

Our 1st Speaker for Tonight is: Dr Susan Osbeck



PRINCIPAL CONSULTANT AT ESR TECHNOLOGY

She has been active in supporting clients with Non-Intrusive Inspection in the Oil and Gas Industry since 2011.

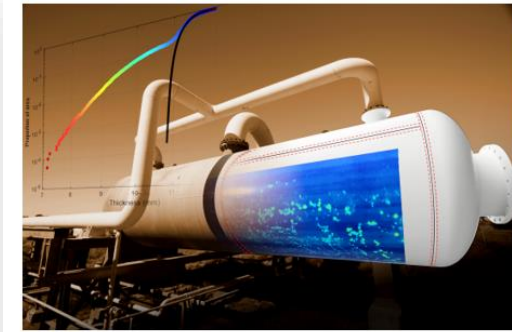
She was co-author of the updated HOIS recommended Practice for NII (HOIS-R-103) and the HOIS Guidance notes for NII (HOIS-G-103).

Susan has experience in a variety of fields including bioengineering, radiation protection, radiography, integrity management, data analysis, and surface science.

She holds degrees in Physics and Medical Physics, and a PhD in Engineering from Robert Gordon University where she investigated improving interfacial bonding between carbon fibres and epoxy resins for the aerospace industry.

The Updated HOIS Recommended Practice for Non-Intrusive Inspection

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**HOIS Recommended Practice for
Non-Intrusive Inspection of Pressure Vessels**

HOIS-RP-103

February 2020

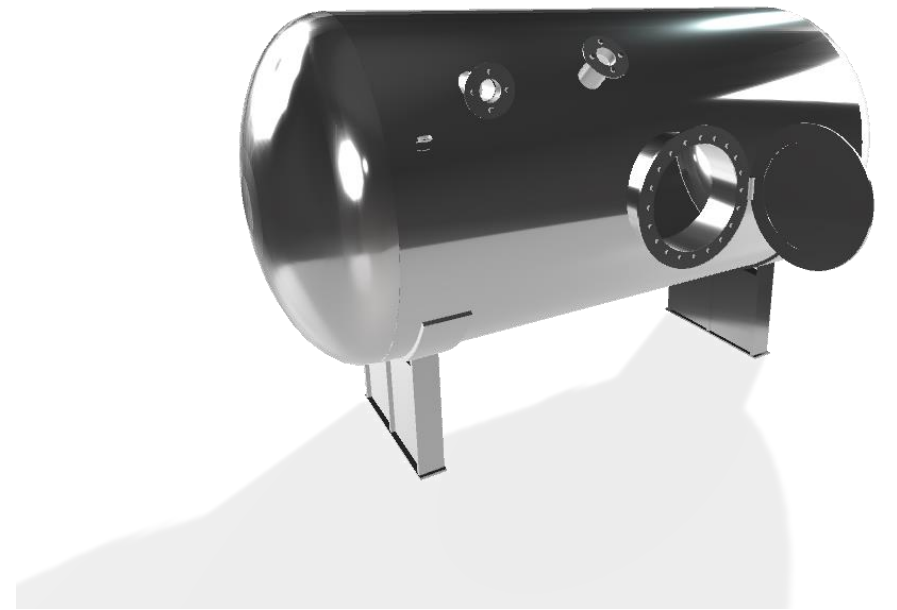


Contents

- Introduction.
- Non-intrusive inspection.
- History of the recommended practice.
- Summary of the NII process.
- Changes to the recommended practice.
- The new guidance notes.
- Experience of applying the recommended practice.
- Future projects.

Introduction

- Integrity management decisions for pressure vessels rely on inspection.
- Confirms corrosion risk assessment.
- Traditionally done by internal visual inspection (IVI) with human entry.
- Vessel needs to be:
 - Shutdown
 - Isolated
 - Cleaned
- Costly and hazardous activity.



Non-Intrusive Inspection

- NII is a process not a technique.
- Non-destructive testing (NDT) techniques are used.
- Inspection is carried out externally with the vessel (usually) online.
- Internal visual inspection is more flexible.
- Robust NII requires a different approach to IVI.
- Particular emphasis on understanding the degradation types as probability of detection is morphology specific for NDT techniques.
- Industry recognised need for a framework to improve confidence.

History of the Recommended Practice

Pre 2000

- NII being applied to high value cases.
- Inspection design concepts from Nuclear Industry being introduced.

2000-2006

- HOIS development of NII Guidelines (driven by Operator Members and UK HSE).
- Mitsu-Babcock Group sponsored project (GSP 235) outputs shared and included in HOIS development.
- Pilot projects (ESR Technology with ConocoPhillips and Marathon) followed by wider application by limited number of operators.

2007

- HOIS Guidelines published as DNV-RP-G103.
- Wider industry uptake.

2007-2010

- Extensive application with early adopters working in the North Sea.
- Experience in field leads to revision of RP.

History of the Recommended Practice

2011

- Second revision published which includes option for deferment and has evaluation requirements specified.

2011-2017

- NII beginning to be used by most major operators with application of the RP in Norway, Australia and Middle East and wider onshore application (gas plants and refineries).
- Development and issue of HOIS RP on Statistical Analysis of Inspection Data.
- Operators building internal NII systems and processes. Setting targets around use of NII.

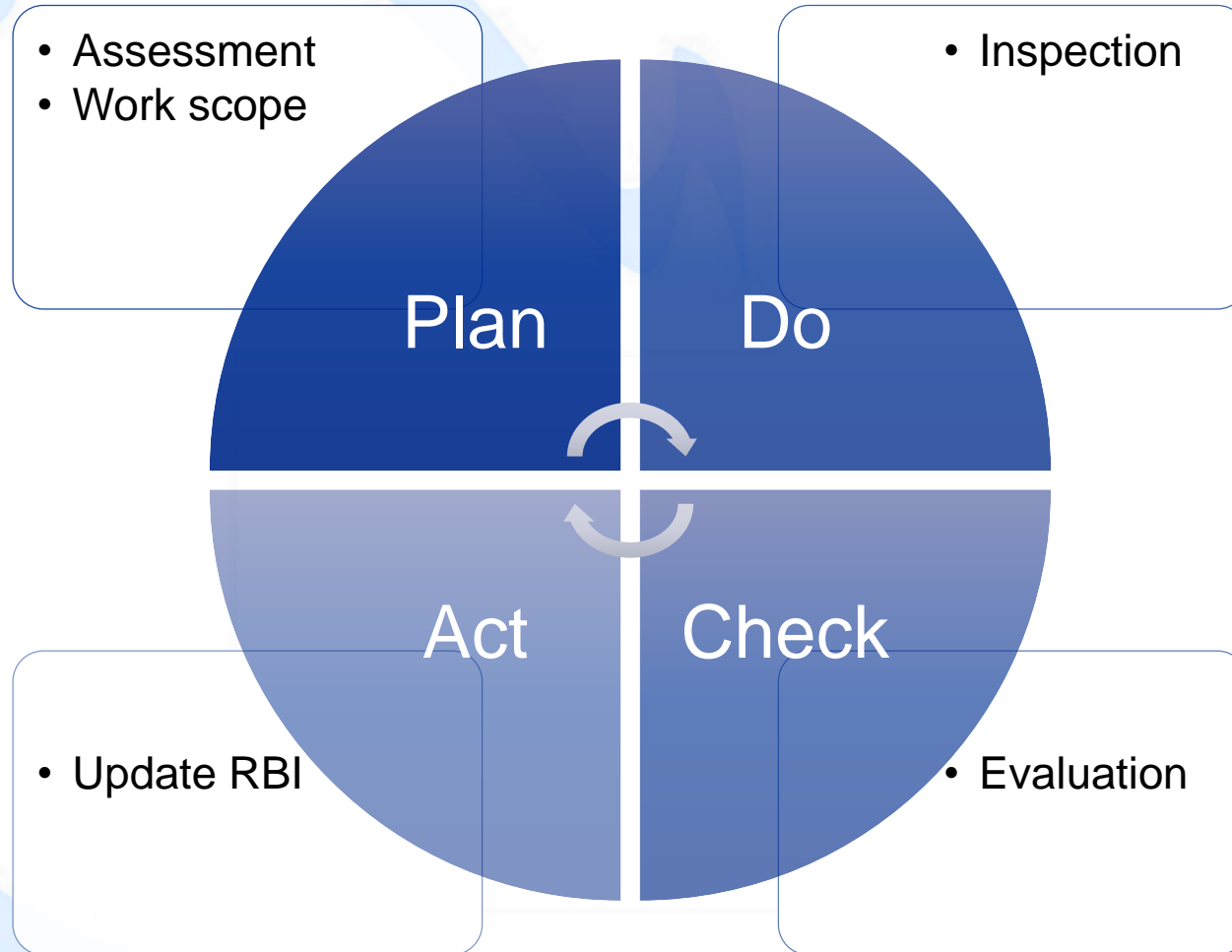
2017-2019

- OGTC support for greater industry uptake of NII.
- Greater experience and demand for NII leads to further revision of RP.
- Design for through life NII being considered in new projects.

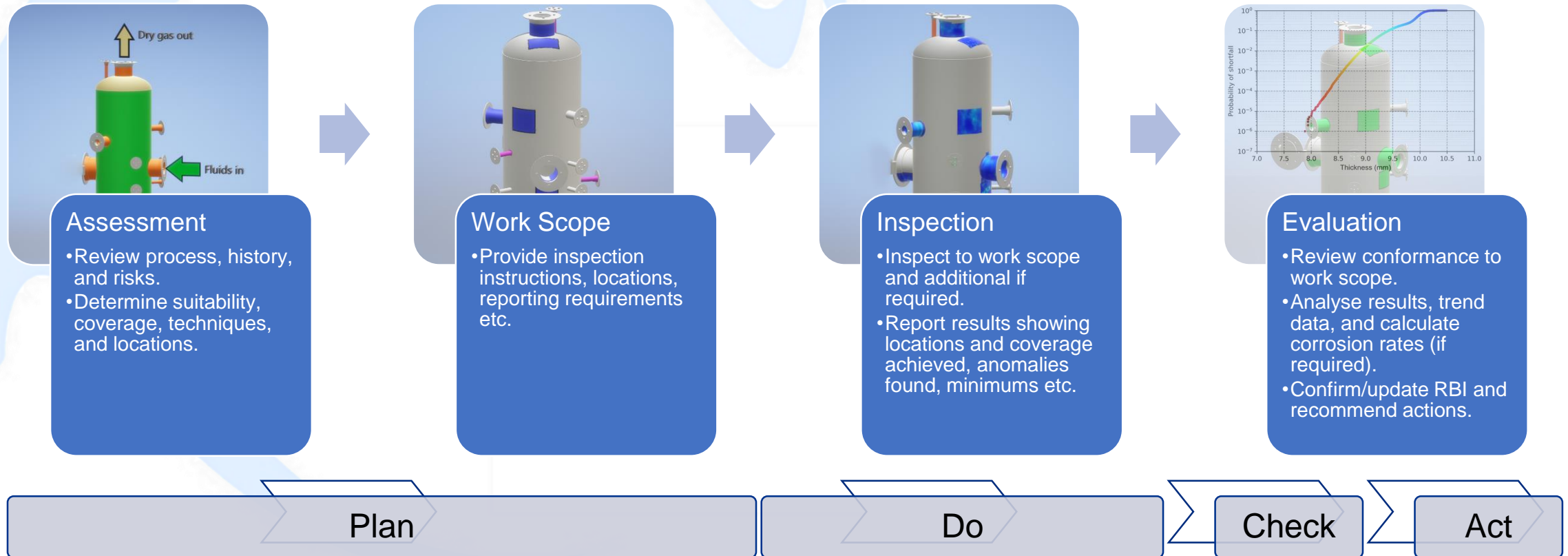
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- Third revision published through HOIS as HOIS-RP-103 with simplified application and clarification of requirements.
- Supporting Guidance Notes produced by HOIS with OGTC support published as HOIS-G-103.

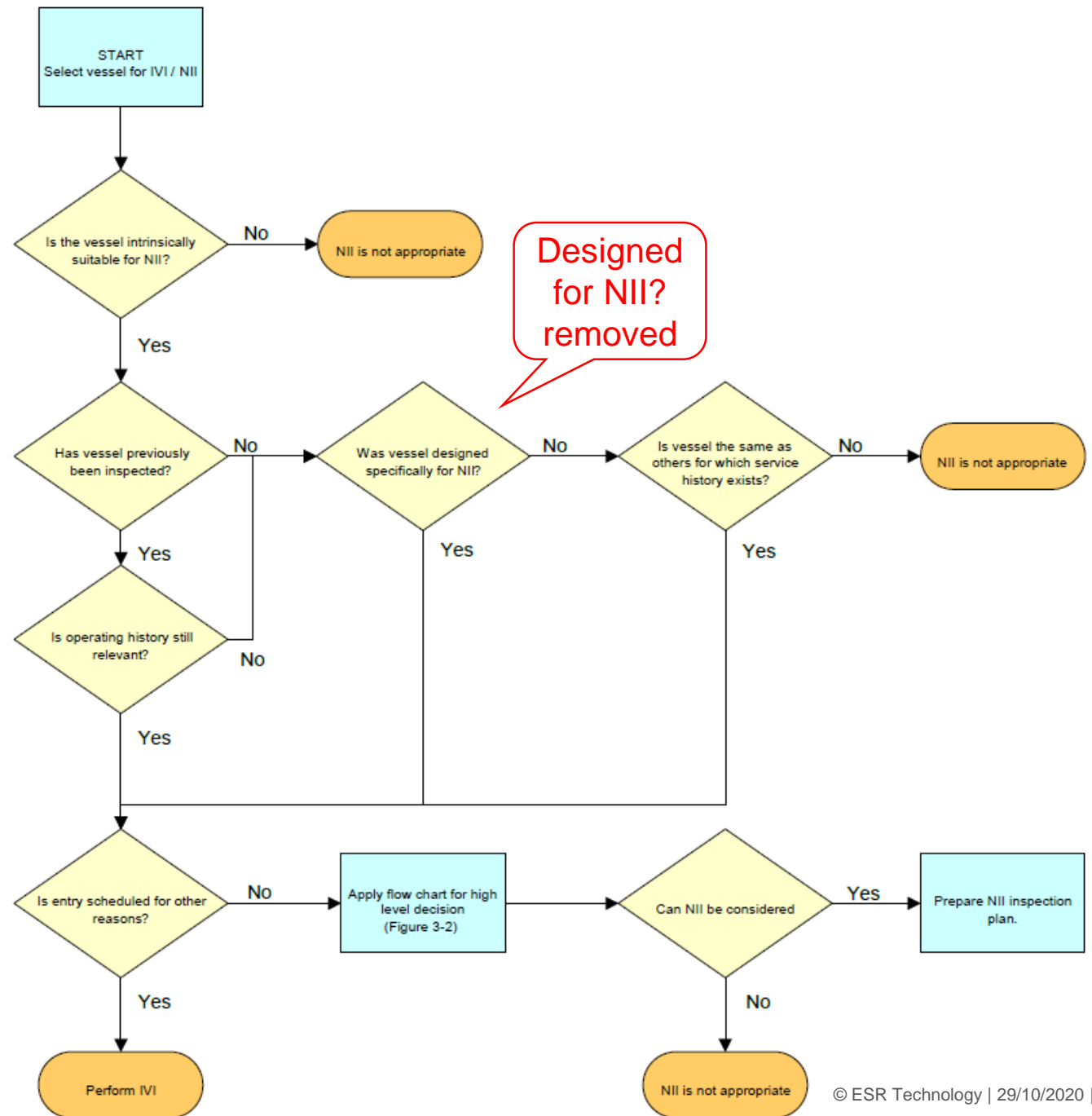
The NII Process



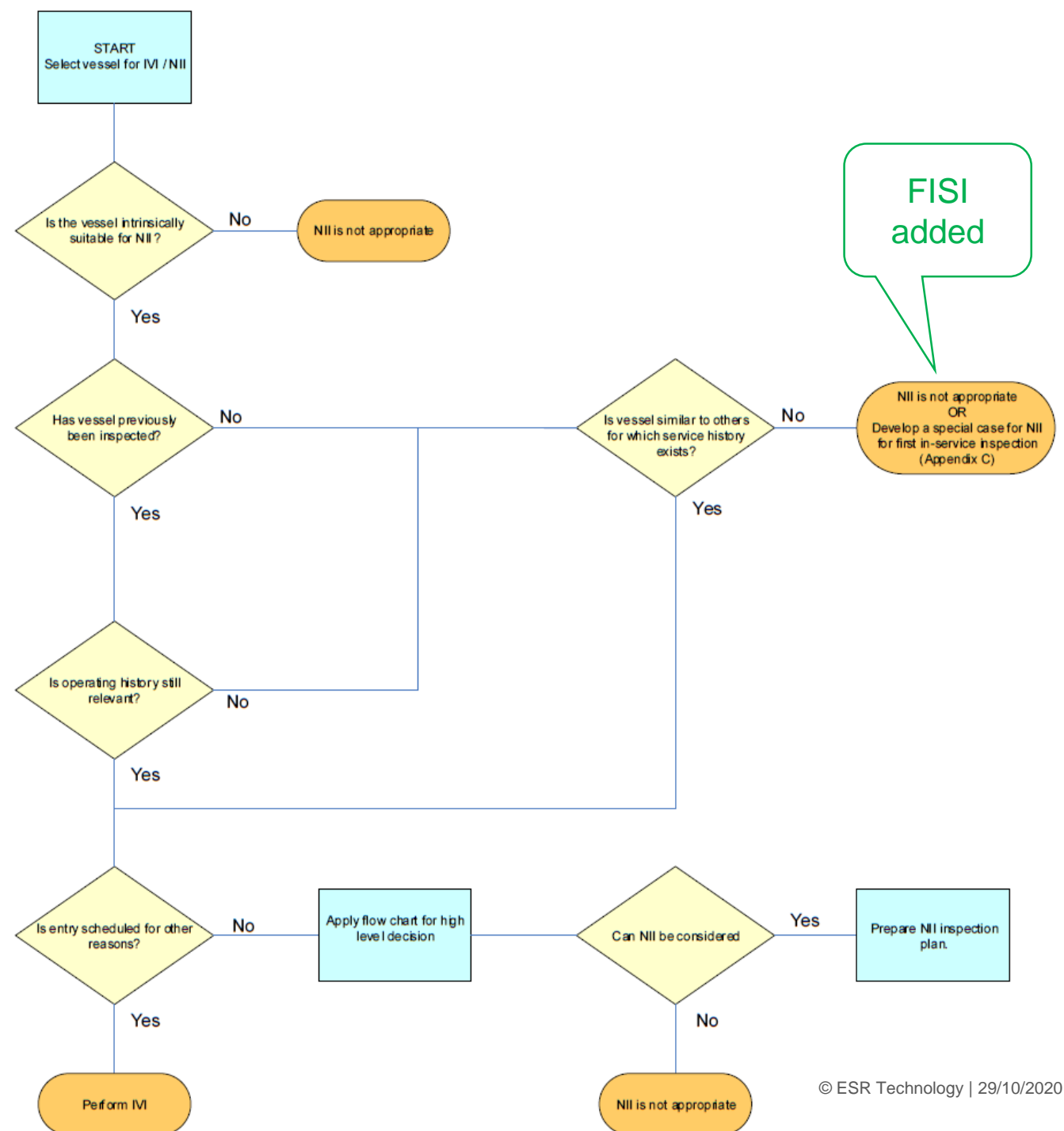
The NII Process



NII Assessment - Screening

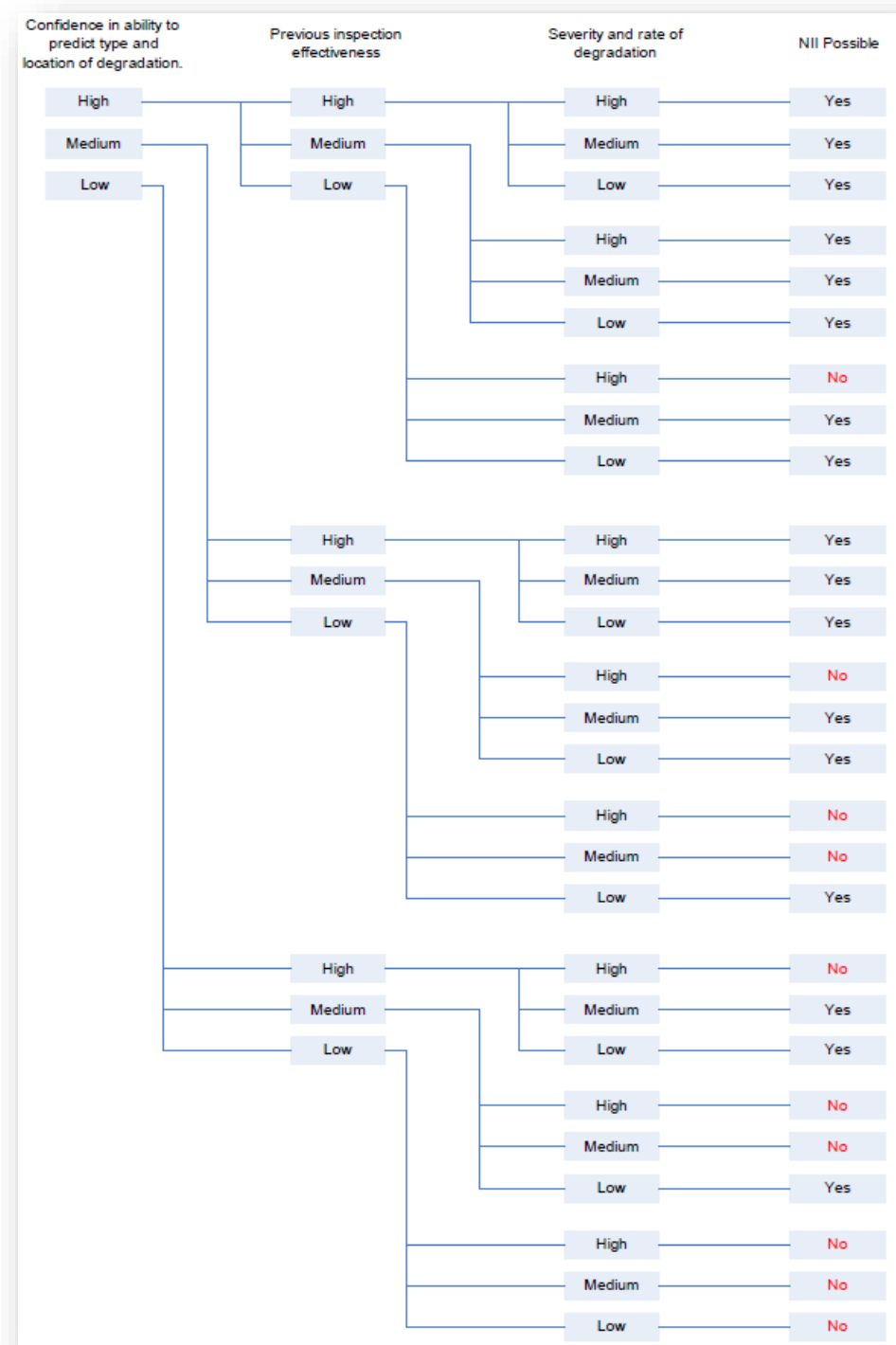


NII Assessment - Screening



NII Assessment - Suitability

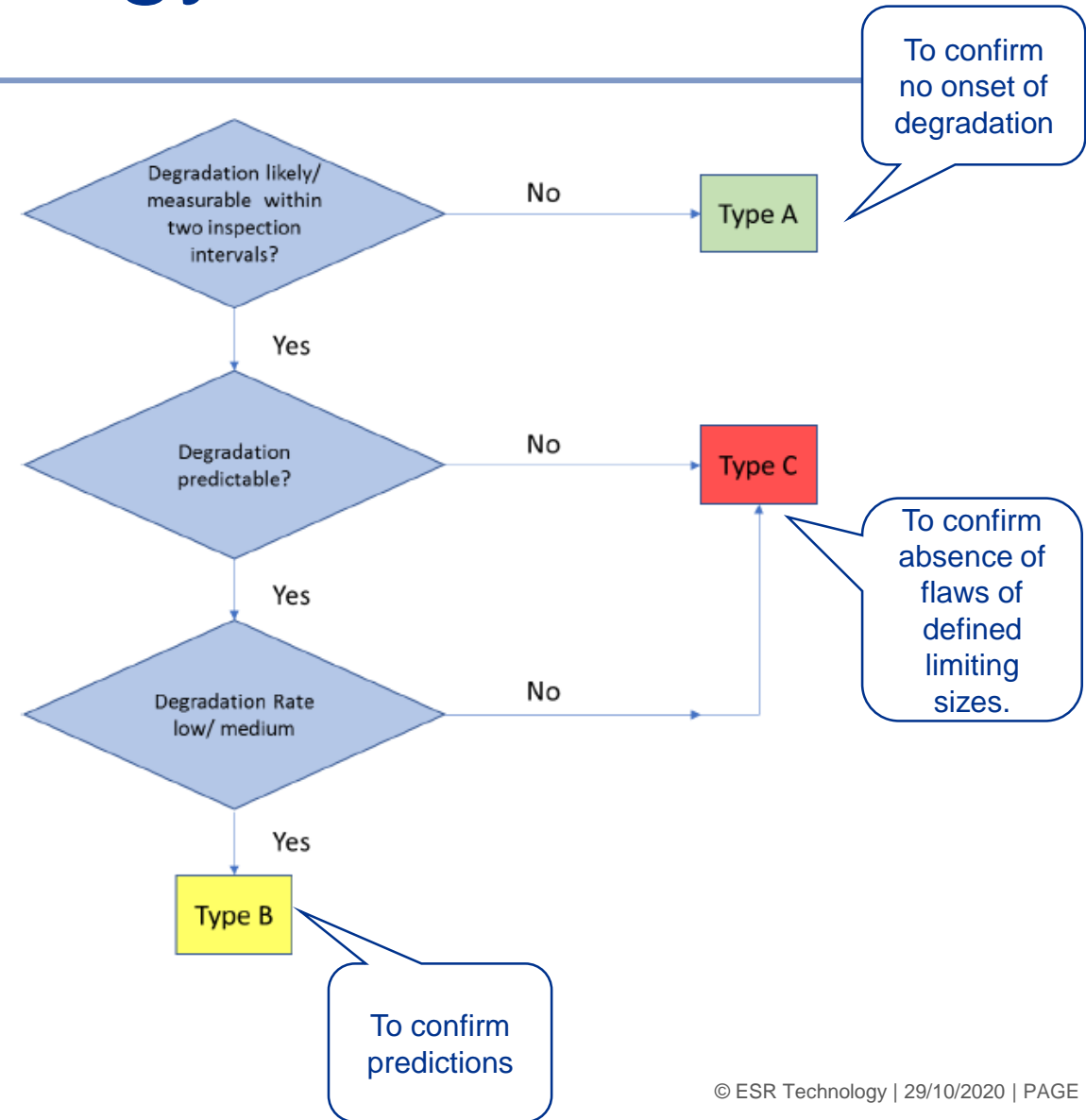
- Confidence in ability to predict type and location of degradation.
- Previous inspection effectiveness.
- Severity and rate of degradation.
- **New Guidance Notes** provide suggestions for selection.



NII Assessment – Strategy

Type	Definition
A	Degradation mechanism NOT expected to occur, or The current condition and likely corrosion rate is such that 1 mm of wall loss would not be seen within two inspection intervals and upset conditions are unlikely.
B	Degradation mechanism (wall loss only) expected, with low/medium progression (will not affect integrity within two inspection intervals). Location of degradation can be predicted.
C	Degradation expected with medium/high progression (may affect integrity within two inspection intervals). Locations cannot be predicted.

Type A strategy updated to explicitly allow carbon steel.



NII Assessment – Requirements

- **New** inspection requirements defined quantitatively by strategy type:
 - Coverage calculations.
 - Probability of detection requirements (depth and aspect ratio).
 - Accuracy.
- Strategy and inspection requirements rely on good understanding of likely degradation.

$$C_R = F_{COV} \times F_{CONS} \times F_{ZONE} \times C_1 \text{ or}$$

$$C_R = 2.5\%$$

Hence a coverage less than 2.5% is not permitted.

Table 4-7 Technique detection performance requirements for Type C strategy

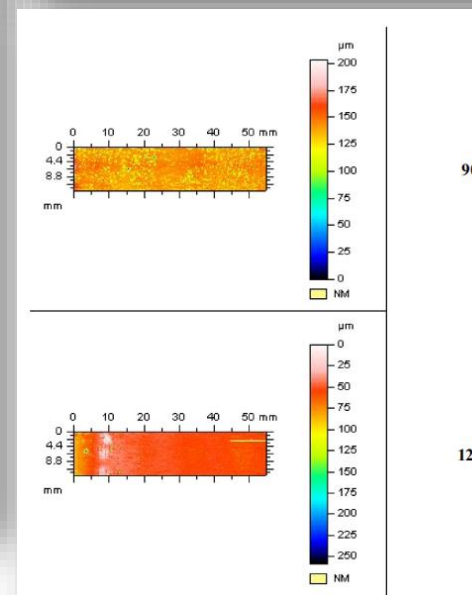
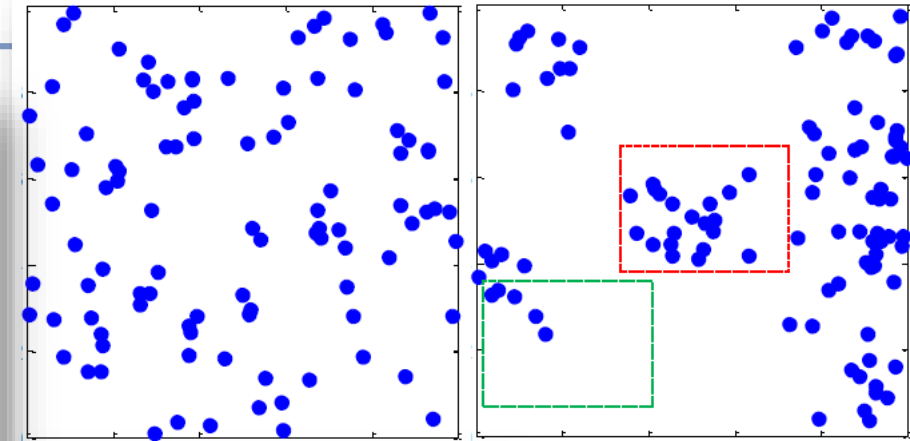
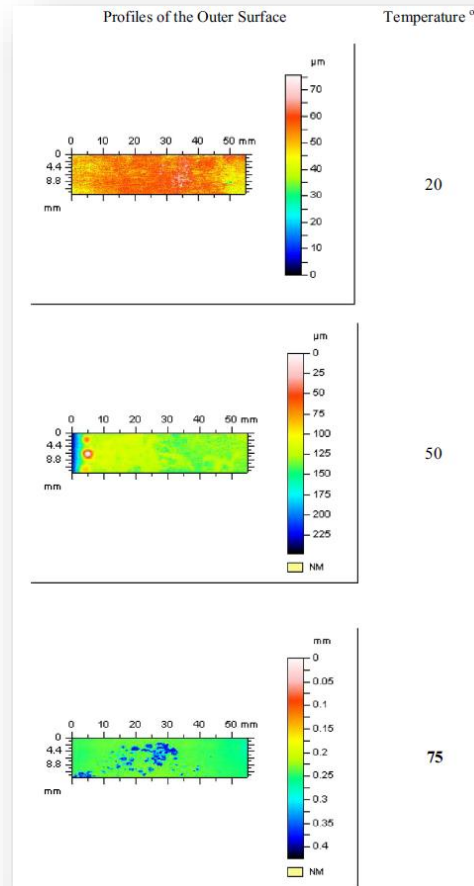
COF	Depth for POD>90%
High	Lesser of 1.5 mm or 0.5 x CA
Medium	Lesser of 2 mm or 0.75 x CA
Low	Lesser of 2 mm or 0.75 x CA

Table 4-5 Wall thickness measurement accuracy requirements in a Type B strategy

COF	80% tolerance on wall thickness
High	±0.30 mm
Medium	±0.40 mm
Low	±0.60 mm

Degradation Threat Assessment

- Determines type of tools required, locations for inspection, and inspection requirements.
- **New** concepts of density and homogeneity related to spatial distribution.
- Discussed further in Guidance Notes.



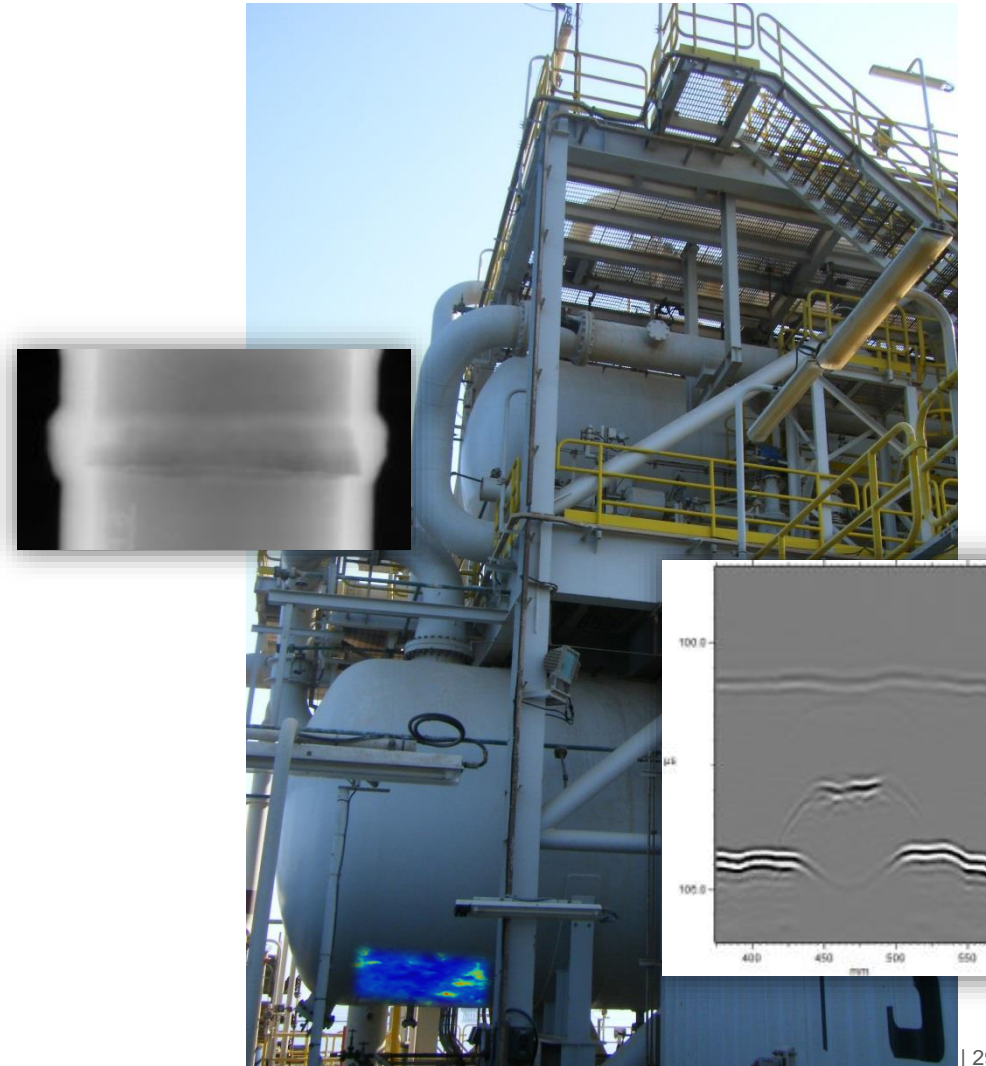
HOIS-RP-103

NII Work Scope and Inspection

Recommended Techniques – updated (simplified)

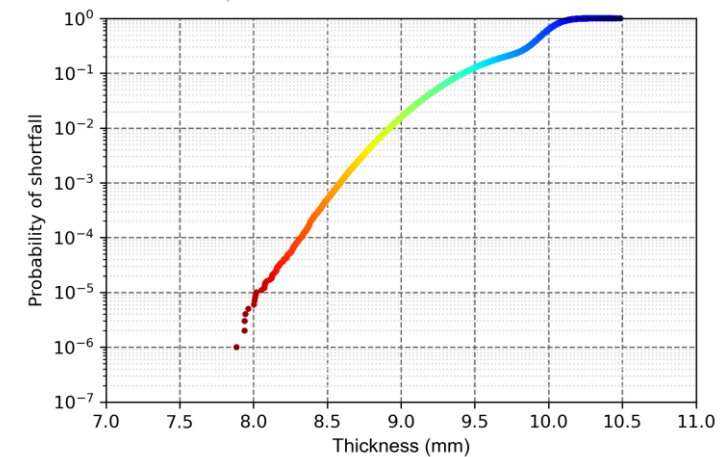
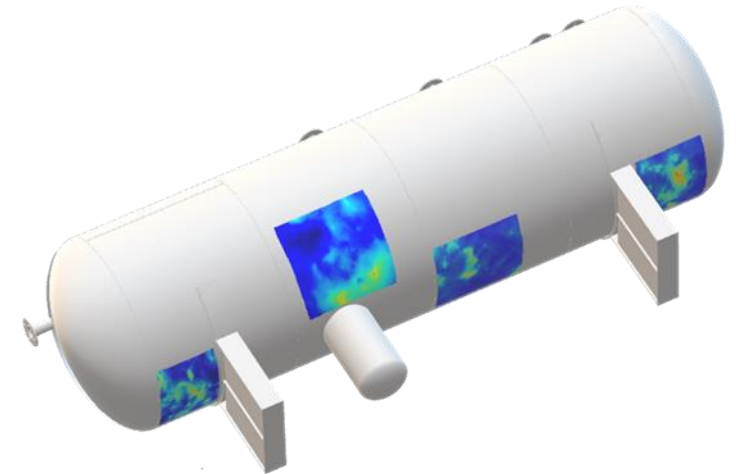
Table 4-18 Suggested inspection methods by vessel feature

Vessel feature	Suggested techniques	Applicable strategy	Note #
Cylindrical and spherical shell (carbon steel)	0° corrosion mapping (PA and single probes)	A, B, C	1
	TOFD fast screening	A, B, C	1
	M-skip (screening)	C	2
	EMAT (screening)	C	2
	SLOFEC/MEC (screening)	C	2
Shell cladding on corrosion resistant alloy clad vessels	UT angled beam shear waves (PA and single probes)	A	3
	UT PA angled beam compression (DMA probe)	A	3
	TOFD fast screening	A	3
	0° corrosion mapping (PA & single probes)	A	4
Base metal/cladding interface on corrosion resistant alloy clad vessels	0° corrosion mapping (PA & single probes)	A	5
	TOFD fast screening	A	6
Seam and girth butt welds	TOFD	A, B, C	7
	UT PA angled beam	A, B, C	7
Set on and set through nozzle barrels	0° linear scans of probes (PA and single probes)	A, B	8
	0° corrosion mapping (PA and single probes)	A, B, C	9
	Radiography	A, B, C	10
Set on and set through nozzles (flange face)	UT PA angled beam	A, B, C	11
Nozzle to vessel welds	UT PA angled beam; Complex geometry TOFD (CGTOFD)	A, B, C	12



NII Evaluation

- Evaluation section separates out conformance and analysis.
- Conformance includes:
 - Coverage.
 - Locations.
 - Techniques and POD.
- **Updated** definitions of conformance.
- Analysis **updated** to include information from HOIS Statistical Analysis RP.



Summary of Changes to the RP

Updates

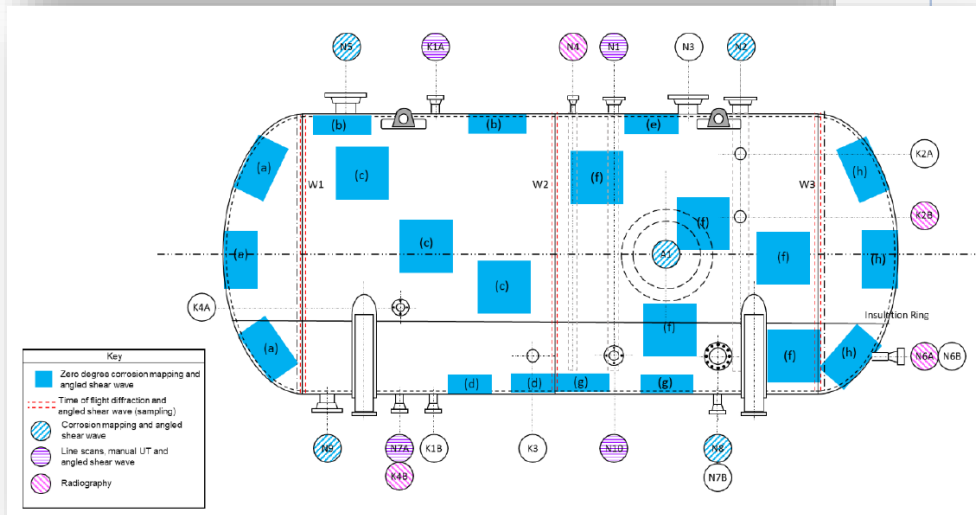
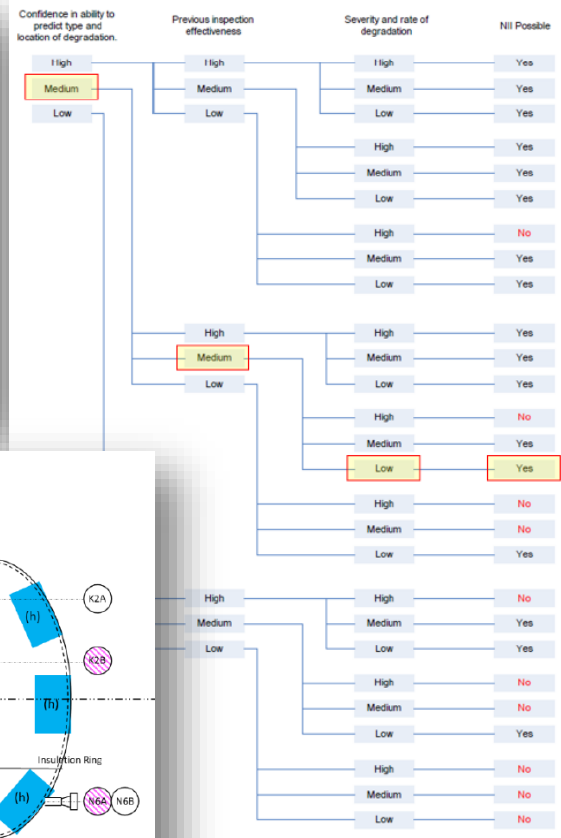
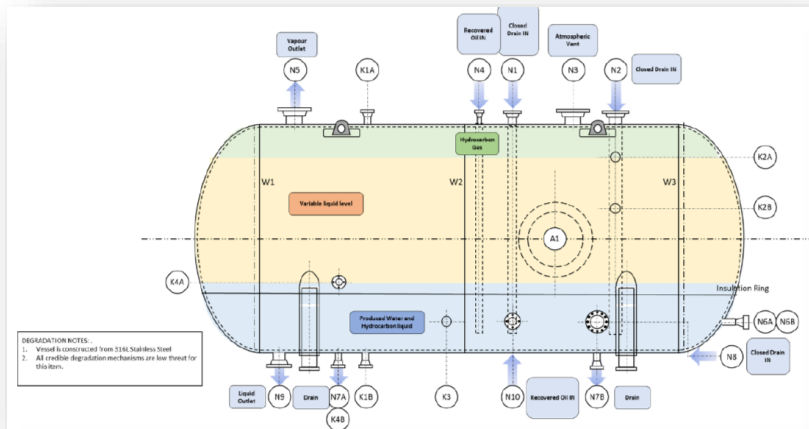
- HOIS publication now; not DNVGL.
- Removed screening condition: designed for NII.
- Type A strategy explicitly allows carbon steel vessels.
- Technique selection advice.
- Conformance levels and evaluation phase.

New

- Strategy flowchart.
- Quantified definition of requirements by strategy type.
- Concepts of homogeneity and spatial distribution of corrosion.
- First in-service inspection guidance.
- Sections/appendices:
 - Review of candidate inspection techniques
 - Clad vessels
 - Design for inspectability
 - Repeat NII
 - NII as the first in-service inspection (FISI)
 - HOIS work on NII and IVI trials
 - Evaluation of inspection performance achieved

The NII Guidance Notes

- OGTC and HOIS project



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Applying the Recommended Practice

- Hydrogen sulphide absorber.
- IVI required:
 - Removal and replacement in the correct order and orientation of >30 trays.
 - Internal scaffolding.
 - Some surfaces obscured from visual inspection anyway.
 - Five-week outage.
- NII campaign:
 - Type A and B inspection.
 - Three weeks with vessel in-service.
 - Cost 50% less than IVI.



What Next?

- Interest in NII continues to grow.
- Advanced inspection techniques becoming more standard.
- HOIS recommended practice for NII on clad vessels published.
- Remote internal inspection (RII) recommended practice being developed.
- Digital twin guidance document being developed.
- Inspections delivering increasing amounts of quantitative data.
- Growing recognition of value of data and benefits of statistical analysis in support of NII.

Q&A:
Dr Susan Osbeck



Q&A Summary

Q&A: Dr Susan Osbeck



Q. Using NII how to you assess a vessel with internal cladding (cladding v wall)?

A. Understanding the type of cladding you are inspecting is important because weld overlay cladding has a much noisier grain than roll bonded cladding so you will get poorer ultrasonic signals. Not all degradation mechanisms in a clad material can be detected using NDT techniques in NII; particularly weld cladding. The aim of the inspection, therefore, moves to detecting any wall loss at the parent material. You can use NII for weld clad vessels but with increased coverage, and having a good understanding of risk.

Q&A: Dr Susan Osbeck



Q. What about if Access is limited?

A. If you needed 100% coverage (i.e. a Type C), but access was limited you can still do it with but with a shorter inspection interval. If you didn't need 100% coverage, then it would be a case of reviewing whether that inaccessible area was at higher risk than the other areas that you can reach. If it was, then NII may not be suitable, but if it experiences similar conditions to areas you can reach, then NII may be suitable with the same inspection interval. You would have to review that after the inspection at the evaluation phase.

Q&A:
Dr Susan Osbeck



Q. For this more comprehensive 3rd Edition, are HOIS currently running / initiating Training Courses to ensure that there is X-Industry, high levels of competence in NII implementation ?

A. ESR Technology offers bespoke training packages in NII.

Q&A:
Dr Susan Osbeck



Q. Can NII be used for internally coated pressure vessels?

A. Yes you can by using a Type C inspection (i.e. 100% coverage) which is a much bigger task. A cost/benefit analysis for a Type C inspection may be useful.

Q&A: Dr Susan Osbeck



Q. How does the update to the RP impact operators that have existing NII assessments in place? are the existing NII assessment in place acceptable? Upon completion of the next NII, do the existing NII assessment need to be revised in accordance with the new RP?

A. Rev3 has not made prev. NII's invalid that was not the intention. The updates should simply have made it easier to plan an NII. Previously planned NIIs are likely to still be suitable but you may find it useful to test out the new Recommended Practice on a few vessels and see if the coverage calculations etc. agree. For any new NII's see new guidance. It is best not to repeat a previous NII scope exactly the same, additional or different areas for inspection should be included. There's guidance on this in the updated RP.

Q&A: Dr Susan Osbeck



Q. Where we have say a solid duplex vessel, hydrocarbon service, no predicted degradation, and no IVI. What's your thoughts: **A.** on NII for first in-service inspection after a few years in service? **B.** High coverage versus low coverage; **C.** Also similar question for C/S vessel with CRA cladding ?

A. It depends on what info. you actually have like good fabrication records, process monitoring etc.

B. NII for first in-service inspection will need greater coverage than a standard NII.

C. Clad Vessels have other risks, and first inspection by NII not really advised.

Rem. A good IVI up front will greatly reduce future NII.