2nd draft.

WORLD CLASS MAINTENANCE

# CUI Case Description.

## Corrosion under isolation

## Cost-effective proactive CUI Management; wish or truth?

**4 stages in the case description**

- Where was it located?
- What about the insulation?
- What after removal of the insulation?
- What about the integrity?
- What about overall asset condition?

# Key aspects of the WCM CUI Methodology:

- Developed by Industry partners for Industry
- Open for review of basic principles; no “black box”
- Based on cafeteria model: use the parts which will help you, don’t use what hinders your already present approach
- Developed by specialists from various disciplines; NDT, Coatings, Corrosion, Asset management
- Supported by discipline organizations: KINT(Inspection); ION(Surface protection); Chair of “Studiekern Corrosie”; also supported by VNCI.

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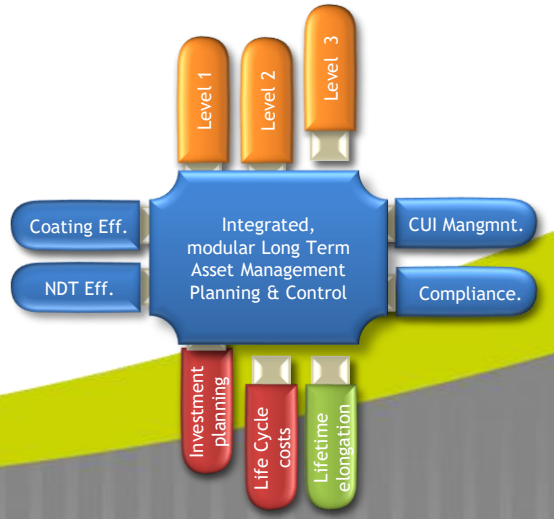
# Key aspects of the WCM CUI Methodology:

- Risk based, using EN 16991 RBI Framework
- Integrates Condition classification; CEN 17385
- Uses straightforward linear prediction of risk related to remaining time to (normative-)failure (TTF).
- Flexible to use user-specific criterion for TTF (like 50% WT; default 10% WT).
- Not sensitive for presence of all data. Will use worst-case assumption where appropriate.
- Not a (usually) huge book; focused onto application

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# The deliverables as per working groups:

The most important topics discussed in this working group:

- The appropriate method for assessing risks

- The assessment of the state of insulation

- The Corrosion behavior of Carbon steel and stainless steel in the case of CUI.

- The decision model to assess the risks present depending on the coating life and applied inspection method


- A presentation to let the usefulness, necessity and impact of a CUI management program land within the (your) organization (enclosed).


- The best practice that defines risk-based CUI management as a management program.

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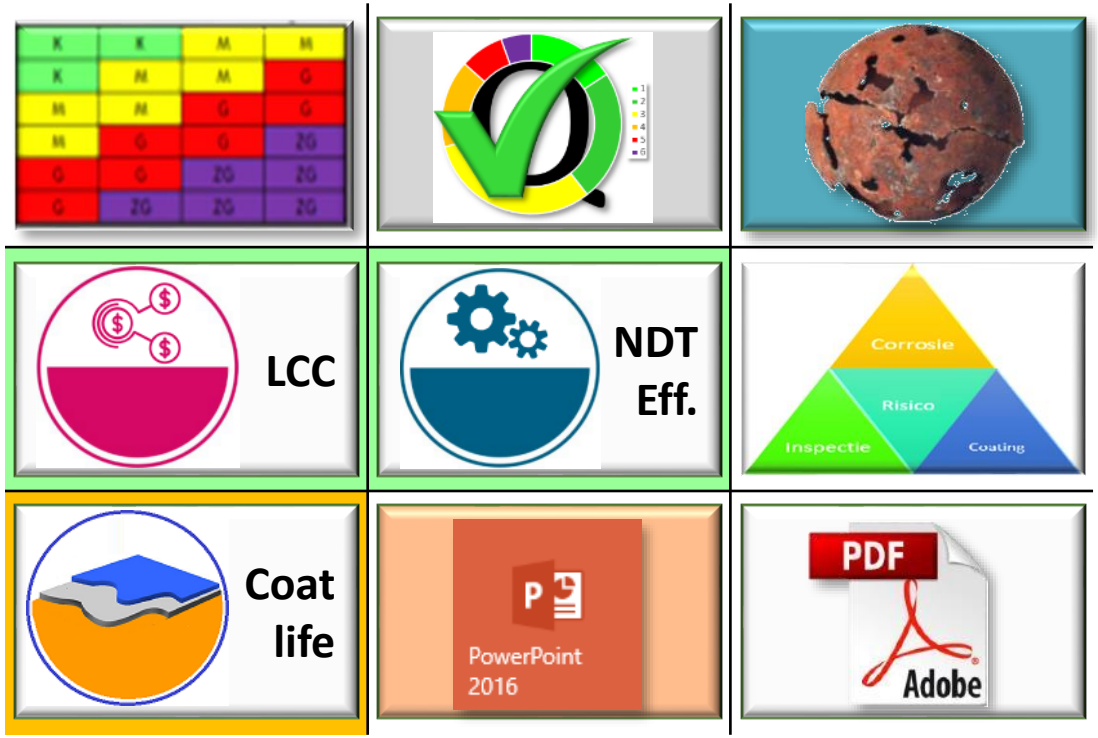
# Delivery by modules:

Click on the relevant module to go to the topic.

Green = Work group NDT Eff.

Beige = Work group Coatings.

Click on the plug-in model in order to return to this page.

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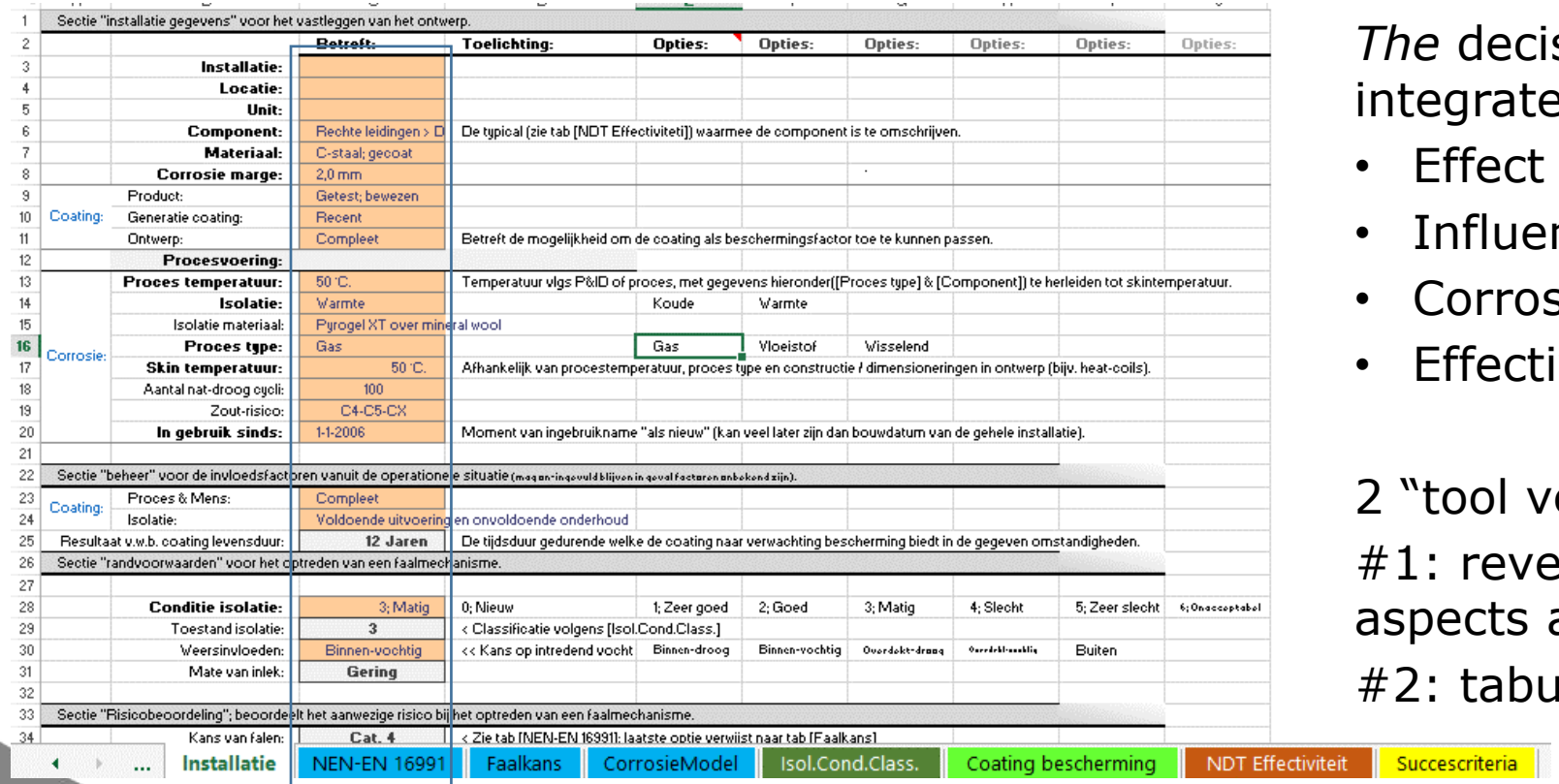
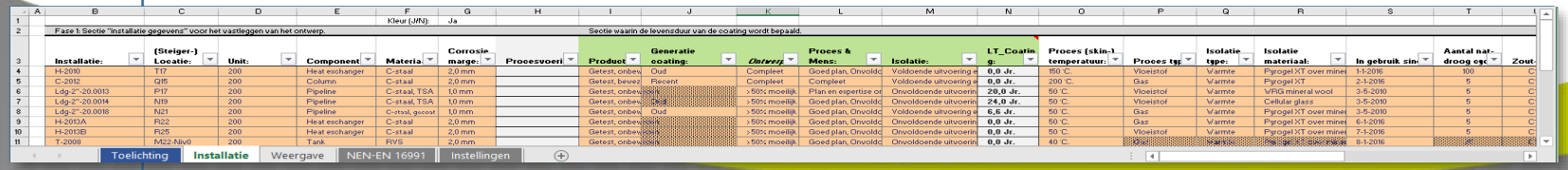
# CUI: Integration of influencing factors



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Sectie "installatie gegevens" voor het vastleggen van het ontwerp. | | | | | | | | |
| 2 | | | **Betreft:** | **Toelichting:** | **Opties:** | **Opties:** | **Opties:** | **Opties:** | **Opties:** | **Opties:** |
| 3 | | **Installatie:** | | | | | | | | |
| 4 | | **Locatie:** | | | | | | | | |
| 5 | | **Unit:** | | | | | | | | |
| 6 | | **Component:** | Rechte leidingen > D | De typical (zie tab [NDT Effectiviteti]) waarmee de component is te omschrijven. | | | | | |
| 7 | | **Materiaal:** | C-staal; gecoat | | | | | | |
| 8 | | **Corrosie marge:** | 2,0 mm | | | | | | |
| 9 | | Product: | Getest; bewezen | | | | | | |
| 10 | Coating: | Generatie coating: | Recent | | | | | | |
| 11 | | Ontwerp: | Compleet | Betreft de mogelijkheid om de coating als beschermingsfactor toe te kunnen passen. | | | | | |
| 12 | | **Procesvoering:** | | | | | | | |
| 13 | | **Proces temperatuur:** | 50 °C. | Temperatuur vlgs P&ID of proces, met gegevens hieronder([Proces type] & [Component]) te herleiden tot skintemperatuur. | | | | | |
| 14 | | **Isolatie:** | Warmte | | Koude | Warmte | | | |
| 15 | | Isolatie materiaal: | Pyrogel XT over mineral wool | | | | | | |
| 16 | Corrosie: | **Proces type:** | Gas | | Gas | Vloeistof | Wisselend | | |
| 17 | | **Skin temperatuur:** | 50 °C. | Afhankelijk van procestemperatuur, proces type en constructie / dimensioneringen in ontwerp (bijv. heat-coils). | | | | | |
| 18 | | Aantal nat-droog cycli: | 100 | | | | | | |
| 19 | | Zout-risico: | C4-C5-CX | | | | | | |
| 20 | | **In gebruik sinds:** | 1-1-2006 | Moment van ingebruikname "als nieuw" (kan veel later zijn dan bouwdatum van de gehele installatie). | | | | | |
| 21 | | | | | | | | | |
| 22 | Sectie "beheer" voor de invloedsfactoren vanuit de operationele situatie (mogen ingevuld blijven in geval factoren onbekend zijn). | | | | | | | | |
| 23 | Coating: | Proces & Mens: | Compleet | | | | | | |
| 24 | | Isolatie: | Voldoende uitvoering en onvoldoende onderhoud | | | | | | |
| 25 | | Resultaat v.w.b. coating levensduur: | **12 Jaren** | De tijdsduur gedurende welke de coating naar verwachting bescherming biedt in de gegeven omstandigheden. | | | | | |
| 26 | Sectie "randvoorwaarden" voor het optreden van een faalmechanisme. | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | **Conditie isolatie:** | 3; Matig | 0; Nieuw | 1; Zeer goed | 2; Goed | 3; Matig | 4; Slecht | 5; Zeer slecht | 6; Onacceptabel |
| 29 | | Toestand isolatie: | 3 | < Classificatie volgens [Isol.Cond.Class.] | | | | | | |
| 30 | | Weersinvloeden: | Binnen-vochtig | << Kans op intredend vocht | Binnen-droog | Binnen-vochtig | Overdekt-droog | Overdekt-nevelig | Buiten | |
| 31 | | Mate van inlek: | **Gering** | | | | | | | |
| 32 | | | | | | | | | | |
| 33 | Sectie "Risicobeoordeling"; beoordeelt het aanwezige risico bij het optreden van een faalmechanisme. | | | | | | | | | |
| 34 | | Kans van falen: | **Cat. 4** | < Zie tab [NEN-EN 16991; laatste optie verwijst naar tab [Faalkans] | | | | | | |

Installatie | NEN-EN 16991 | Faalkans | CorrosieModel | Isol.Cond.Class. | Coating bescherming | NDT Effectiviteit | Succescriteria



Toelichting | Installatie | Weergave | NEN-EN 16991 | Instellingen

*The* decision model in which risks are integrated.

- Effect of failure
- Influence of coating lifespan rating
- Corrosion rate assessment
- Effectiveness of NDT

2 “tool versions”:

#1: reveals in which manner the various aspects are connected.

#2: tabular form, for planning purposes.

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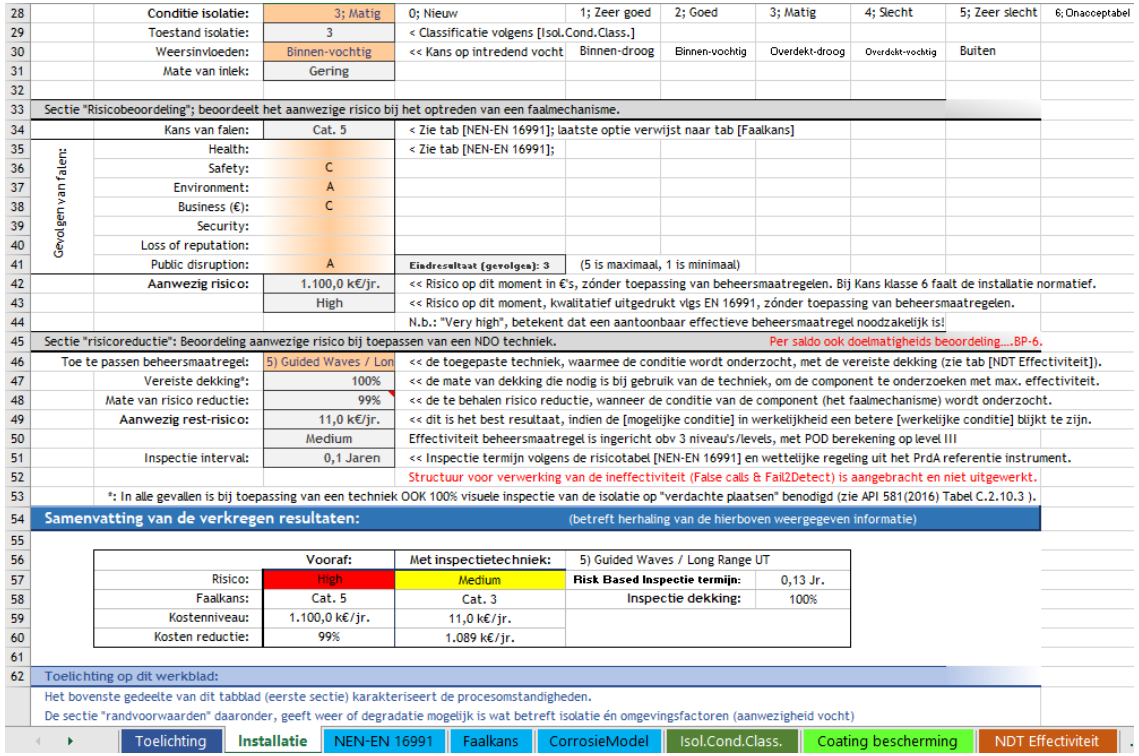
# CUI: Integration of influencing factors



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Conditie isolatie: | 3; Matig | 0; Nieuw | 1; Zeer goed | 2; Goed | 3; Matig | 4; Slecht | 5; Zeer slecht | 6; Onacceptabel | |
| Toestand isolatie: | 3 | < Classificatie volgens [Isol.Cond.Class.] | | | | | | | |
| Weersinvloeden: | Binnen-vochtig | << Kans op intredend vocht | Binnen-droog | Binnen-vochtig | Overdekt-droog | Overdekt-vochtig | Buiten | | |
| Mate van inlek: | Gering | | | | | | | | |

Sectie "Risicobeoordeling"; beoordeelt het aanwezige risico bij het optreden van een faalmechanisme.

| | | | |
|---|---|---|---|
| Kans van falen: | Cat. 5 | < Zie tab [NEN-EN 16991]; laatste optie verwijst naar tab [Faalkans] | |
| Gevolgen van falen: Health: | | < Zie tab [NEN-EN 16991]; | |
| Safety: | C | | |
| Environment: | A | | |
| Business (€): | C | | |
| Security: | | | |
| Loss of reputation: | | | |
| Public disruption: | A | Eindresultaat (gevolgen): 3 | (5 is maximaal, 1 is minimaal) |
| Aanwezig risico: | 1.100,0 k€/jr. | << Risico op dit moment in €'s, zónder toepassing van beheersmaatregelen. Bij Kans klasse 6 faalt de installatie normatief. | |
| | High | << Risico op dit moment, kwalitatief uitgedrukt vlgs EN 16991, zónder toepassing van beheersmaatregelen. | |
| | | N.b.: "Very high", betekent dat een aantoonbaar effectieve beheersmaatregel noodzakelijk is! | |

Sectie "risicoreductie": Beoordeling aanwezige risico bij toepassen van een NDO techniek. Per saldo ook doelmatigheids beoordeling....BP-6.

| | | |
|---|---|---|
| Toe te passen beheersmaatregel: | 5) Guided Waves / Lon | << de toegepaste techniek, waarmee de conditie wordt onderzocht, met de vereiste dekking (zie tab [NDT Effectiviteit]). |
| Vereiste dekking*: | 100% | << de mate van dekking die nodig is bij gebruik van de techniek, om de component te onderzoeken met max. effectiviteit. |
| Mate van risico reductie: | 99% | << de te behalen risico reductie, wanneer de conditie van de component (het faalmechanisme) wordt onderzocht. |
| Aanwezig rest-risico: | 11,0 k€/jr. | << dit is het best resultaat, indien de [mogelijke conditie] in werkelijkheid een betere [werkelijke conditie] blijkt te zijn. |
| | Medium | Effectiviteit beheersmaatregel is ingericht obv 3 niveau's/levels, met POD berekening op level III |
| Inspectie interval: | 0,1 Jaren | << Inspectie termijn volgens de risicotabel [NEN-EN 16991] en wettelijke regeling uit het PrdA referentie instrument. |
| | | Structuur voor verwerking van de ineffectiviteit (False calls & Fail2Detect) is aangebracht en niet uitgewerkt. |

*: In alle gevallen is bij toepassing van een techniek OOK 100% visuele inspectie van de isolatie op "verdachte plaatsen" benodigd (zie API 581(2016) Tabel C.2.10.3 ).

**Samenvatting van de verkregen resultaten:** (betreft herhaling van de hierboven weergegeven informatie)

| | Vooraf: | Met inspectietechniek: | 5) Guided Waves / Long Range UT | |
|---|---|---|---|---|
| Risico: | High | Medium | Risk Based Inspectie termijn: | 0,13 Jr. |
| Faalkans: | Cat. 5 | Cat. 3 | Inspectie dekking: | 100% |
| Kostenniveau: | 1.100,0 k€/jr. | 11,0 k€/jr. | | |
| Kosten reductie: | 99% | 1.089 k€/jr. | | |

Toelichting op dit werkblad:

Het bovenste gedeelte van dit tabblad (eerste sectie) karakteriseert de procesomstandigheden.
De sectie "randvoorwaarden" daaronder, geeft weer of degradatie mogelijk is wat betreft isolatie én omgevingsfactoren (aanwezigheid vocht)

Toelichting | Installatie | NEN-EN 16991 | Faalkans | CorrosieModel | Isol.Cond.Class. | Coating bescherming | NDT Effectiviteit

Cost effective and proactive? #How?.

- Risk of doing nothing
- Consideration in advance by LCC with respects to Inspection or Upgrade
- Traceable effectiveness through an open approach
- Based on effectiveness of "chain links"

2 "types of result":

- "As-is" risk in the current situation
- "To-be" risk and costs in case of effective control

WORLD CLASS MAINTENANCE

# CUI: Assessment condition of insulation.

Starting points:

Based on condition classification.

(Degree of) leakage is the decisive criterion.

EN 2767 / CEN 17385

**Attached reference images for the inspection of insulation.**

| | | | | | |
|---|---|---|---|---|---|
| **Terms of reference:** | | It only concerns functional requirements, for the function: shielding the underlying insulation against environmental influences. | | | |
| | | This concerns the inspection of the condition of the plating with the watertight finish. | | | |
| | | The main question is therefore: to what extent is the insulation able to prevent leakage/ingression into water; leak-tight = no watering. | | | |
| | **Remark:** | A category 4 may apply to new construction if drainage to/into the insulation is possible. | | | |
| | | A control measure can consist of carrying out a risk analysis with Fitness For Purpose. | | | |
| **Class:** | **Condition:** | **Action:** | **Explanation:** | **Specific:** | **Reference image:** |
| 0 | New | Follow standard inspection regime for CUI management. | New, just installed, meets new construction requirements (CINI etc). | New build quality without watering. |  |
| 1 | Very good | Follow standard inspection regime for CUI management. | Used, meets all requirements. | Not deformed, no watering. |  |
| 2 | Good | Follow standard inspection regime for CUI management. | Used, limited deviation without consequences for the occurrence of watering. | Deformed, no watering. |  |
| 3 | Mediocre | Action within a maximum of 6 years. | As 2, with deviation that can lead to watering. | Irrigation cannot be ruled out. |  |
| 4 | bad | Action carried out within a maximum of 3 years. | As 3, with a deviation which allows watering in, making it necessary to plan an action. | Watering under certain weather conditions |  |
| 5 | Very bad | Immediate measure, implemented within a maximum of 1 year. | As 4, with such an amount of watering that intervention is necessary within 1 year. | Watering in and collecting (hold-up) water. |  |
| 6 | Unacceptable | Immediate investigation of the remaining integrity is necessary. | As 5 with watering & damage formation to such an extent that leakage of steam and/or product leaks out. | There is an acute danger to integrity. |  |

Introduction | Installation | NEN-EN 16991 | FailureRate | CorrosionModel | Isol.Cond.Class. | Coating protection | NDT Effect ...

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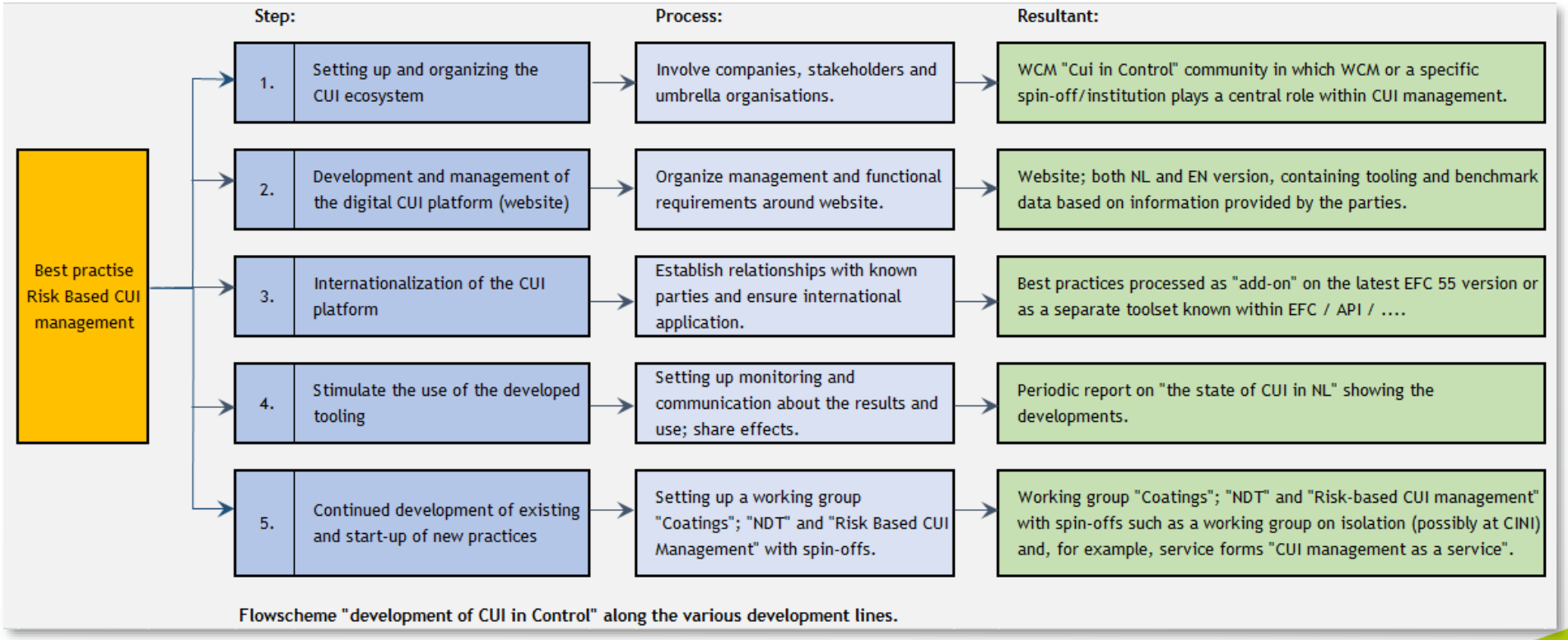
# Sustainable CONTROL on Corrosion under Insulation

## Duurzame GRIP op Corrosie Onder Isolatie

## Work packages and planning




Flowscheme "development of CUI in Control" along the various development lines.

Corrosie onder Isolatie

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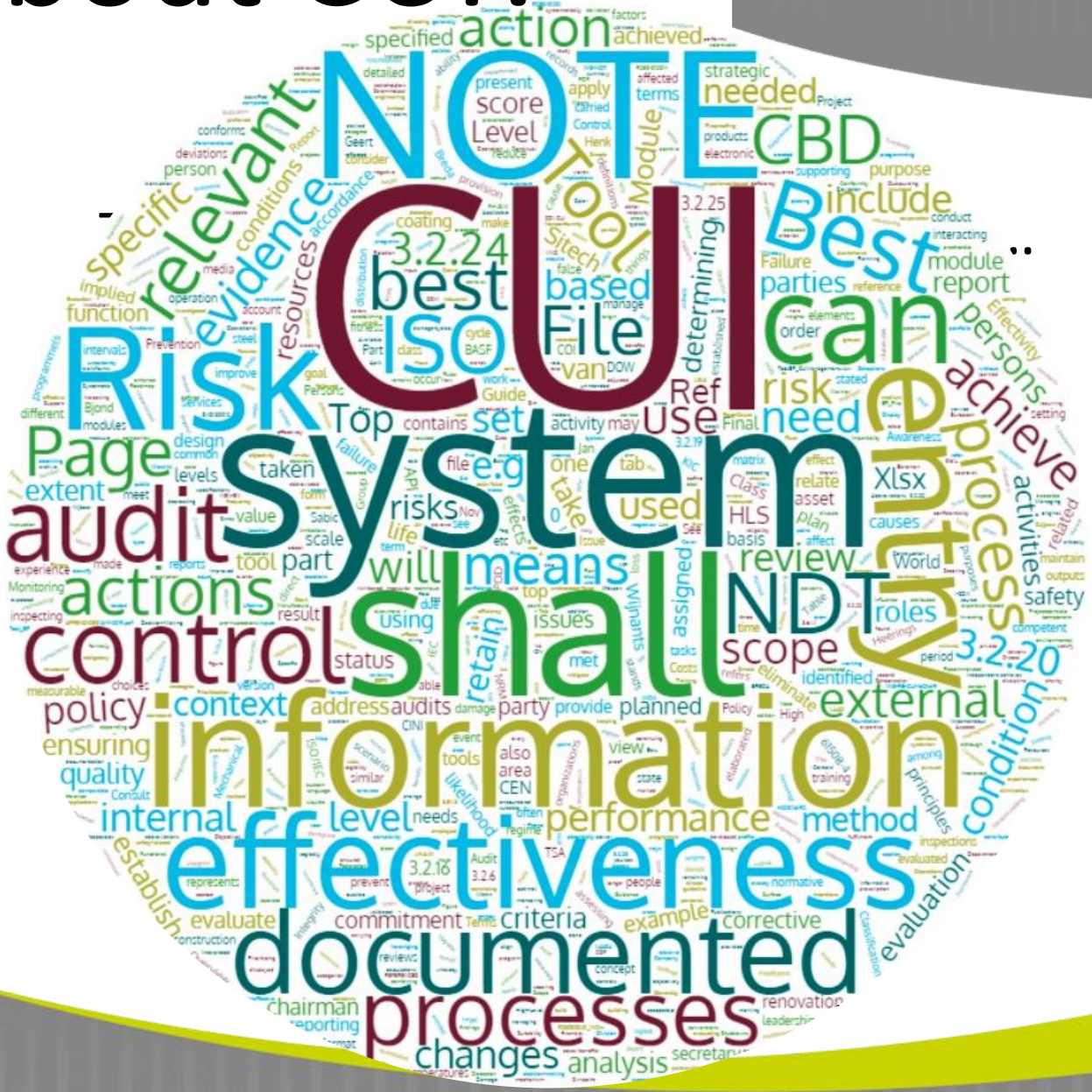
# What about CUI?

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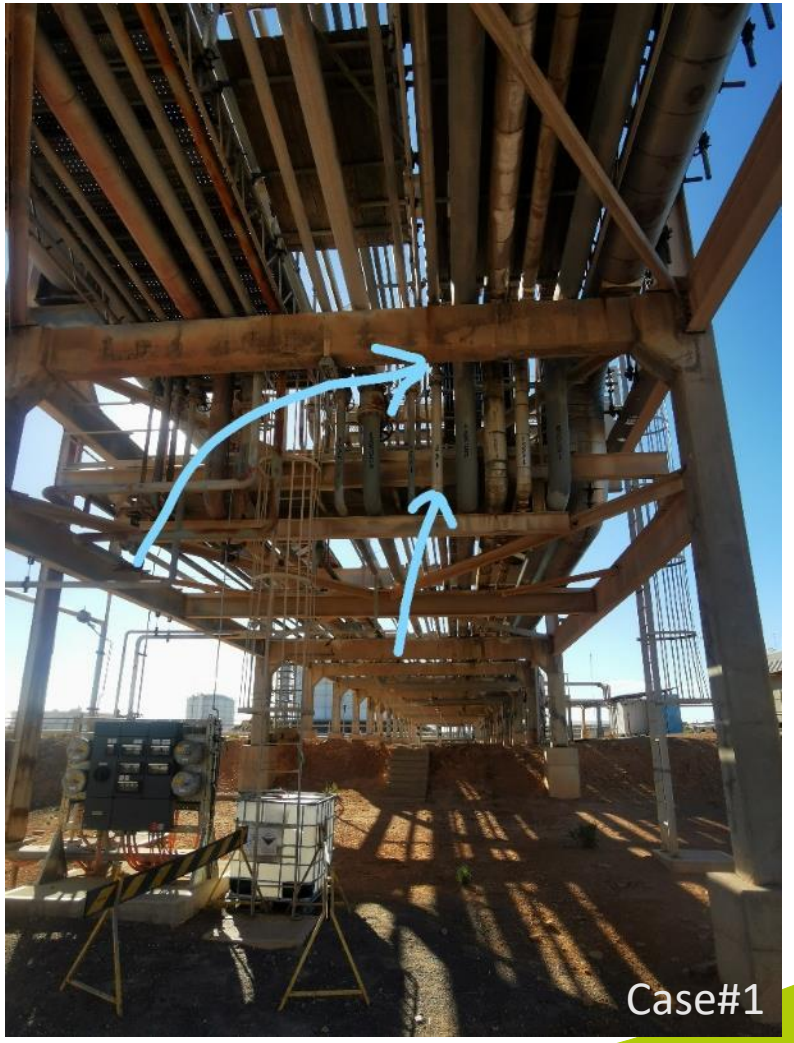
# Where was it?

Inspection program on a piping-bridge
No failure in this case
Serious doubts in general

Generic features:

- Hard to reach
- Enclosed in other piping
- Scaffolding required
- No sight from lower level

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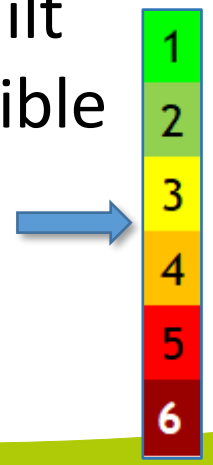
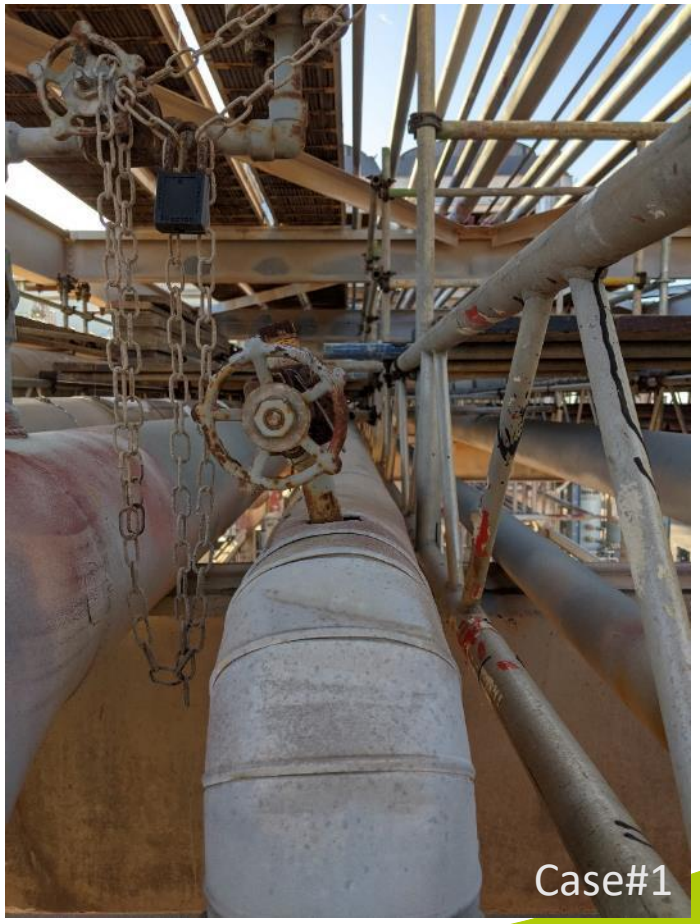
# What about the insulation?

After installing scaffolding:

Generic features:

- Insulation dented
- Connections still in place
- Connection hand-valve as built
- However: water ingress possible
- ➔ condition class: 3 (4)

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# What after stripping?

After stripping:

Generic features:

- Very localized attack
- Thick corr. layer D
- => D/10 thickness gone
- Remaining thickness?


Case#1

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# What about the integrity?

Trying to remove the valve:

Connection failed:

- Corroded through the wall
- Complete failure
- No remaining thickness
- Lucky escape!!!


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# What do we have now?

- Clear case. Usual case: failure – strip - look
- Condition insulation “as found” Usually not inspected (who’s interest)
- Cause – effect clear Usually unknown – we suspect….
- Level of required detail now known Usually unknown – supposedly good
- Being “as built” doesn’t mean “all good”!
- Assessment and acceptance criteria need to be explicit and clear
- In case of class 3+: direct measure required. Assumptions rule…..

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# Where are we going now?

**From**

Personal interpretation

Unclear “ ‘as-found’ baseline” **(*1)**

Unclear relationship **(*1)** and defect

No additional monitoring

**To:**

Standardized assessment

Clear “ ‘as-found’ identification” **(*2)**

Relationship **(*2)** and defect

Additional monitoring

➔ stricter identification of “being at risk”

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# How do we get there?

Best practise for Condition Classification and reporting developed.

Case histories are being collected in order to underpin the applied approach. These typically contain the as-found condition wrt insulation and the as-found condition wrt asset integrity.

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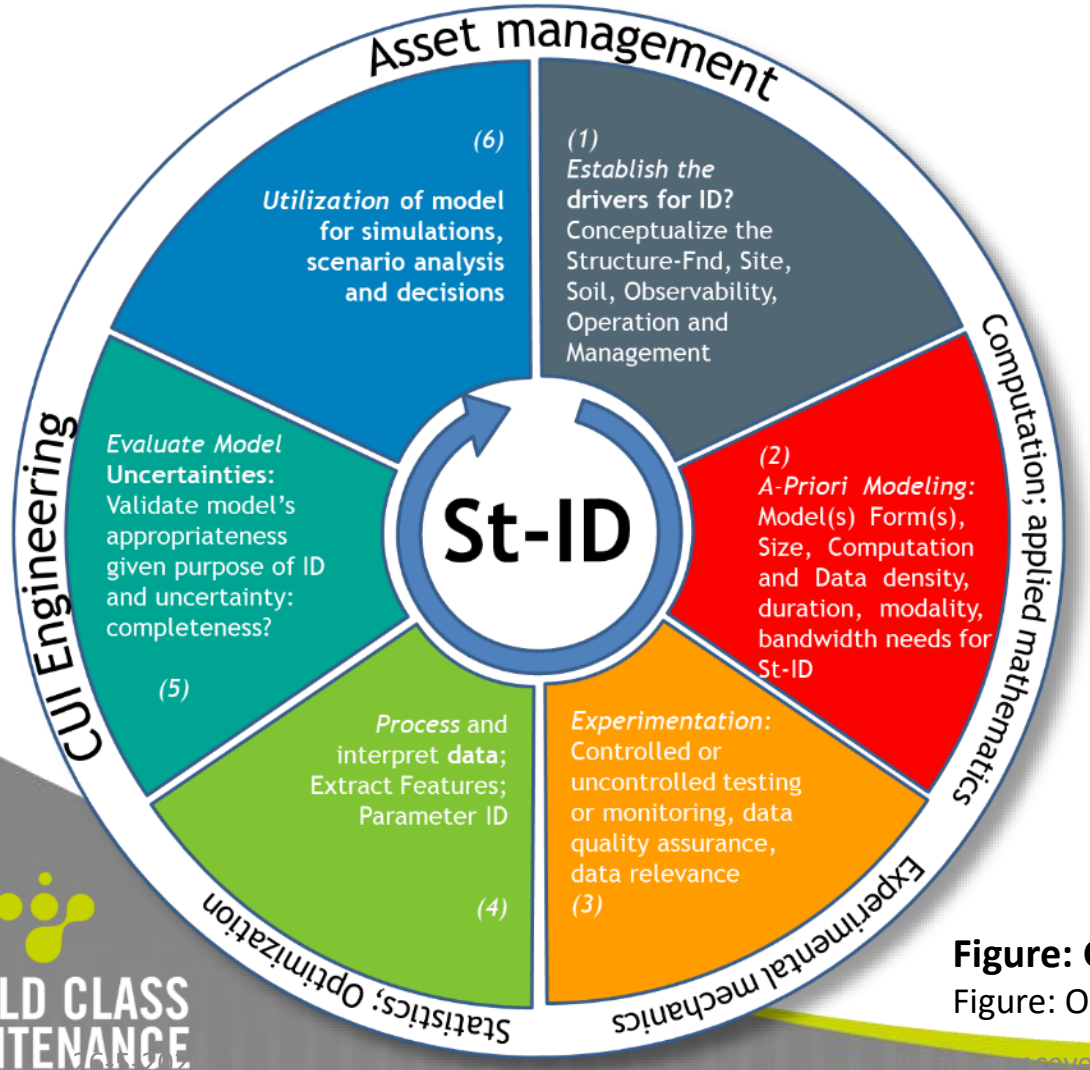
# WCM CUI Methodology in perspective of process management




- Figure shows critical elements for effective Asset management.
- These elements are to be linked to themes in a development, in order to ensure the effectivity of the approach
- Management concept is based on controlling CUI by controlling these themes.
- Key issue: *use an explicit model in order to be able to manage developments.*

**Figure: Grip on CUI by means of managing the key parameters**
Figure: Original: Structural Identification of Constructed Systems

# Applied approach for condition assessment. CEN 17385

Default approach:

Assessment by means of 3 parameters.

- Severity
- Degradation level
- Extent

| Severity | Degradation level | Extent | | | | |
|---|---|---|---|---|---|---|
| | | Class 1: Minimal (≤2 %) | Class 2: Insubstantial (>2 %, ≤ 10 %) | Class 3: Substantial (>10 %, ≤30 %) | Class 4: Significant (>30 %, ≤70 %) | Class 5: Widespread (>70 %) |
| Minor defects | 1: Low | Y1 | Y1 | Y1 | Y1 | Y2 |
| | 2: Medium | Y1 | Y1 | Y1 | Y2 | Y3 |
| | 3: High | Y1 | Y1 | Y2 | Y3 | Y4 |
| Serious defects | 1: Low | Y1 | Y1 | Y1 | Y2 | Y3 |
| | 2: Medium | Y1 | Y1 | Y2 | Y3 | Y4 |
| | 3: High | Y1 | Y2 | Y3 | Y4 | Y5 |
| Critical defects | 1: Low | Y1 | Y1 | Y2 | Y3 | Y4 |
| | 2: Medium | Y1 | Y2 | Y3 | Y4 | Y5 |
| | 3: High | Y2 | Y3 | Y4 | Y5 | Y6 |

Legenda:

| Condition class: | Interpretation: |
|---|---|
| Cond. class: 1 | Excellent |
| Cond. class: 2 | Good |
| Cond. class: 3 | Fair |
| Cond. class: 4 | Poor |
| Cond. class: 5 | Bad |
| Cond. class: 6 | Very Bad |

Result: 4

| Defect severity: | Degradation level: | Extent: | Condition class: |
|---|---|---|---|
| Critical | 2: Medium | Class 4 | Condition class: 4 |

The degradation is widespread. Elements have widespread defects in finish and function. There may be a number of (severe) defects that can lead to a loss of function. Reliability is compromised. With regard to the total defect impact, the elements are evaluated as degraded. This may be partly caused by faults in material choice, poor basic quality, execution and ageing.

WORLD CLASS MAINTENANCE

# Applied approach for condition assessment. CEN 17385

Amended approach:

Assessment *on asset level* by means of 2 parameters.

- Condition
- Extent

| Single element Cond. | Extent | | | | |
|---|---|---|---|---|---|
| | Class 1: Minimal (≤2 %) | Class 2: Insubstantial (>2 %, ≤ 10 %) | Class 3: Substantial (>10 %, ≤30 %) | Class 4: Significant (>30 %, ≤70 %) | Class 5: Widespread (>70 %) |
| X2 | Y1 | Y1 | Y1 | Y1 | Y2 |
| X3 | Y1 | Y1 | Y1 | Y2 | Y3 |
| X4 | Y1 | Y1 | Y2 | Y3 | Y4 |
| X5 | Y1 | Y2 | Y3 | Y4 | Y5 |
| X6 | Y2 | Y3 | Y4 | Y5 | **Y6** |

Legenda:

| Condition class: | Interpretation: |
|---|---|
| Cond. class: 1 | Excellent |
| Cond. class: 2 | Good |
| Cond. class: 3 | Fair |
| Cond. class: 4 | **Poor** |
| Cond. class: 5 | Bad |
| Cond. class: 6 | Very Bad |

| SE-condition: | Extent: | Condition class: |
|---|---|---|
| 4 | Class 4 | Condition class: 3 |

The degradation is identifiable in places. Elements have defects in finish, material and components in places. Elements may occasionally be degraded without critical consequences. Well-executed and long-lasting repairs may be regularly undertaken. Repairs using less suitable means may also have been carried out in places. The technical state is qualified as reasonable with respect to the total defect impact. The quality of the materials applied and/or defects in design, detailing and execution play a significant role in this.

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# Applied approach for condition assessment. CEN 17385

Note that the amended approach supports two kinds of assessments:

Assessment *on asset level* by means of

- Detailed condition level with assessing of all elements.
- General condition level with rating on “outliers / deviations”

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# CUI Sustainably in control


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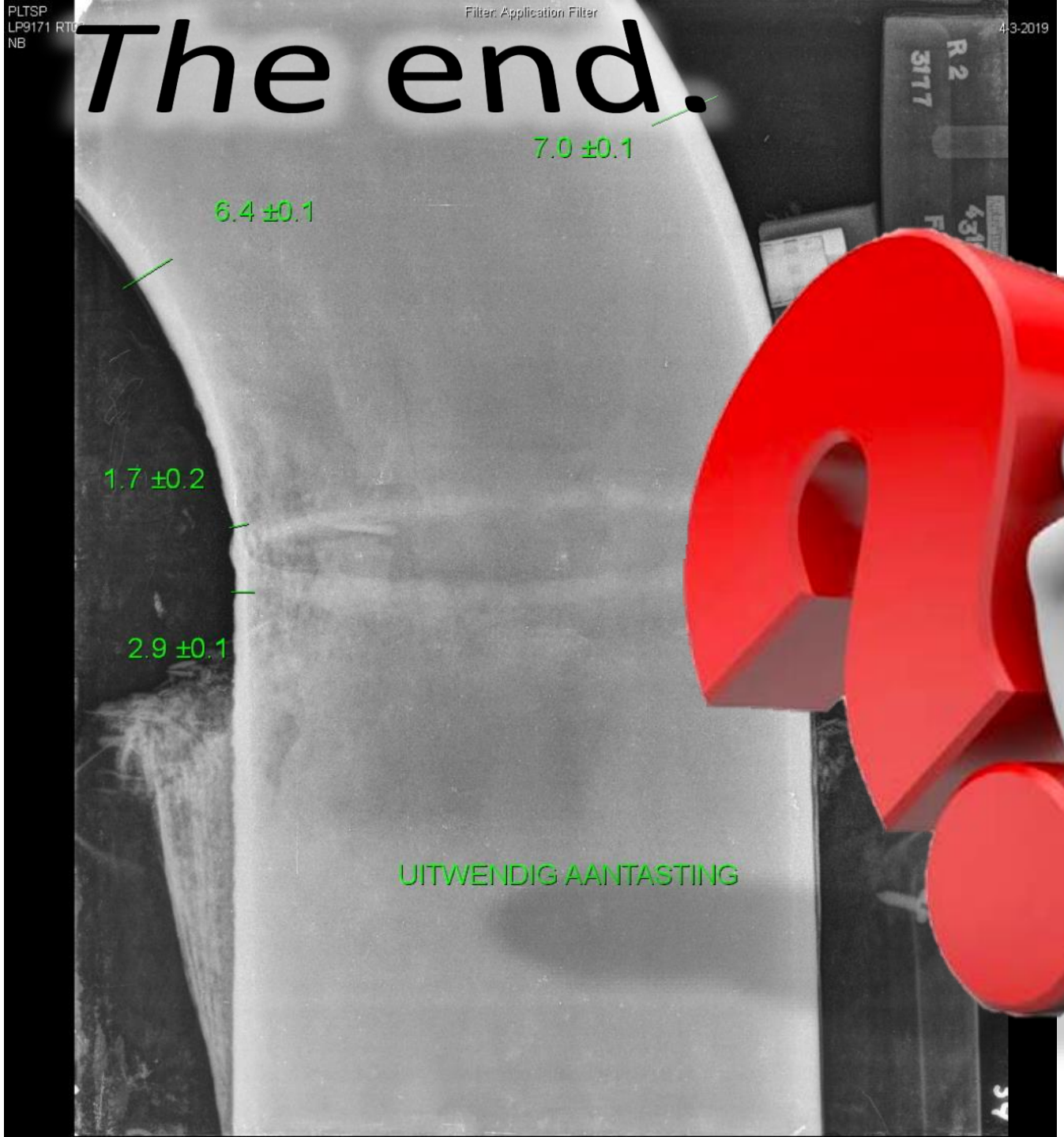
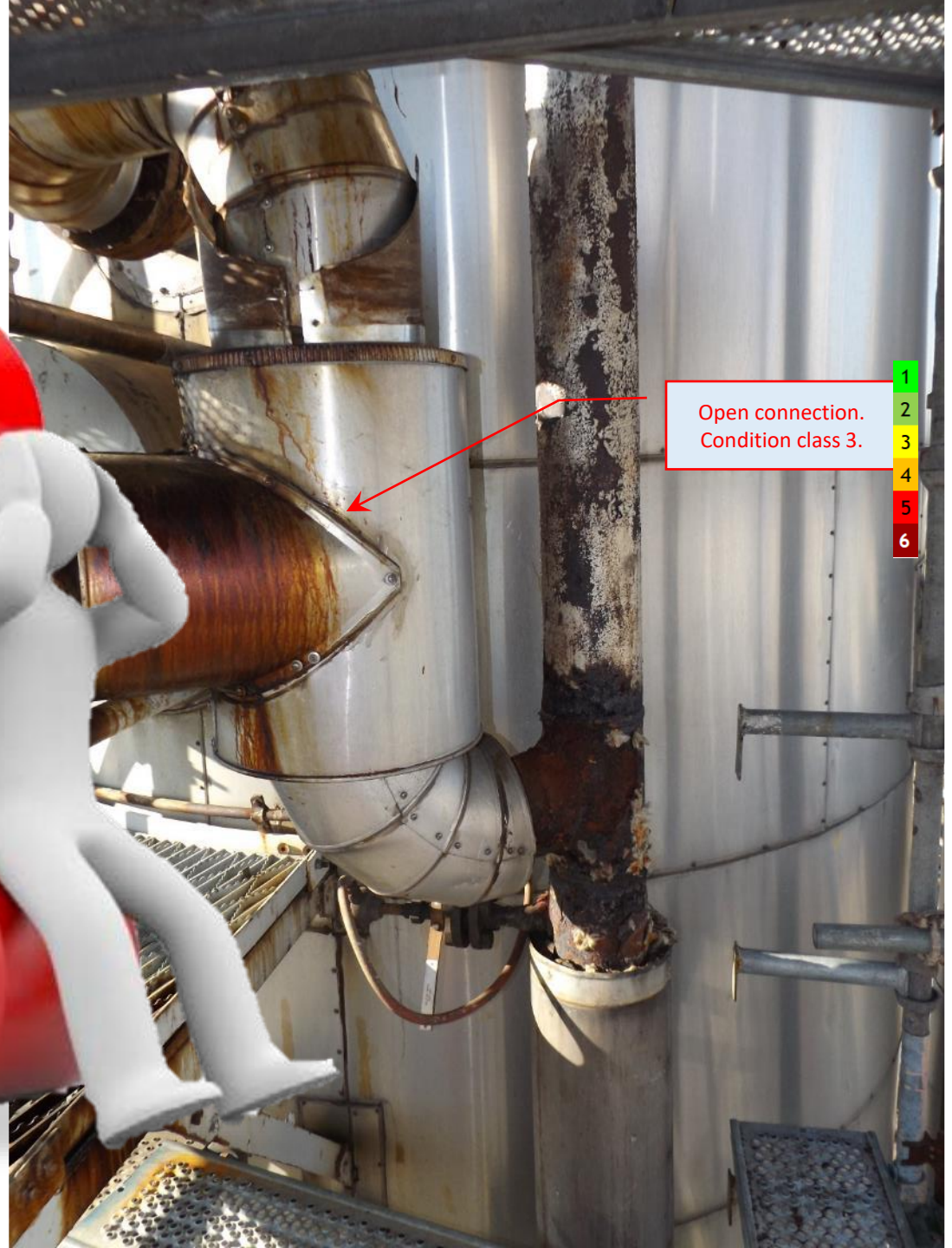
# CUI Sustainably in control


WORLD CLASS
MAINTENANCE

# The end.


PLTSP
LP9171 RT
NB
Filter: Application Filter
4-3-2019
7.0 ±0.1
6.4 ±0.1
1.7 ±0.2
2.9 ±0.1
UITWENDIG AANTASTING


Open connection.
Condition class 3.
1
2
3
4
5
6