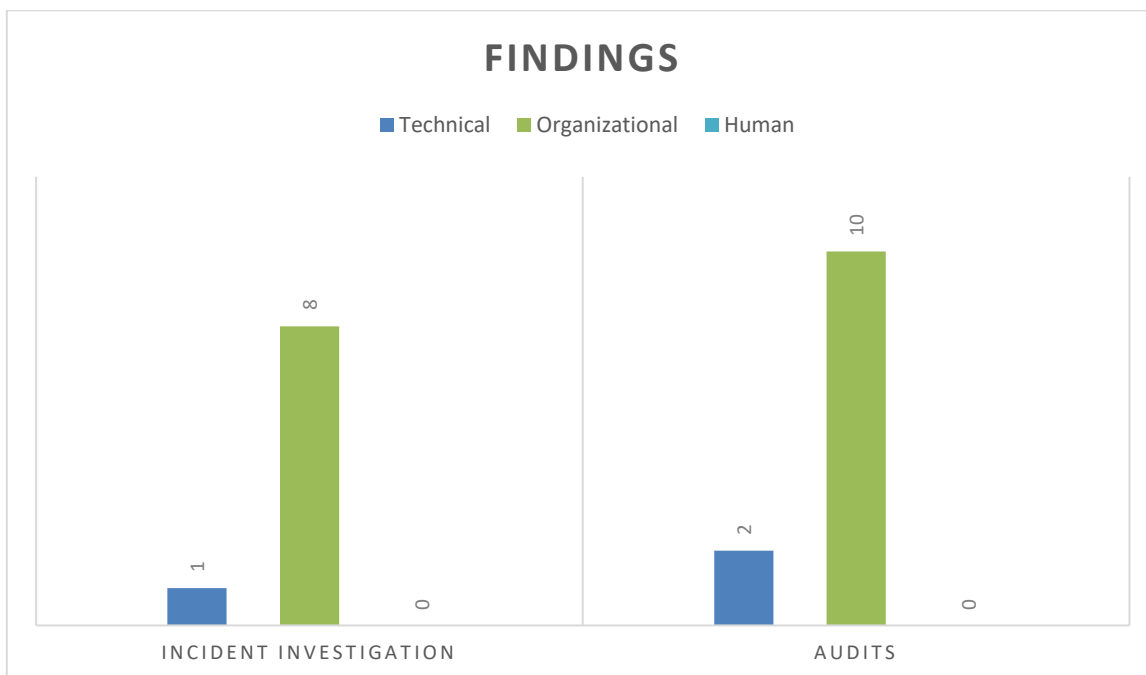


Figure 5-1: Distribution of findings between human, organization, and technology

### 5.2 Target group

The technical findings were then analysed based on the sub-categories developed from CUI causes described in DNV-RP-G109 «Risk based management of Corrosion Under Insulation», and the organizational findings based on PFS indexes. Through the analysis, target groups for each finding were defined. As shown in Figure 5-2, each target group links to different organizational levels, as well as projects and external premises. Most of the findings had several target groups and were also relevant for several organizational levels within the company.

Projects/design	Design	Fabrication	Installation			
Operational personnel	Maintenance personnel	ISO maint. personnel	Union	Inspection	Operator	CCR (surveillance)
Operational management	Maintenance manager	Operations manager	Platform manager	Site manager		
Expert support	Maintenance and inspection planner	Related disciplines isolation/CUI: material, process, TS, WE, ISO			Technical integrity	Experts in ISO companies
Operations management	Owner maintenance philosophy and strategy	Operations manager	Owner yearly plan for the installation	Owner maintenance program	Chief Engineer (owner governing doc CUI)	Contract responsible
Top management	Owner KPIs	Budget responsible	Owner installation lifespan	Learning responsible	Owner work-processes and quality	
External premises	PSA	Standardization body	National and international governments		NOROG/IOGP	Research/universities

**Figure 5-2: Target groups organized based on organizational level.**

*Projects or design* is the groups involved in engineering of the original design i.e., design, fabrication, and installation. This category also includes re-design, changes and upgrades performed in modifications and repair projects.

*Operational personnel* are the groups performing the work at the installation/plant during operation and maintenance. This includes day to day routine checks, operation of plant, and maintenance/inspection. Operational personnel are involved in both planned and unplanned maintenance and inspection.

*Operational management* is the group managing the installation/plant and will be the group responsible for the day-to-day operational decisions and prioritization. Operational management is responsible of managing the daily operation and maintenance tasks/operations.

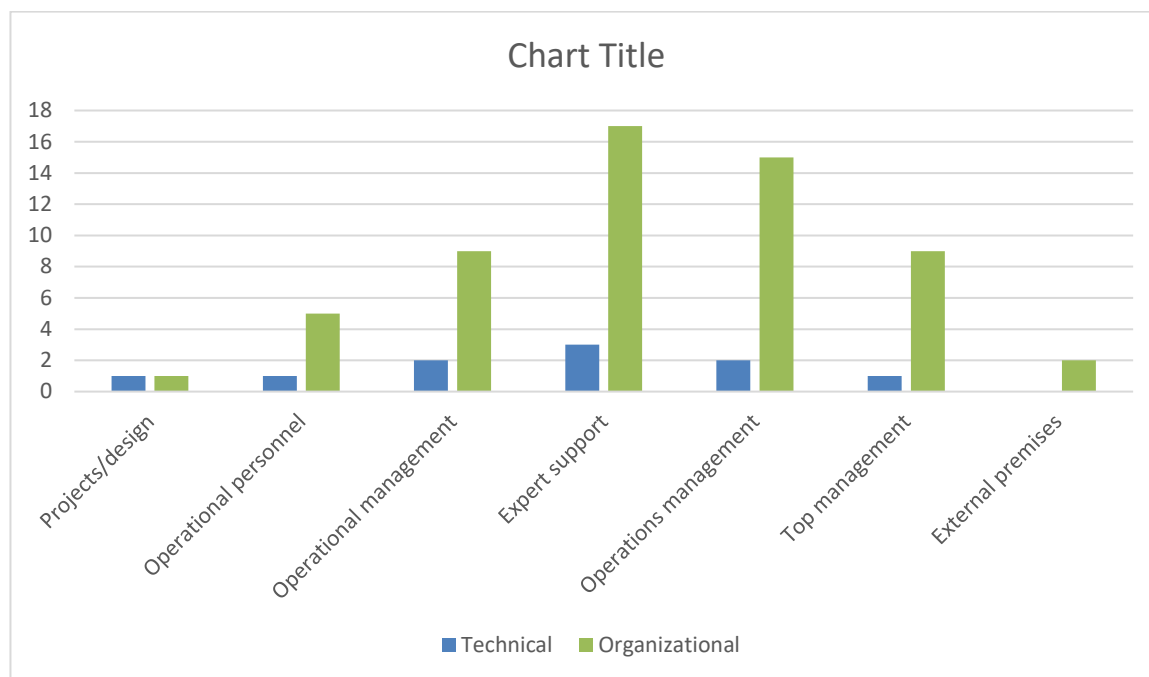
*Expert support* includes groups supporting the operation with expert discipline competence (e.g., process, material, surface protection, mechanical), expert maintenance and integrity competence and over-all integrity management responsibilities.

*Operations management* is the group representing the management responsible for the overall operation and maintenance priorities and decisions made for the asset. Operations management will typically include the maintenance program owner, operation plan owner, owner of operation and maintenance philosophies and strategies, owner of technical requirements, etc.

*Top management* is the group responsible for setting and defining the governing and financial framework for operation and maintenance of the assets. This can include Key Performance Indicators (KPIs) for e.g., finance, production, HSE, maintenance, etc., annual and long-term budget, lifespan plan, plan for learning and work processes.

*External premises* is the group that includes everyone involved in creating and updating external premises as e.g., rules, regulations, and standards, as well as subject development at a research level for CUI.

Figure 5-3: Distribution of findings between categories of target groups illustrates findings sorted on the different target groups. It shows that the main target groups for observations in the selected audits and investigations for CUI are local management and the onshore Operations Management, as well as Expert Support.



**Figure 5-3: Distribution of findings between categories of target groups**

DNV has not evaluated the quality of the investigation and audit observations (whether they have identified the correct problems and underlying causes) and has therefore not evaluated if the observations have been placed at the correct level in the organization. The categories presented in Figure 5-3 are therefore only a representation of the distribution of findings as given in the reports.

### 5.3 Communication platforms

First, all the communication platforms used by PSA were connected to the different target groups identified in step two. An overview of current communication platforms used by the PSA and the target groups most likely to be reached by these platforms are given in Figure 5-4.

Projects/design	Ptll.no	Subject seminars	External conferences	Social media															
Operational personnel					Audits and investigations	Safety forum*													
Operational management					Audits and investigations	Status meeting installations onshore	Ptll.no												
Expert support	Ptll.no	Subject seminars	External conferences	Social media	CUI forum NO	CUI forum UK & NO	Dialog	RNNP	Studies										
Operations management	Ptll.no	Subject seminars	External conferences	CUI forum NO	CUI forum UK & NO	RNNP	Studies topics/subjects	Audits and investigations	Status meeting										
Top management	Ptll.no	Dialog	Safety forum	Social media	RNNP	Audits and investigations	Status meeting												
External premises		Subject seminars	External conferences	CUI forum NO	CUI forum UK & NO	Audits and investigations	Studies	Status meetings international authorities											

**Figure 5-4: Communication platforms for each target group.**

The Figure 5-4 shows that some groups are reached by many communication platforms. The “Expert Support” roles and “Operations Management” seem to have more of PSA’s communication platforms and meeting places that reach them, such as conferences, seminars, and studies.

For the “Top Management” there are less targeted meeting places where PSA will meet personnel, but it is assumed that there is a higher level of expectations and culture for them to actively seek out information on the PSA website, subscribe to Dialog and follow PSA on social media. This may however vary between companies and individuals.

For the roles represented in “External Premises” there are several arenas where governing bodies nationally and internationally meet regularly and exchange information. Some of these communication platforms also include CUI expert support roles and operational management.

Figure 5-4 and Figure 5-3 also indicate that the target groups of “Operational Personnel” and “Operational Management” both have a substantial number of observations relevant for them, and at the same time very few communication platforms towards the PSA. For “Operational Personnel” it seems that only roles such as the Safety Delegate and Unions are involved in Safety Forum, and only personnel directly involved in audits and investigation will be informed about the results in the audit and investigation reports.

To further investigate this finding, it was decided to interview a few representatives from the industry for the purpose of:

1. verifying the assumption that “Operational Personnel” and “Operational Management” are reached by few communication platforms from the PSA, and
2. further explore how communication from PSA towards these target groups could be improved.

Four (4) interviews were conducted and covered the following roles: Operations and Maintenance Manager, CUI inspector, Offshore Installation Manager (OIM) and Maintenance and Inspection Planner. The Inspection Planner (representing the “Expert Support” target group) was added to the interviews because the other interviews pointed to this role as key carrier of CUI knowledge, and one of the roles that was believed to receive most of the CUI relevant information from the PSA.

The interviews confirmed that the “Operational Personnel” and the “Operational Management” working offshore shifts receive very little information from the PSA and have very few arenas where they can meet others in the same roles and learn from each other. This included both information sent directly from the PSA and indirectly internally in the companies. Further, the interviews provided an impression that these roles were depending on the “Expert Support” roles to “do the learning for them”, by reflecting the learning points from PSA in the risk-based inspection analysis, and in the long-term maintenance and inspection plans, as well as by updating the companies’ procedures.

In the interviews some improvement suggestions for communication platforms towards “Operational Personnel” and the “Operational Management” were given:

- Having a tailored e-mail service where information from the PSA would be distributed based on defined guide words. This would ensure that CUI relevant information would reach those specifically interested in CUI, and avoid relevant information being hidden and missed among other information.
- Stronger participation by the PSA on conferences such as Overflatekonferansen and the Non-Destructive Testing (NDT) Associations yearly conferences. These are important arenas for roles in different companies working with testing and inspection and maintenance of surface protection and insulation.

- The PSA could in their letters and communication with the companies' authority point of contact (myndighetskontakt) specifically ask the companies to forward CUI relevant information to certain roles in the companies.
- The PSA could investigate improving descriptions of observations in audit and investigation reports to better highlight the CUI specific problems and their key causes. It was commented that CUI relevant observations were a bit hidden in the descriptions given in the reports which made it difficult for "Operational Personnel" and "Operational Management" to identify observations of CUI relevance.

## 5.4 Learning theory and implications for CUI management

Learning is defined as a process to increase competence. Competence is defined as knowledge, skills and behaviour/attitude. Learning can be a process on both an individual and/or organizational level.

On an individual level, we often talk about formal and informal competency. Formal competency is the competency individuals can get by education in schools and universities or by taking courses. The informal competency is the competence individuals receive through life, interaction with others and experience.

Individuals have different "preferred learning style". Tactical people increase competence best if they learn by touch, feel, and have practical experience. Tactical learners are predominant to choose vocational education and many work within relevant discipline offshore/onshore. Visual and auditory learners may choose a more academic education.

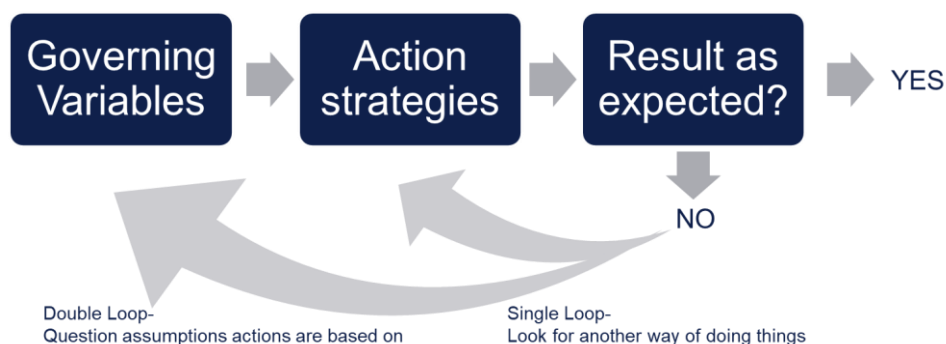
Our preferred learning style will, among other factors, set the premises for transfer of competence from PSA. Audit reports and incident investigations are presented on written form which favour the "visual" target groups and disfavour "Operational personnel".

Independent of learning style to construct your own competence is the best learning strategy on an individual level. Participate in accident investigations is one of the best ways of achieving competence. Tabletops/scenario training/dilemma training are other construction ways of creating, retaining, and transferring competence.

For learning, there are many different theorists related to CUI. Argyris (ref.:/1/) explained that we have mental maps with regards to how to act in a situation. The mental maps are controlled by our governing variables, which are the boundaries and guidelines that we operate by. They are influenced by environmental, cultural and our own internal values. There might be a mismatch between the things that we do (theory in use), and what we intend to do (espoused theory of use).

Argyris and Schön (ref.:/1/) defined the Single Loop Learning, see Figure 5-5: Single and Double Loop Learning Figure 5-5. If something goes wrong, it is in our nature to look for another strategy that will address and work within the governing variables.

Double Loop Learning, question and change the governing variables through identifying the ways in which they contribute to problems. This closes the gap between espoused theory of use and theory in use (outcome and intention). This perspective can also be seen in light of Lev Vygotsky's theory, as he believed strongly that language plays a central role in the process of "making meaning" and shaping thoughts.



**Figure 5-5: Single and Double Loop Learning**

Arygris explains that organisations that are good at learning are those that encourage open questioning and exploration. Deutero learning or Trippel Loop Learning is also a term used; meaning the ability to learn how to learn.

From the DNV study, ref. /3/ all operators had a strategy to manage CUI with a risk-based approach. Normally CUI occurs after some years of operation. By this time a lot of both organisational memory and documentation may be lost e.g., the premises for the existing CUI strategy is not clear, the premises for the design of the pipelines are not documented and historical data of recorded parameters may be lost.

CUI is a conflicting goal between “*biggest threat to the mechanical integrity of oil and gas industry facilities*” as mentioned in ref.:/3/ and the budget set for inspection and maintenance. If a company has control of CUI for many years this will strengthen the belief in “theory in use”. Since CUI results are as expected, inspection budgets will not be increased and perhaps vital parameters for CUI no longer will be monitored. If then suddenly there is an incident related to CUI, it is difficult for organisation to understand that the situation has changed, and that results are not as expected just based on “outliners” from inspection spot-checks. To change the situation awareness requires strong evidence of the need to change in a consistent way. To both understand the need for and to change situation awareness based on “early warnings” is difficult, as was revealed in the investigations of the Helge Ingstad collision.

In the companies’ evaluation of probability of CUI, there exists large differences in complexity and number of parameters used in the assessments. In preparation for the DNV report Ptil - Maintenance management - corrosion under insulation (CUI) ref. /3/ the overview shown in Figure 5-6 was made, highlighting the different parameters used in the industry.

## Parameters used per company

	Company A	Company B	Company C	Company D	Company E	Company F
Type of material	Y	Y	Y	Y	Y	Y
Operational temperature	Y	Y	Y	Y	Y	Y
Temperature fluctuation	N	N	N	N	Y	N
Type of coating	Y	Y	Y	Y	Y	Y
Age of coating	N	Y	Y	Y	Y	N
Quality of coating	Y	N	Y	Y	N	N
Local environment, access to water	N	N	Y	Y	Y	N
Dew-point	N	N	Y	N	N	N
Insulation type	N	Y	Y	Y	Y	N
Cladding type	N	N	Y	Y	Y	Y
Cladding workmanship	N	N	Y	Y	N	Y
Wall thickness	Y	N	Y	Y	Y	N
Pipe dimensions	N	N	Y	Y	Y	N
Lay-out	N	N	Y	Y	Y	N
Inspection results	Y	Y	Y	Y	N	Y
Inspection extent	N	N	Y	Y	N	N
Heat tracing	N	N	Y	N	Y	Y
Material selection in nuts and bolts	Y	N	Y	Y	N	N
Other elements	N	N	N	Y	Y	N

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**Figure 5-6: CUI parameter overview**

This overview shows the complexity in assessing CUI and understanding the foundations of the results hence, organisational memory and prevailing culture can make it difficult to question the assumptions for the existing strategy. If the organisations do not have good premises for double loop learning, they may not make the necessary changes to their strategy in time. To make a revised CUI strategy both extensive inspection, historical data and experts are needed.

PSA could support this situation by challenging CUI strategies and the premises for the existing strategies used in the industry.

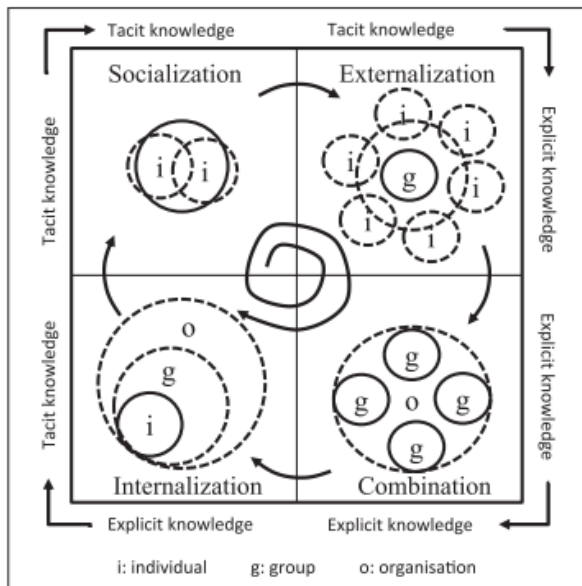
In organizational learning, ref.: /5/ knowledge management often refers to the following steps:

- create/build knowledge
- retain knowledge
- transfer knowledge

Nonaka & Konno, ref.: /2/ has focused on the spiral of knowledge created in an organisation from tacit to explicit knowledge; with the interaction between individuals, groups and organizations, see Figure 5-7. This model focus on how knowledge is transferred from tacit knowledge by individuals through groups and at the end ending up at explicit knowledge in the organisation. On an organizational level, formal competence will typically be stored/retained in responsibility hierarchies, management systems, standards, work processes and work instructions while the cultural aspects, “the-way – we -work here” will represent the informal organizational competence. For this spiral to function properly towards CUI individuals e.g., need to be well involved in daily processes for feeding back improvements, and in giving input to strategies and plans.

Transferring individual competence to explicit competence on an organisational level also requires a strong culture for structuring and celebrating continuous improvements. PSA could enhance this process by questioning how involvement and experience transfer is taken care of within CUI. As also described in the report “evaluation of effect of PSA investigation” ref. /8/ PSA can be even better in focusing on organisational aspects.





**Figure 5-7 Spiral of organizational knowledge creation (Nonaka & Konno, 1998)**

Garvin ref.: /5/, defines five building blocks that organizations need to master for effective organizational learning, see Table 5-1. These building blocks are related to “constructing” competence and focuses on different aspects of creating, retaining and transfer of knowledge.

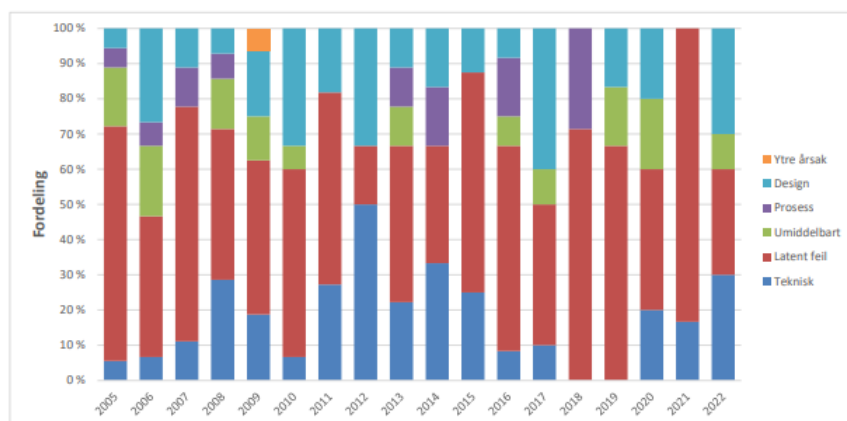
**Table 5-1: Building blocks for effective organizational learning**

Building blocks	Description	Knowledge process
Systematic problem solving	Decisions are based on scientific methods to diagnose problems. Accuracy and precision are critical.	Create and retain
Experimentation	Experimentation with new approaches includes the systematic search for and systematic testing of new knowledge. This activity comprises both time (e.g., demonstration projects) and continuous (e.g., research and development) experiments	Create and retain
Learning from experience	Learning from individual experience and history requires constant reflection upon successes and failures to provide implications applicable to all individuals. Learning should result from careful planning (e.g., post-mortem evaluations) rather than chance.	Create, retain and transfer
Learning from others	Learning from the experiences and best practices of others comprises benchmarking with clients or other external organizations to develop new ideas. Managers need to be open to criticism and new ideas	Create, retain and transfer
Transferring knowledge	Transferring knowledge quickly and efficiently throughout the organization through written or oral reports, personnel rotations, or training.	Transfer

If competency is only created and retained on an individual level without being transferred and retained on an organizational level, there is a risk of drainage since the competency is dependent on individuals. If key individuals are lost, key competence is also lost. It is therefore important to ensure permanent “storage” for competence on an organizational level. *If we only talk about “learning” on the organisational level without describing the outcome as “improvement”, there is a risk of not retaining the competence; leaving nothing to transfer.*

The O&G industry in Norway and PSA is currently very focused on “learning” while the “improvements” initiatives have for some years not been that much in focus. If the PSA focus more on “improvements” initiatives for CUI in the audits and investigations the industry will benefit from this.

CUI is not mentioned specifically as a topic in Risikonivå i norsk petroleumsvirksomhet (RNNP) in the period of 2017-2022. RNNP 2022 shows the following historical picture when it comes to Hydrocarbon leaks, where corrosion is part of the category “teknisk” (technical degradation), see Figure 5-8. However, it is not known how significant part of the technical degradation category that is actually due to CUI.



**Figure 5-8: 2022 RNNP overview Hydrocarbon leaks**

From PSA’s annual reports, CUI was mentioned with a longer section in the 2017 report and with two minor sentences in the 2018 report. In the 2019 annual report, CUI was not mentioned. In 2020, only the Nafta leak at Slagentangen was mentioned as an ongoing investigation. In the annual report for 2021, the investigation of the incident with corrosion on the Troll C gas compressor coolers was mentioned. Further, hydrocarbon leaks were mentioned as a prioritised area, but CUI was not specifically mentioned. In the annual report for 2022, CUI was mentioned with a longer text and pointing back to the two investigations in 2020 and 2021.

Based on the limited focus on CUI in RNNP and annual reports from PSA, CUI may not be the highest risk on the agenda for the operators.

It is important that PSA takes an active role as competence retainer and transferer. Only PSA probably knows the “best in class” operator and those with a potential for improvement. Arranging experience sharing sessions where the weaker can learn from the better ones will be an important channel for creating, retaining, and transferring competence.

PSA is probably also the actor with best overview of how different companies’ follow-up and close findings from audits and investigations. Generic presentations on relevant “improvements” when it comes to CUI will also benefit the industry.

To prevent CUI depends on multiple factors and will vary for different operators depending on the design and age of the installation/plant. To ensure learning and improvement towards CUI it is important to have in place competence on technology, processes, and people.

- Technology represented by the pipe/equipment material, corrosion mechanisms, coating, insulation, PFP etc. Competence is very much stored in standards and engineering practices that constantly need to be improved.
- Work process is represented by the design process, construction, maintenance, inspection method, the CUI strategy and the PSA audit. Process elements can be stored in organisations, but it is recommended for PSA to play an important part in retaining and transferring of competence related to this.
- People are represented by the piping/statical mechanical engineer, the welder, the maintenance engineer, the technical authority for containment and the PSA audit team. Storing/improving elements will be to arrange for e.g., tabletops/dilemma training with individuals and groups in organisations.

Target groups as described in chapter 4.2 and potential learning activities to create, retain and transfer competence within Technology, Process and People are described in Table 5-2.

**Table 5-2: Target groups and learning activities**

Target group Who can learn:		Create, Retain and Transfer competence		
		Technology	Process	People
Individual	All	<ul style="list-style-type: none"> <li>Participate in accident investigations to creating, retaining, and transferring competence.</li> <li>Tabletops/scenario training/dilemma training can be ways of creating, retaining, and transferring competence.</li> </ul>		
Group	Projects/design	<ul style="list-style-type: none"> <li>Create awareness about insulation and coating for piping/nozzles ref. /3/</li> <li>Create awareness of differences in standard ref. /3/</li> </ul>	<ul style="list-style-type: none"> <li>Retain and transfer information from Field survey</li> <li>Input to parameters used in the assessments.</li> <li>Involved in evaluating strategy.</li> <li>Focusing on developing strategy for CUI based on double loop learning.</li> <li>Tailored e-mail service from PSA on CUI</li> </ul>	<ul style="list-style-type: none"> <li>Transfer knowledge about CUI; corrosion, coating, insulation, CUI strategies for deck penetration and HDG bolts in CRA systems ref. /3/</li> </ul>
	Operational personnel			
	Operational management			
	Expert support		<ul style="list-style-type: none"> <li>Use of digital twin to create, retain and transfer competence</li> </ul>	<ul style="list-style-type: none"> <li>Create a common ground for CUI management between maintenance and technical integrity.</li> </ul>
Organisation	Operations management	<ul style="list-style-type: none"> <li>Enhance improvement in standards to retain competence</li> <li>Be an advocate for standards as competence transfer</li> <li>Reduce conflicting goals</li> <li>Challenge the assumptions for the CUI strategies</li> </ul>		
	Top management			
Networks	External premises (among others PSA)	<ul style="list-style-type: none"> <li>Consolidate on parameters to create a common view. Retain and transfer competence on biggest uncertainties within CUI</li> </ul>	<ul style="list-style-type: none"> <li>PSA to arrange sharing sessions where the weaker organisations can learn from the better ones to creating, retaining and transfer competence.</li> <li>PSA to challenge organisations on assumptions for the CUI strategies.</li> <li>PSA to improve descriptions of observations in audit and investigation reports to better highlight the CUI specific problems and their key causes.</li> <li>PSA to share on a generic level improvements companies implements after findings on CUI</li> </ul>	

## 6 CONCLUSION

There are generally many target groups for CUI and many communication platforms available, however not all target groups are well covered by communication platforms. The target groups for “Operational Personnel” and “Operational Management” working offshore shifts have few communication platforms towards the PSA, although a substantial number of observations in audit and investigation reports are relevant for them. These groups receive very little information from the PSA and have very few arenas where they can meet others in the same roles to exchange experience and learn.

Measures to improve communication towards these target groups could be to develop a tailored e-mail service where information from the PSA would be distributed based on defined guide words, such as CUI; stronger participation by the PSA on conferences such as and Overflatekonferansen and the NDT Associations yearly conferences; that the PSA request the companies in letters and communication to forward CUI relevant information to certain roles; and, to improve descriptions of observations in audit and investigation reports to better highlight the CUI specific problems and their key causes.

To ensure learning and improvement towards CUI; there is a need to have in place technology, processes, and people. Learning activities for technology, processes and people have been described and linked to the theoretical frameworks for the different target groups, by sorting the seven organizational levels into individuals, organizational and external levels. Learning processes and recommendations are described for each level.

Transferring individual competence to explicit competence on an organisational level requires a strong culture for structuring and celebrating continuous improvements. This requires management involvement and prioritisation.

The O&G industry needs to ensure a double loop learning process and recognise when their CUI strategy is not working. PSA could support and encourage this by challenging CUI strategies as a systematic problem solving, experimentation setting, that may lack the element of experience transfer.

Based on the limited focus on CUI in RNNP and annual reports from PSA, CUI may not be the highest risk on the agenda for the operators. It is therefore important that PSA takes an active role as competence retainer and transferer. This could be done through experience sharing sessions where the weaker can learn from the better ones to facilitate creating, retaining and transfer of competence.

## 7 RECOMMENDATIONS FOR FUTURE WORK

During this project, there were several discussions and suggestions for future projects. Some were too comprehensive for the scope and time limitations of this project, and some were on the side of the project scope.

In this project, some assumptions were made about the target groups that are reached by social media. A social media test experiment was therefore discussed. In the end, it was concluded that a full test of the reach of the social media to the different target groups was too comprehensive to include in this project. It is however recommended to consider this as a future follow-on project.

Another suggestion was to analyse the reply-letters from the affected companies of audits or investigations. It was discussed to perform interviews with the companies responsible for handling the letters and analyse the findings and replies given. The reply-letters where the company explains how they will close-out the findings seem to vary in detail, quality and in what degree they address the issues presented in the findings. This activity was concluded to be out of scope for this project and should be considered for future work.

A third suggestion in the project was to extend the number of interviews with the different target groups to cover representative number of interview subjects within each group; to achieve more empirical valid results. It was concluded that this task will not be included in the scope of this report due to the extent of work required. It is however recommended to consider this as a potential future follow-on project.

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