Planning Non Intrusive Inspections

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Presenter

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- 32 Years Hydrocarbon Experience Around The Globe
  - Current chair API Sub Committee on Inspection (Refining Group)

Current job

- Support company operations worldwide on NDE & Inspection Issues. Specific focus on upstream NDE and Pipeline Issues.
- Active in RBI programs for upstream assets.

Setting The Tone

- This presentation is not about effectiveness of NDE techniques per se – that will be dealt with by many other presenters.
- Its not purely about statistics that will also be explored in other presentations.
- This is about how we plan to perform Non Intrusive Inspections to select how much, by what method and with what confidence to achieve our goals.

Definitions

Before we go too far lets define a few terms:

NII: Non Intrusive Inspection – an examination of a vessel or piping system without any personnel entry. Preferred application whilst component is in service.

IVI: Internal Visual Inspection – an examination often termed CVI Close Visual Inspection where entry of the item is achieved and examination is within 36” of the internal surface.

OSI -On-Stream Inspection – API 510 3.43 an inspection performed from the outside of a pressure vessel while it is on-stream using NDE procedures to establish the suitability of the pressure boundary for continued operation. On-stream is defined as a condition where a pressure vessel has not been prepared for internal inspection.

Methodology for Comparison of Regimes The Problem

Inspection planning requires a compromise between

- probability and rate of degradation
- probability of detection (specific to degradation morphology)
- quality and cost of inspection (both previous and next)

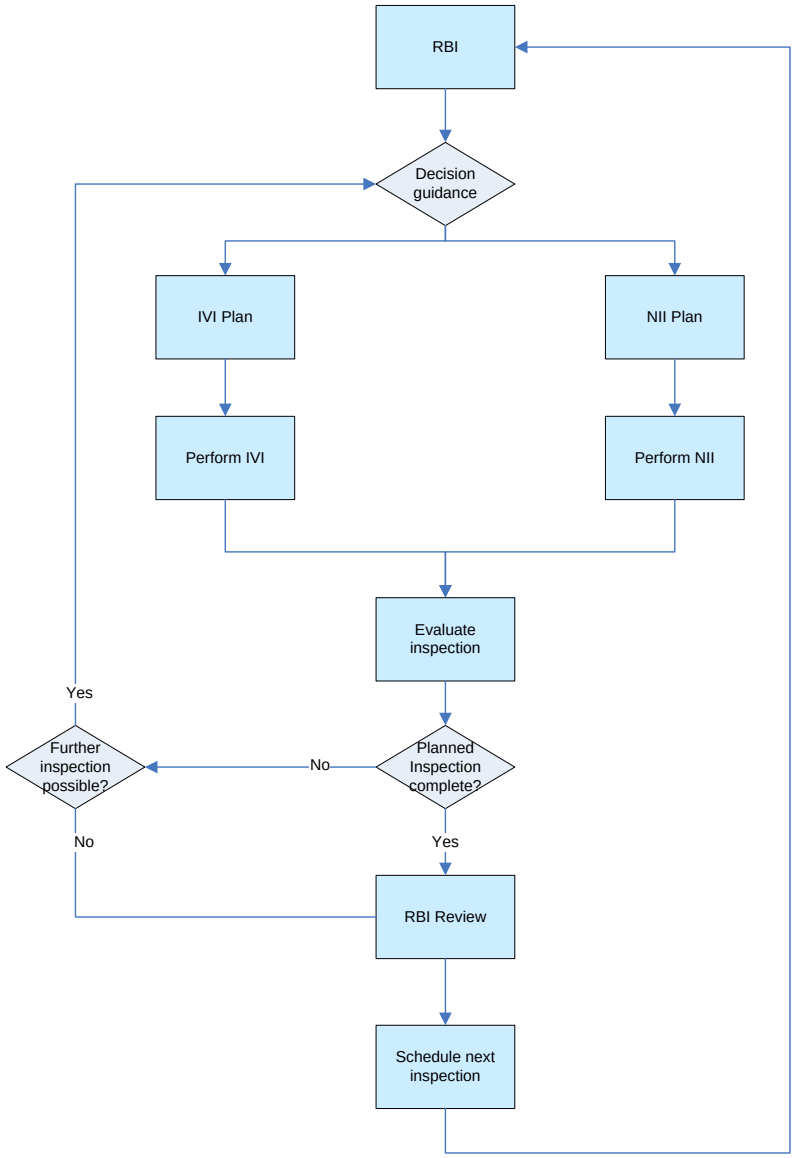
down time / lost production

- accessibility

At present there is no robust methodology for comparing and contrasting alternative inspection regimes.

- POD data used to compare individual inspection activities
- No basis for assessing regimes based on combinations of multiple techniques / interim examination
- Basis for converting RBI assessment to an appropriate inspection regime

Relationship of NII & RBI

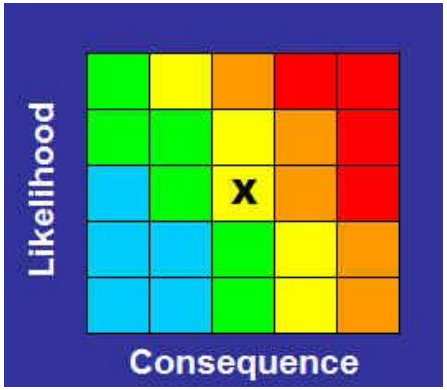


Application of NII in RBI systems

- Existing work in HOIS NII project has looked at how NII is integrated in RBI systems.
- New work phase will review DNV RP-G101for enhancements.

Link Between NII and RBI (cont)

RBI gives a risk ranking based on likelihood / consequence.



But what does this mean in terms of inspection?

- The answer will vary according to the type of inspection
- The answer will vary according to previous inspection quality
- What happens when NII is used as an interim inspection

What is needed is a robust methodology to convert the results of an RBI assessment into an appropriate NII plan

Link Between NII and RBI (cont)

Inspection interval is a trade off between

- probability of detection
- rate of degradation
- previous inspection quality
- inspection results.

Inspection interval is a function of inspection quality

- potentially different depending on NII / IVI
- depends on quality of last inspection complete / incomplete
- NII RP document advises on interval where NII is incomplete

Many RBI software tools produce automated inspection plans

- Currently based on IVI and “conventional” techniques
- different schedules required for IVI and NII

Link Between NII and RBI (cont)

		Confidence Grade			
		0	1	2	3
Risk Classification	1	12 / 0.1	36 / 0.125	36 / 0.16	36 / 0.2
	2	12 / 0.175	36 / 0.23	72 / 0.29	72 / 0.35
	3	24 / 0.25	48 / 0.33	72 / 0.42	96 / 0.5
	4	36 / 0.375	48 / 0.5	84 / 0.625	120 / 0.75
	5	36 / 0.5	48 / 0.67	96 / 0.83	240 / 1.0

Matrices define acceptable NII / IVI intervals

- Based on confidence grade (similar to IP 12 / IP13)
- Use risk classification from RBI
- Function of remnant life or maximum interval
- Methodology needs to be developed to handle different inspection methods, locations, sample size and degradation types.

Methodology for Comparison of Regimes Way Forward

The objective is to provide a semi-quantitative approach to inspection planning process.

- Should allow different combinations / frequencies of inspection to be compared and contrasted in a robust manner.
- Should include traditional inspection techniques
- Should provide a robust basis for interpreting RBI assessment

Based on an understanding of the desired reliability

- eg 10^{-5} depending on RBI assessment of risk

Requires an understanding of POD

- As a function of coverage
- As a function of defect size, distribution and morphology
- As a function of combination of techniques applied

Requires a model for the reduction in reliability against time

HOIS 2000 JIP Members

A mix of owner-users, service providers, regulators and equipment manufacturers focused on NDE & inspection development.

HOIS project on NII – Background

Project objectives to develop a document providing detailed guidance on NII.

- When can NII be used
- How should NII be implemented

Aim was to provide users with a sound approach to NII, allowing benefits to be realised without compromising safety.

Approach was to ensure NII delivers similar or improved capability compared to IVI.

IVI provides ready evidence of condition in many cases

HOIS project on NII – Background

- HOIS Guidance has been used in facilitating NII on a significant number of vessels offshore since 2003.
- Implemented by a range of operators, early applications by HOIS member companies in the UK North Sea but subsequent more widely used both in UK and internationally.
- NII following HOIS guidance is now built into the integrity management approach for a number of operators.
- Document developed by HOIS was published as DNV RP-G103 in 2007.

DNV RP G-103 Non Intrusive Inspection.

The recommended practice provides guidance for:

i) determining when NII is appropriate in principle

ii) information requirements to plan for NII

iii) defining the requirements for the NII method(s) to be selected

iv) selecting methods that meet the requirements

v) evaluating the results of the inspection

vi) documentation requirements.

Planning for an NII.

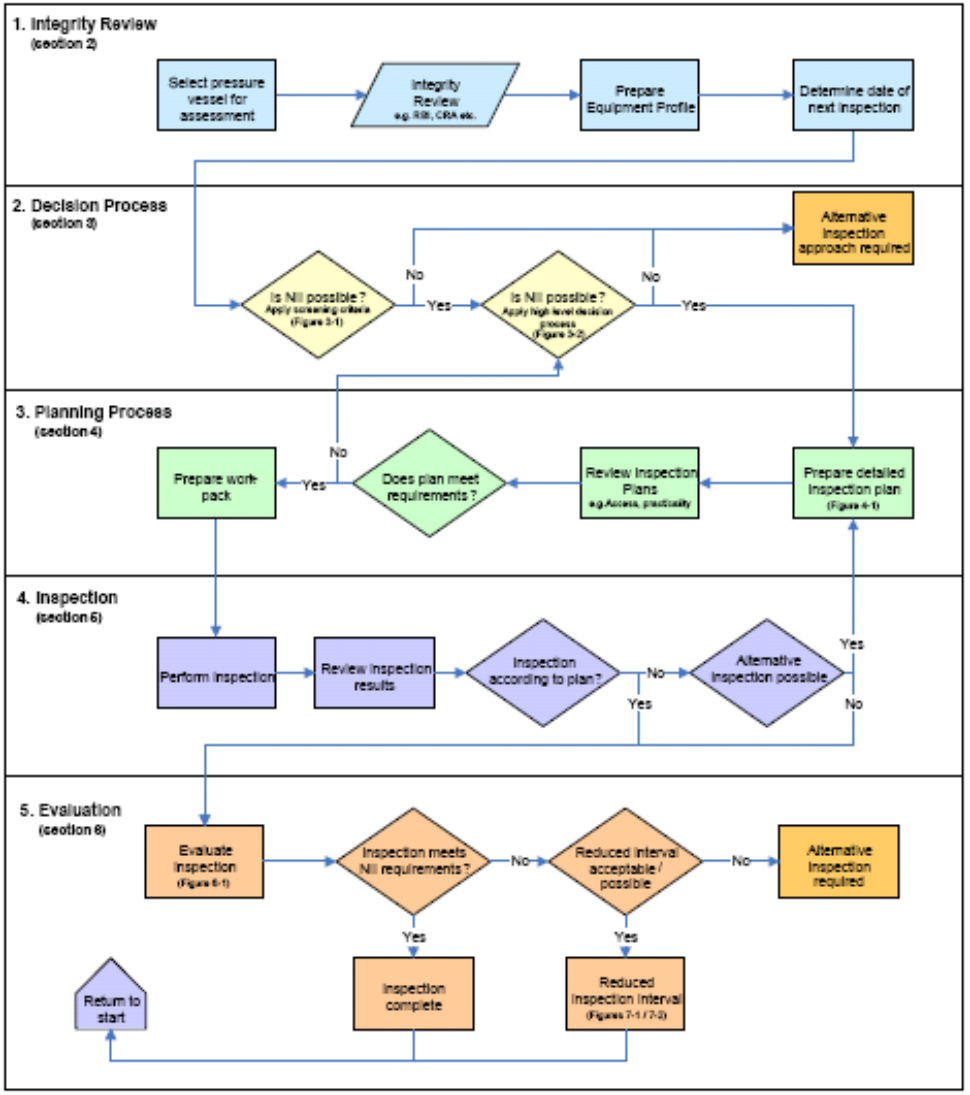
Questions that should be addressed may include:

- **Is the inspection to complement an internal inspection program?**
- **Is the inspection intended to replace an entire internal inspection or an internal inspection regime?**

Potential benefits of performing an NII include:

- Avoids man access which can be hazardous
- Planning for turnaround / shutdown.
- Shortening the turnaround.
- Removal of requirement to break containment.
- Minimizes disturbances to the vessel which could create new problems.
- It may be possible to avoid the need to shut down the vessel operation entirely.
- Allows the inspection to be carried out when a potential problem is identified, without interfering with other operations.

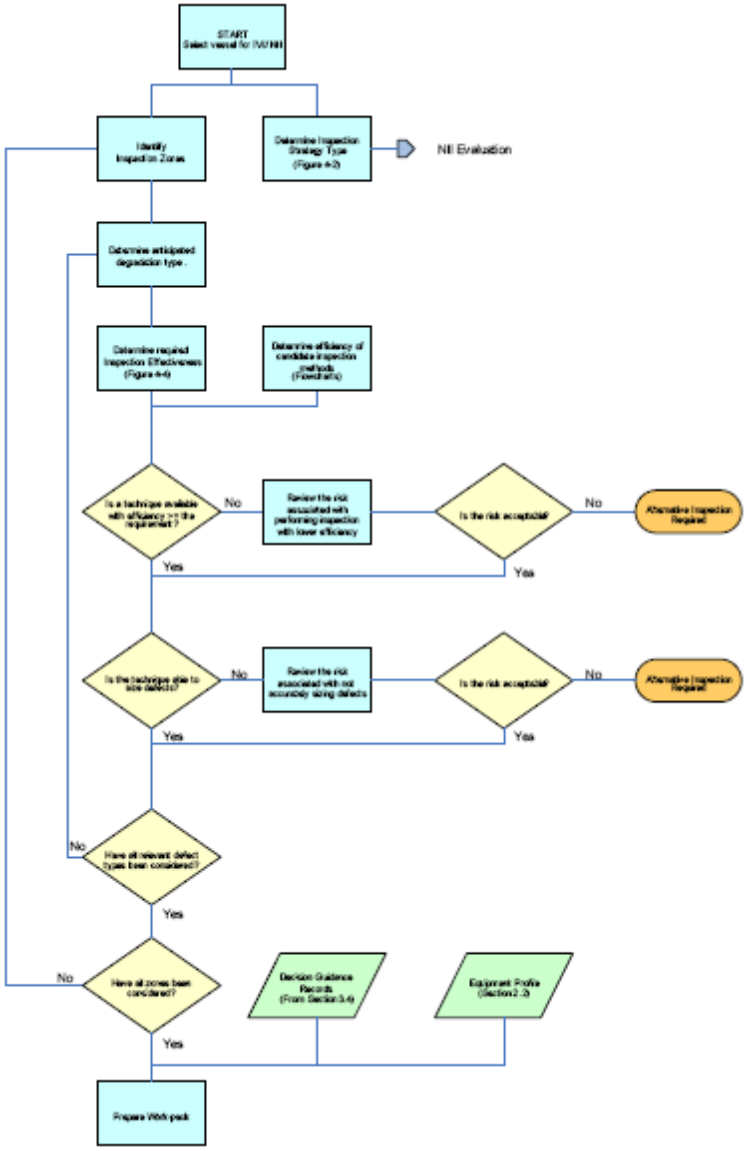
NII Decision Process



NII Screening Process

High Level Screening Guidance

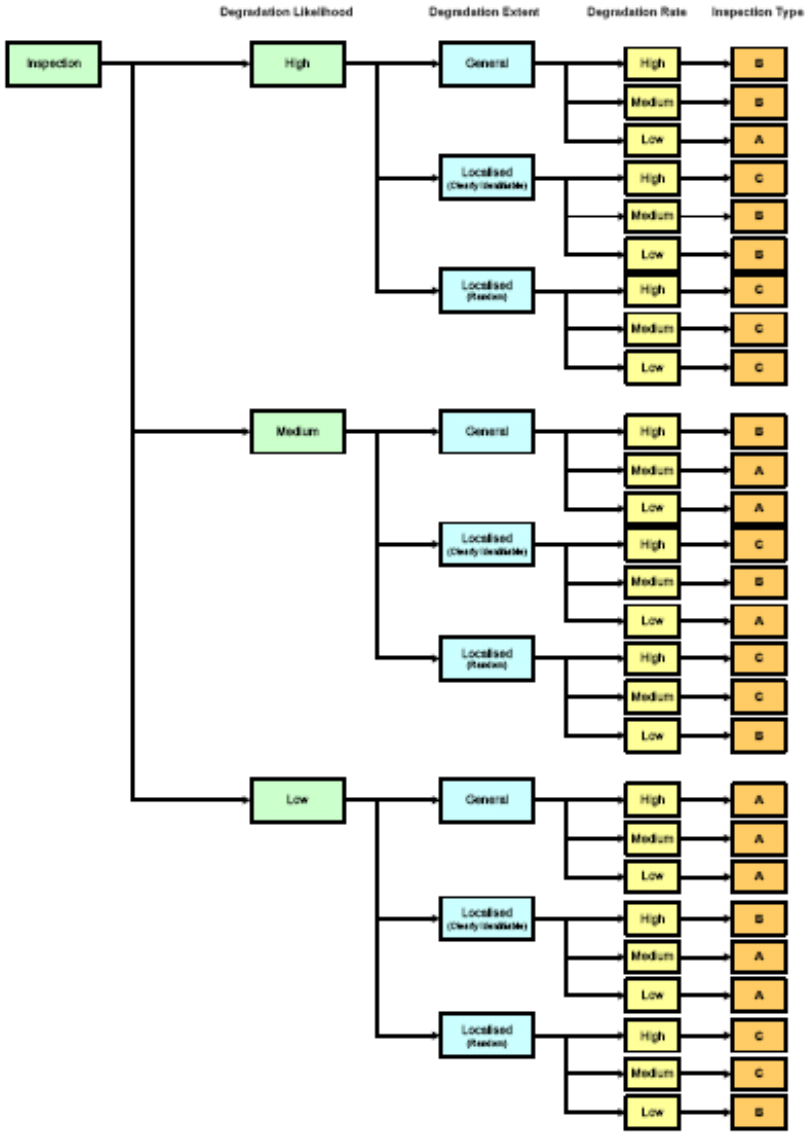
Inspection Planning Flowchart



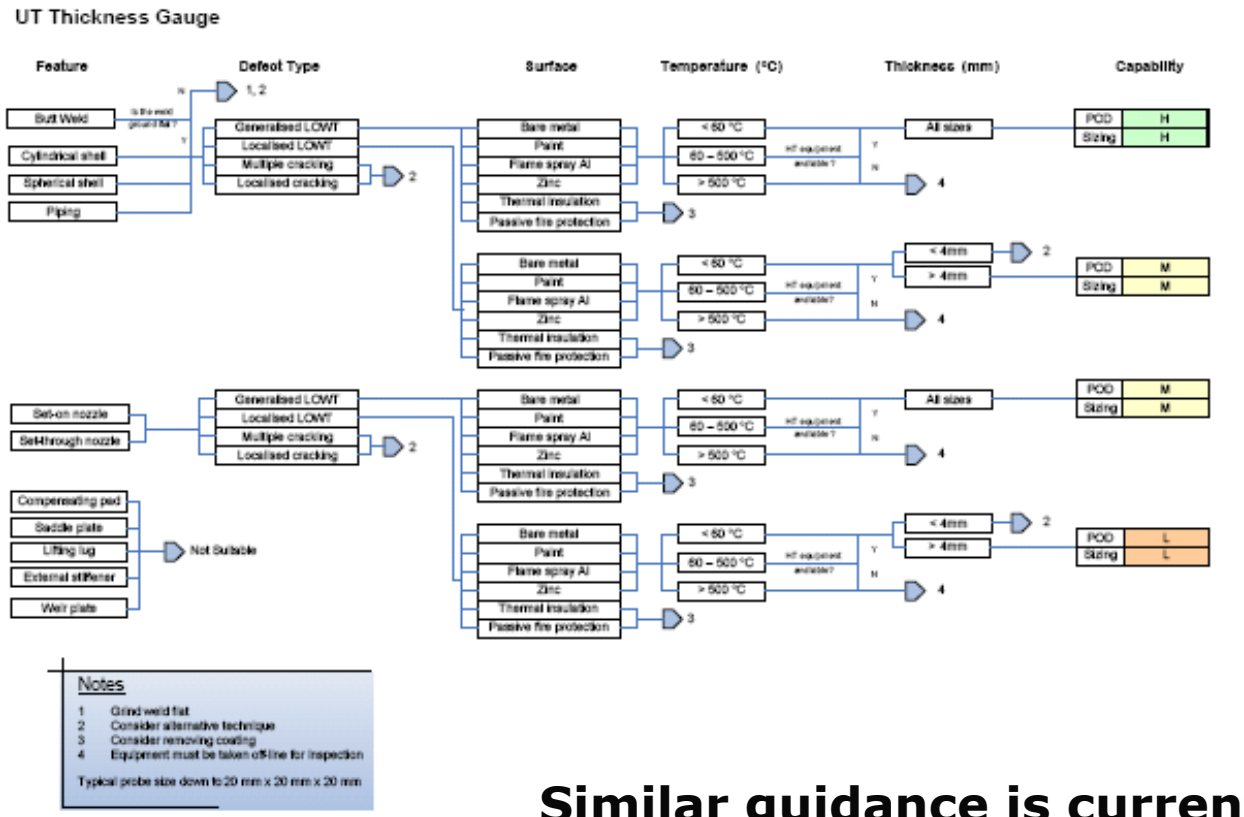
Inspection Type Definitions

Type	Definition
A	Degradation mechanism NOT expected to occur. Inspection is required to confirm there is no onset of degradation mechanisms.
B	Degradation mechanism expected with low/medium progression. Location of degradation can be predicted. Not anticipated to impact on vessel integrity in the medium term (typically at least 2 outage periods). Inspection required to confirm CRA prediction.
C	Degradation expected with medium/high progression. Location of degradation cannot be predicted. MAY impact on vessel integrity in the medium term(2 outage timeframe) Inspection required to confirm absence of flaws of critical size.

Selection of Inspection Type



Flowcharts for NDE selection/effectiveness.



Similar guidance is currently under development for API RP 571

NII Challenges

- There are many cases where the actual inspection falls short of the requirements, e.g. access restrictions, surface conditions. Is there sound guidance on dealing with these cases?
- NII is used increasingly for deferment of internal inspections. How is this handled in the guidance?
- NII is often applied within systems where Risk Based Inspection planning is used. The interactions need to be considered further.

Guidance on impaired NII

- **Actual inspection possible and/or achieved may be less than would be ideal when following the HOIS Guidance.**
- **Section 7 provides guidance on how to identify significance of anomalies.**
- **Considers that response to impaired NII will usually be a reduction in interval determined by extent to which *coverage* is impaired and extent to which basic inspection *capability* is impaired.**

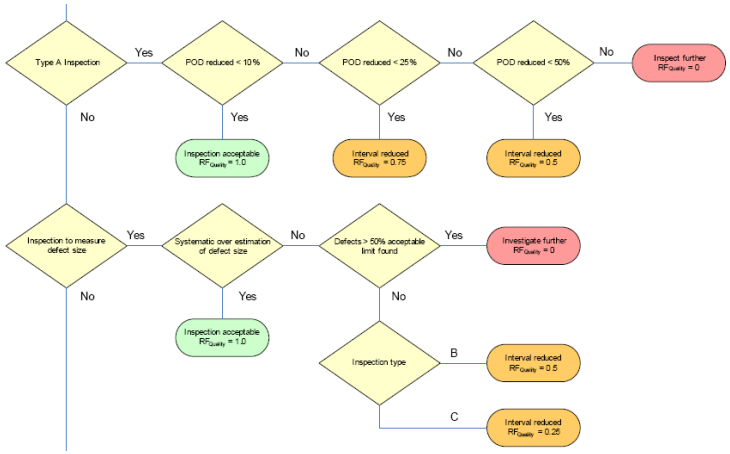
$$Interval_{NII} = RF_{Quality} \times RF_{Coverage} \times Interval_{IVI}$$

Where

$Interval_{NII}$	is the new inspection interval following NII
$RF_{Quality}$	is the factor determined from Figure 7-1
$RF_{Coverage}$	is the factor determined from Figure 7-2
$Interval_{IVI}$	is the inspection interval based on IVI inspection

Guidance on impaired NII

Approach is based on flow charts, principle is sound but has not been widely assessed in practice. Would benefit from more actual testing, either retrospectively or in inspections planned by HOIS members.

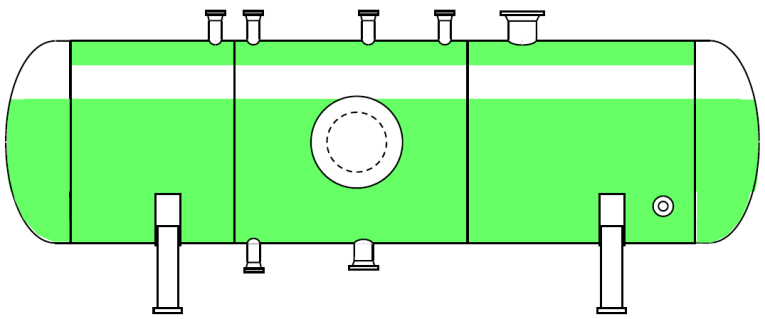


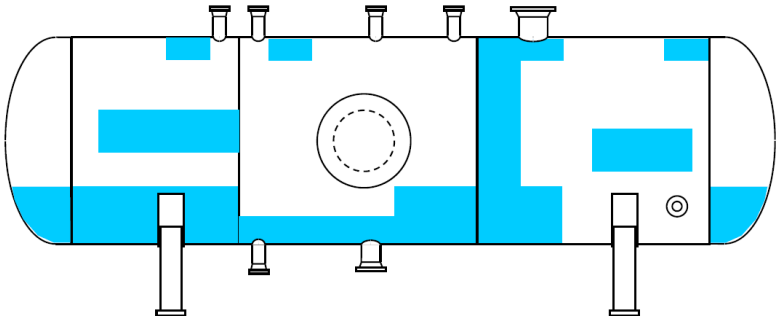
Emphasis at present on inspection effectiveness. A review including input from Corrosion Engineering and Mechanical Integrity disciplines may provide more complete answers? How would this be included in the approach?

Guidance on impaired NII

An understanding of restrictions can often be obtained at the planning stage, e.g. site survey carried out beforehand. There is no clear guidance in the document on impairment identified at this stage, i.e. Interval adjustment is currently only *after* the inspection. This could be addressed.

Restrictions identified should be used to define effective approach for circumstances, e.g. Confidence can be severely influenced by missed coverage with qualitative screening technique and a lower coverage with accurate quantified technique may be more suitable. Important to understand different approaches to optimise when there are restrictions.





Guidance on impaired NII

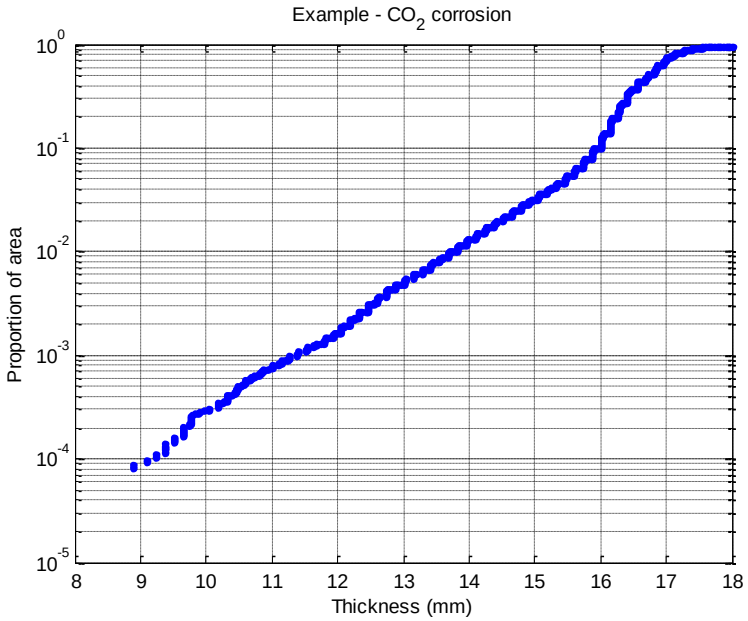
- Statistical analysis is a useful tool for dealing with reduced coverage so should be considered where possible following impaired inspection.
- Type of statistical approach that can be applied and the value of the results depends very much on the nature of the data collected, i.e. Inspection technique is an important factor.
- An understanding of statistical methods and how they might be applied in specific corrosion conditions is very helpful at the planning stage.

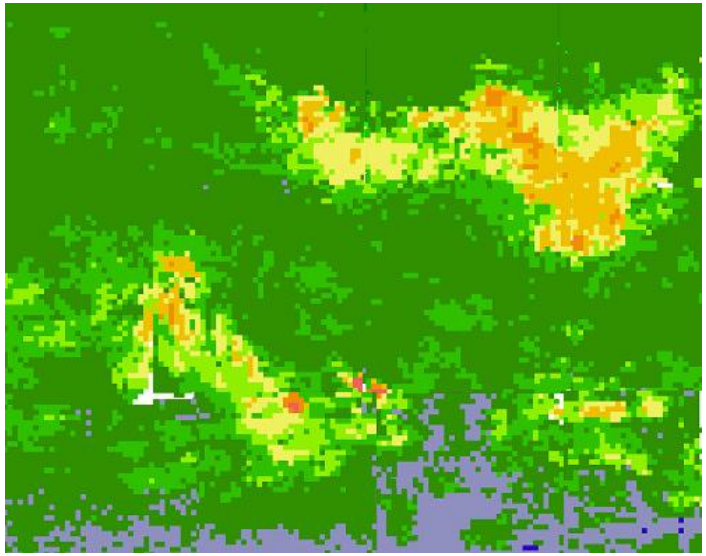
Guidance on Statistical Methods

- Some guidance is provided covering use of statistical methods.
- Application remains limited because of lack of confidence and/or lack of knowledge of when/how/if the methods should be applied.
- Much evidence is available that there is a real basis for use of these methods and they can add value to data gathered.
- NII document at present lacks concrete examples of application in real situations. Addressing this would increase confidence.

Additional guidance on statistics

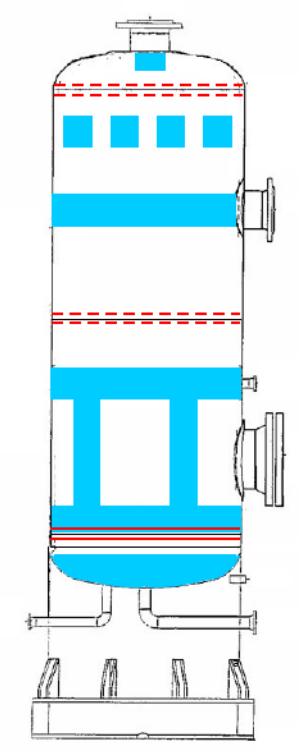
- Propose that guidance includes examples showing that real corrosion processes often result in damage with underlying characteristics that can be approximated by statistical descriptions.

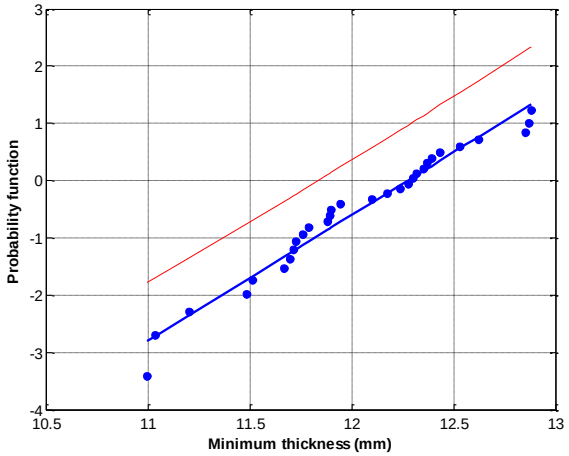




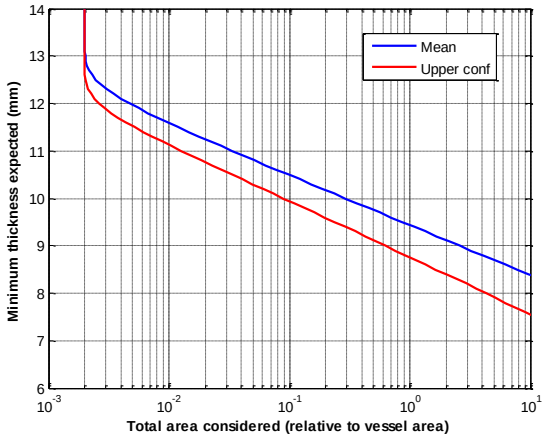
Additional guidance on statistics

- Include examples showing application of estimates based on limited data (e.g. Extreme value analysis).





Estimates of minimums based on EVA and assessment of confidence. Can demonstrate coverage was sufficient or specify additional inspection.



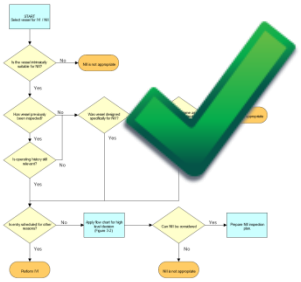
Additional guidance on statistics

- There is value in using statistical methods in planning for NII and also in assessing the results. The guidance could ensure the benefits are achieved in practice by improving understanding of where these methods are appropriate and, more importantly, what the limitations are and when they should not be used.

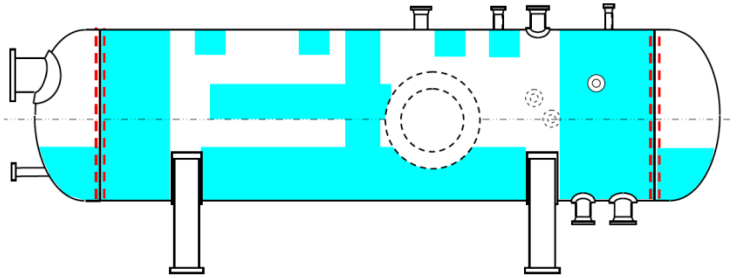
NII in support of Deferment

HOIS NII approach is designed for cases in which NII is used as a *full alternative* to IVI with no change to intervals imposed.

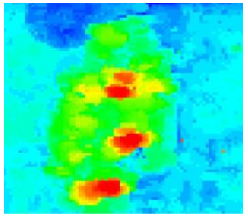
NII Assessment



Workscope meeting requirements



Carry out NII and Evaluate



Full assigned inspection interval

Next Inspection

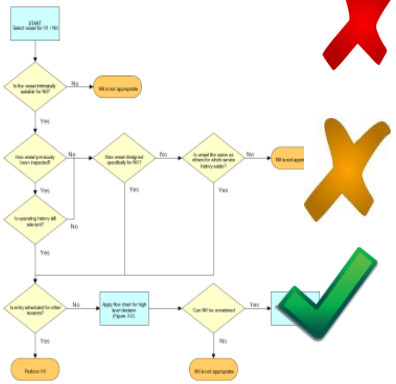
NII in support of Deferment

- There are cases where NII is deemed inappropriate in the published approach but it may be acceptable in support of a short period of deferment.
- In some cases NII may be deemed appropriate but the requirements, aimed at the full assigned interval, are probably more than necessary for a much shorter interval.
- Inclusion of simplified guidance would benefit users.

NII in support of Deferment

- Cases where NII is deemed inappropriate in the published approach but it may be acceptable in support of a short period of deferment.
- Under what circumstances is NII acceptable, what are the key factors affecting the decision and how can the significance of these be adjusted when a shorter interval is to be applied?
- Weighting assigned to factors so that a total impact on the allowable interval can be calculated, e.g.

NII Assessment



NII acceptable to support ¼ of assigned interval

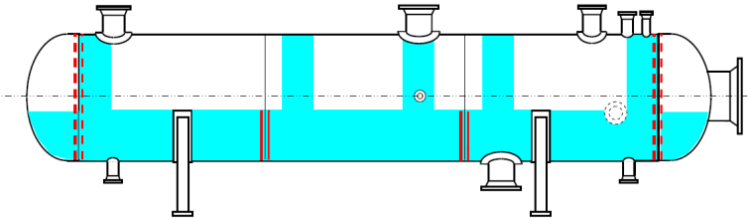
NII acceptable to support ½ of assigned interval

NII acceptable to support assigned interval (present case)

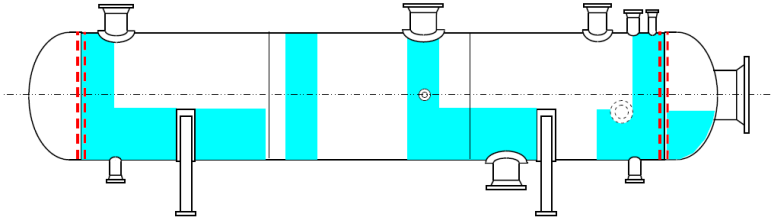
NII in support of Deferment

- Cases where NII may be deemed appropriate but the requirements, aimed at the full assigned interval, are probably more than necessary for a much shorter interval.

- Approach designed to be consistent with existing guidance on change to intervals following NII that does not conform to inspection plan, i.e. correlation between inspection effectiveness and permissible subsequent interval.



Effectiveness factor = 1
Full assigned interval



Effectiveness factor = 0.75 (?)
Up to 75% of assigned interval (?)

Application of NII in RP-G101 Summary of key points

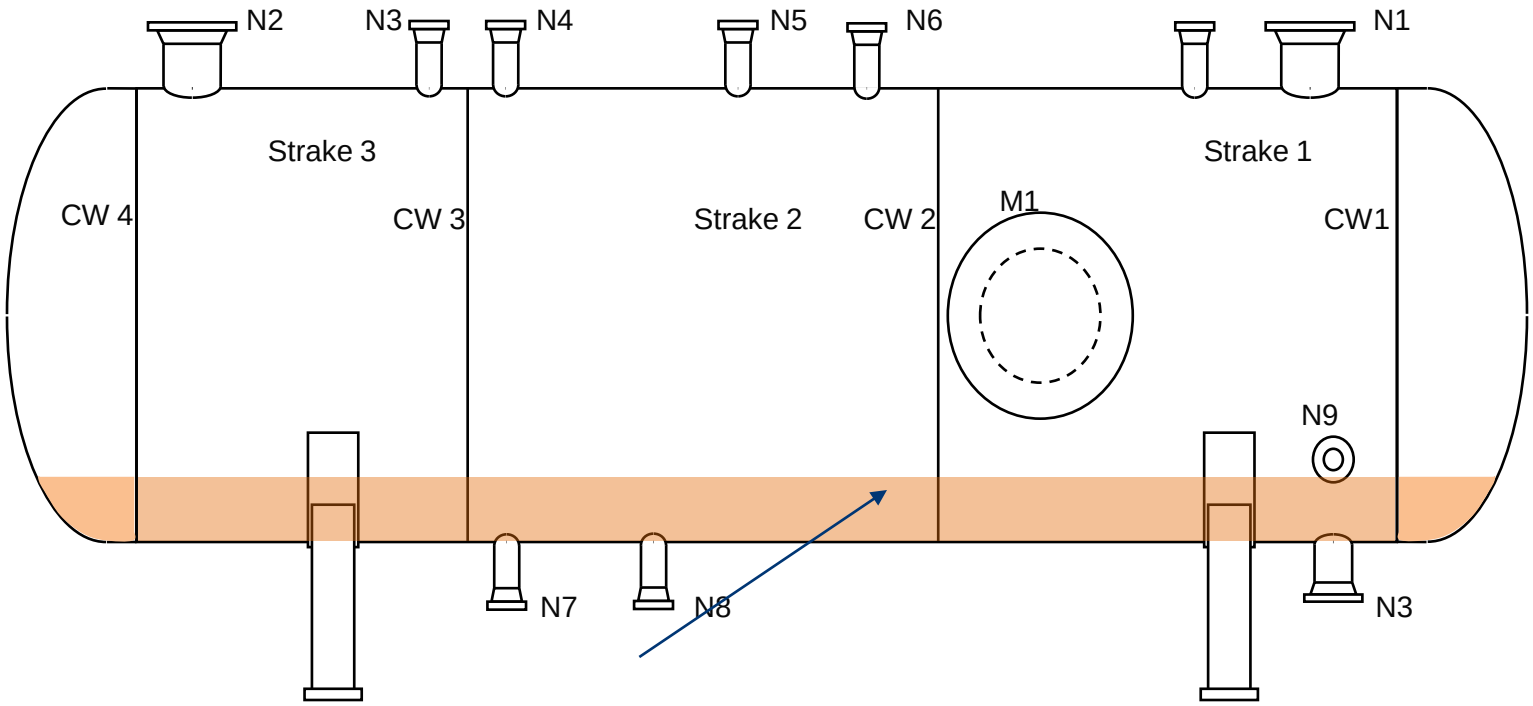
- RP-G101 uses a risk ranking approach, sets intervals and provides an outline approach to planning.
- Is not prescriptive and does not make a clear distinction between NII/IVI (is mainly intended for pipework).
- Provides broad guidance on methods of inspection, coverage, locations etc.
- Focus is on an Effectiveness parameter.
- NII as per published Guidance is easily included in the planning approach.
- Subtle difference in emphasis, RBI documents may emphasise inspection as a means of providing quantified data to update RBI assumptions (corrosion rates etc) whereas HOIS NII emphasises assurance aspect to a greater degree, i.e. provide confidence that significant degradation is not overlooked.

Example One

- Flare Knock Out Drum commissioned in 1995
- Three previous inspections by IVI. Three previous IVI on the HP Flare KO Drum which is expected to have more severe corrosion conditions.
- In the previous two inspections widespread pitting to a depth of 1-2 mm has been identified along the bottom of the vessel shell and ends.
- Managed under RBI programme that sets intervals, next inspection due and intended to be NII.
- RBI approach is underpinned by a corrosion risk assessment and regular integrity reviews.

Summary of Corrosion Review

Upset conditions could have operation below dew point– water condenses at the top of the vessel



Corrosion review indicates potential high corrosion rate over lower part of vessel and confirmed by previous internal inspection

NII Assessment - Summary

- *Confidence in ability to identify types and locations of degradation*

  Three previous IVI on this vessel + info from HP Flare KO Drum and backed up by type 2 CRA → **Medium**

- *Previous inspection effectiveness*

  The previous inspection was by IVI → **Medium**

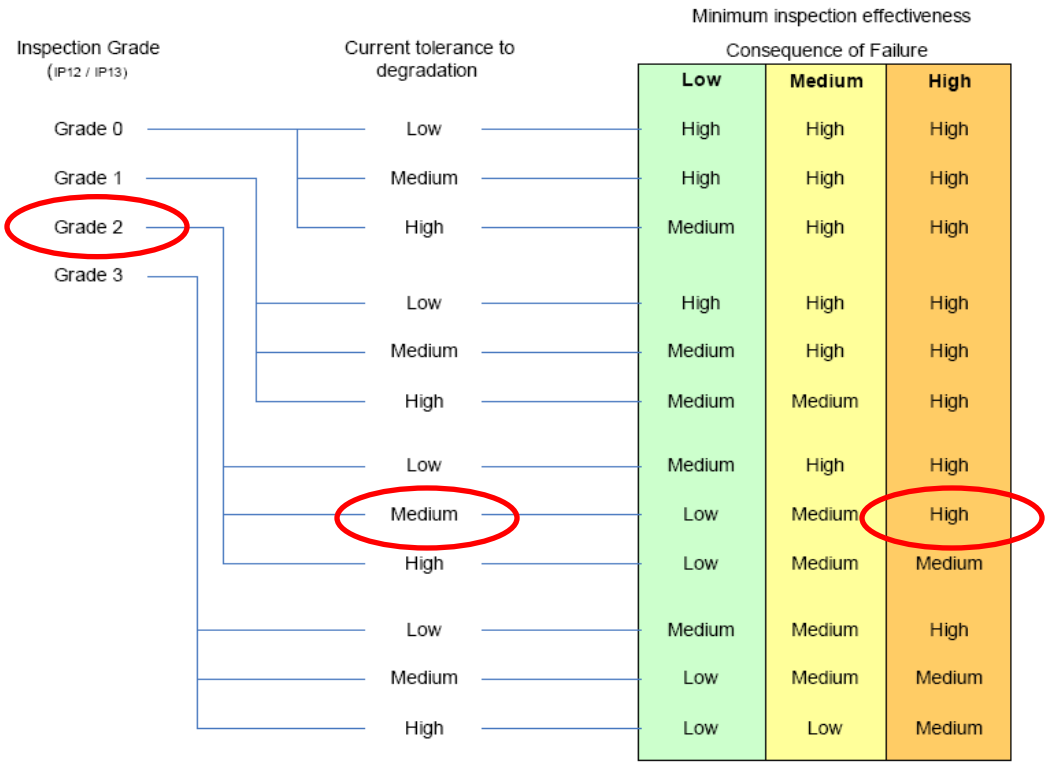
- *Severity and rate of degradation*

  Corrosion rates have been assessed and analysis indicates integrity is unlikely to be affected in the remaining life of the installation → **Medium**

- Outcome is NII is applicable.

NII Requirements

- Vessel is currently Inspection Grade 2
- Consequence of failure has been assessed as High
- Effectiveness required = **High**



NII Requirements

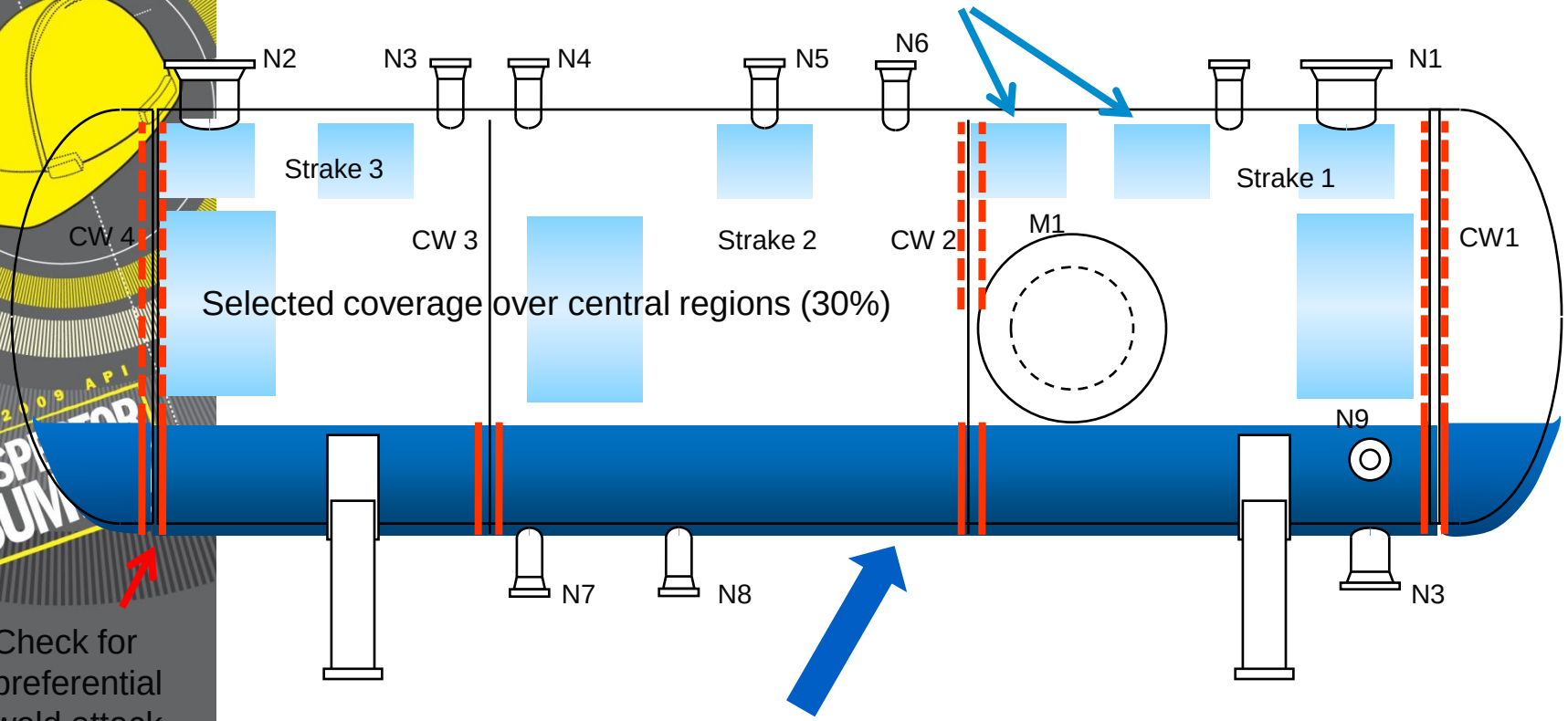
High Effectiveness

- 100% inspection of the planned inspection area using a method which has high efficiency, i.e. expected to have a probability of detection exceeding 90% for the degradation or flaws of concern.
- The area for inspection is to be set such as to allow meaningful extrapolation to un-inspected material expected to be subject to similar (or more benign) corrosion conditions.

A Type B strategy is aligned to the conditions for this vessel and this suggests that inspection coverage can be selective, aimed at ensuring that sufficient sample areas, representative of the worst conditions within each degradation zone, are covered.

NII Plan

Selected coverage (20%) over regions near top of vessel to identify if condensation related corrosion is active

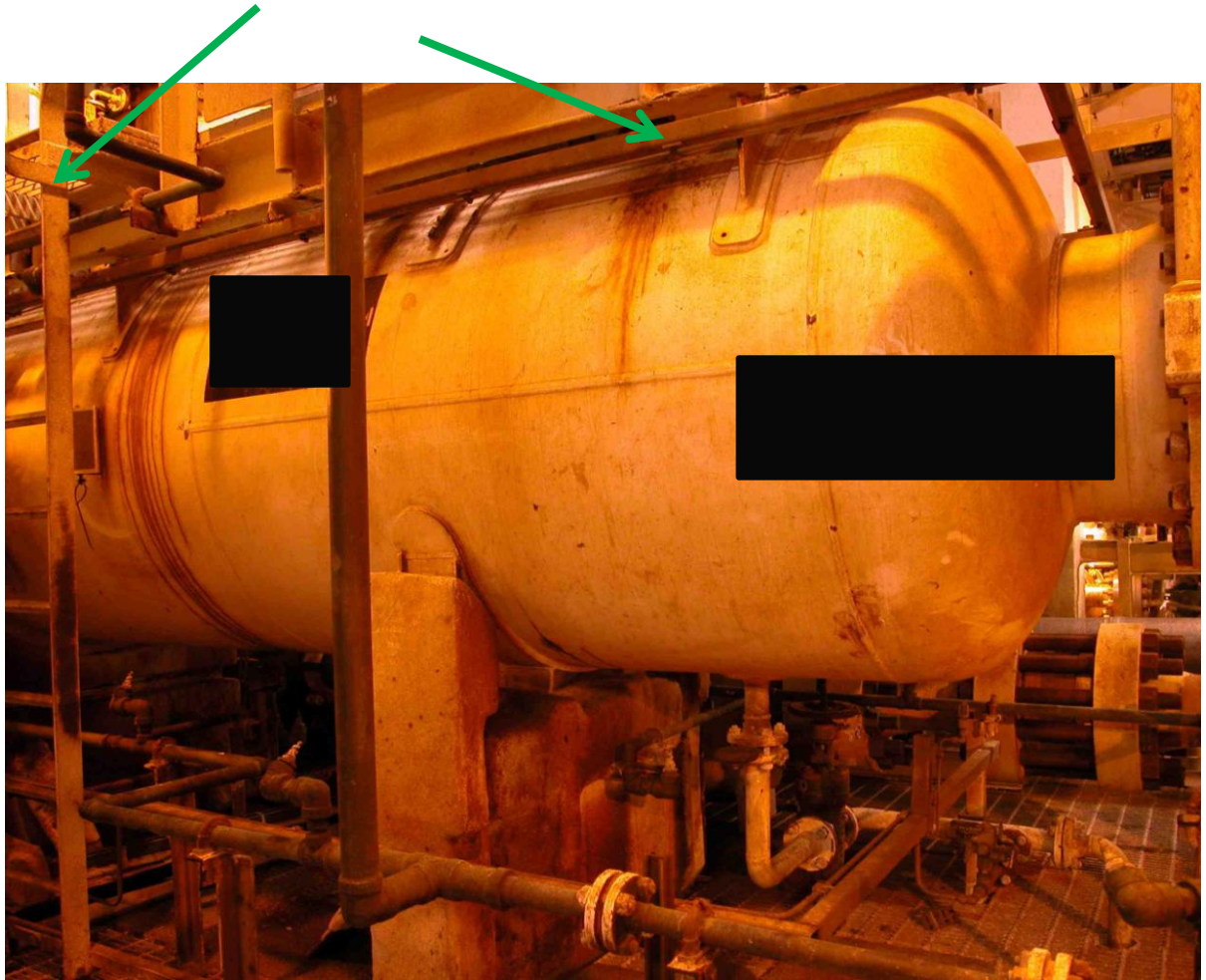


Check for preferential weld attack, particularly in lower regions

Lower region – 100% coverage using technique with high POD for local and general wall loss

What was unknown

- The East side of the upper part of the vessel is not accessible because of structural steelwork (Example)



What was unknown

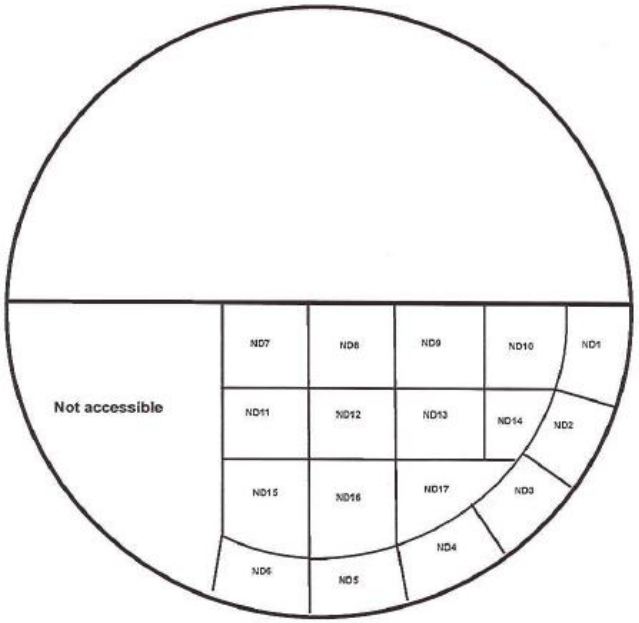
- The West side of the upper part of the vessel has limited access because of structural steelwork (Example)

What was unknown

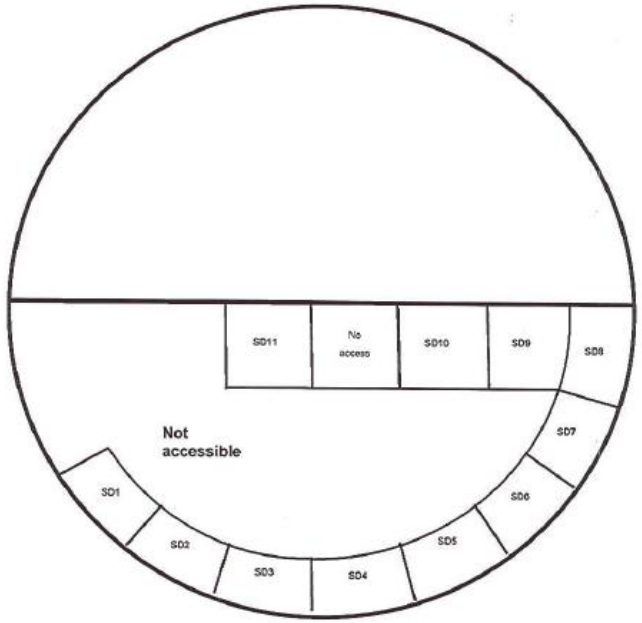
- There is an area towards the liquid drain end where an external water leak has led to severe surface corrosion
- Some of the nozzles at the top of the vessel have excessive and irregular paint build up
- Access to some of the nozzles near the bottom of the vessel is difficult and exposed nozzle barrels are short

What the report might say

Incomplete scanning of areas on dished heads



North Dome

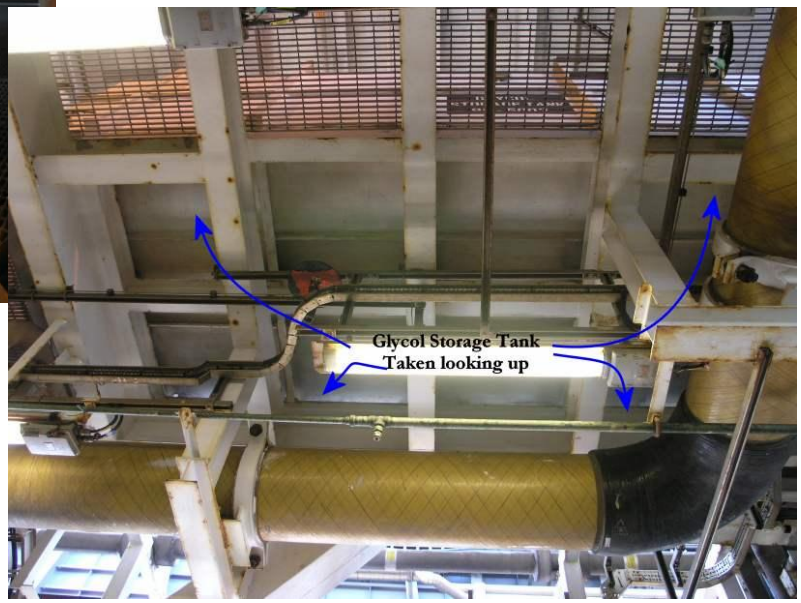


South Dome

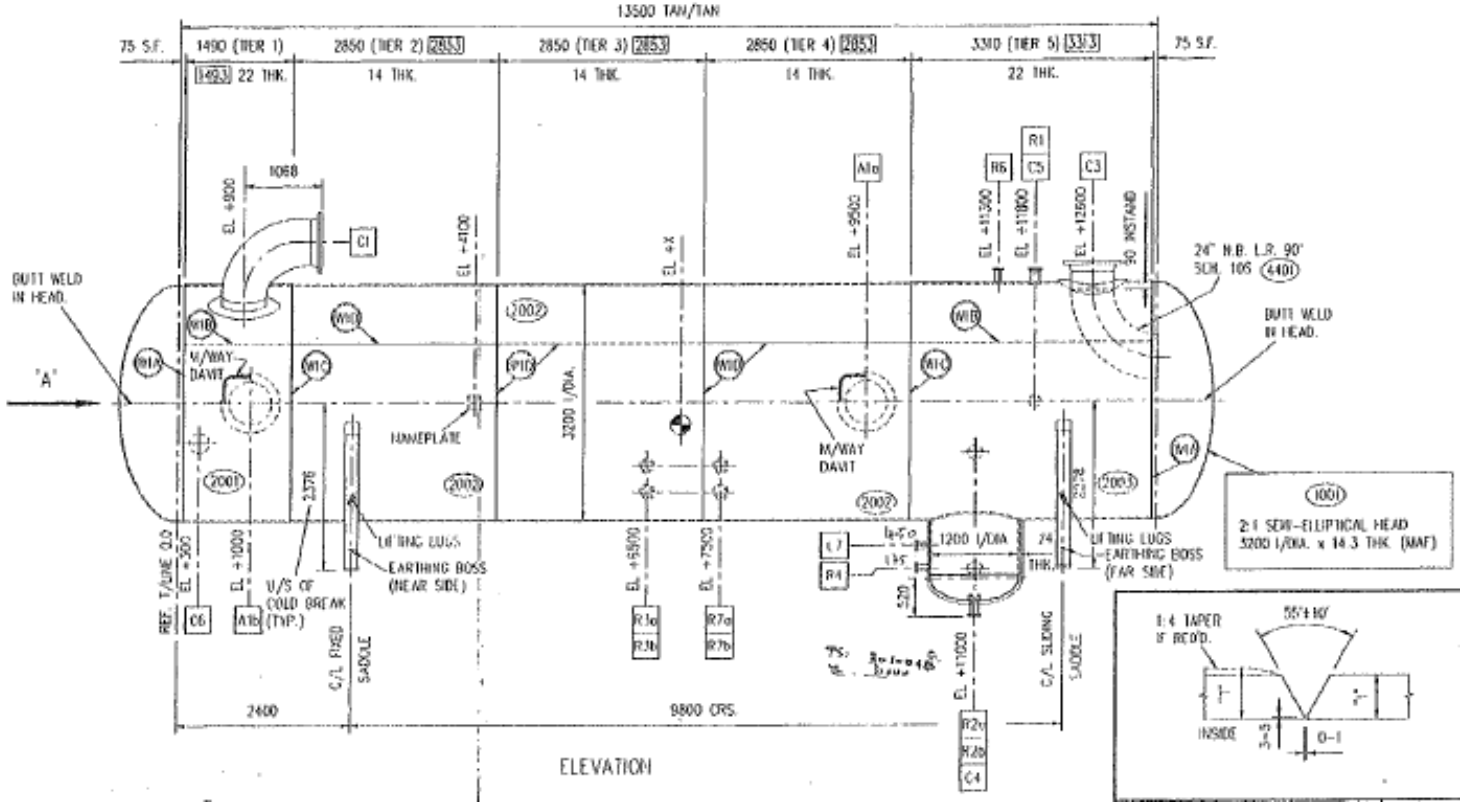
Not an isolated problem!

Easy access from this viewpoint!

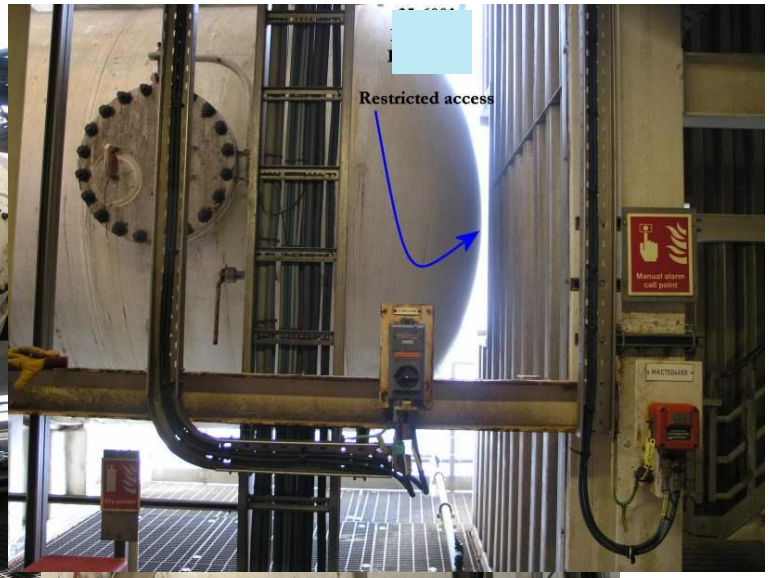
Can we still apply NII?

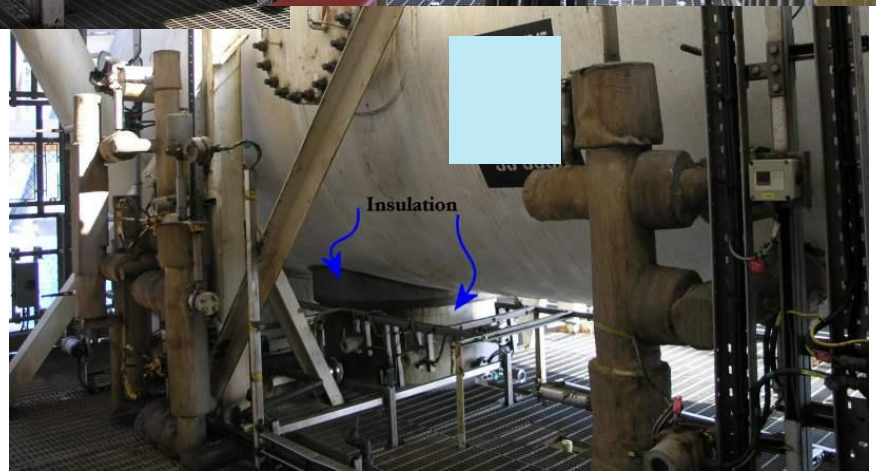


Per the drawing NII should be straightforward!



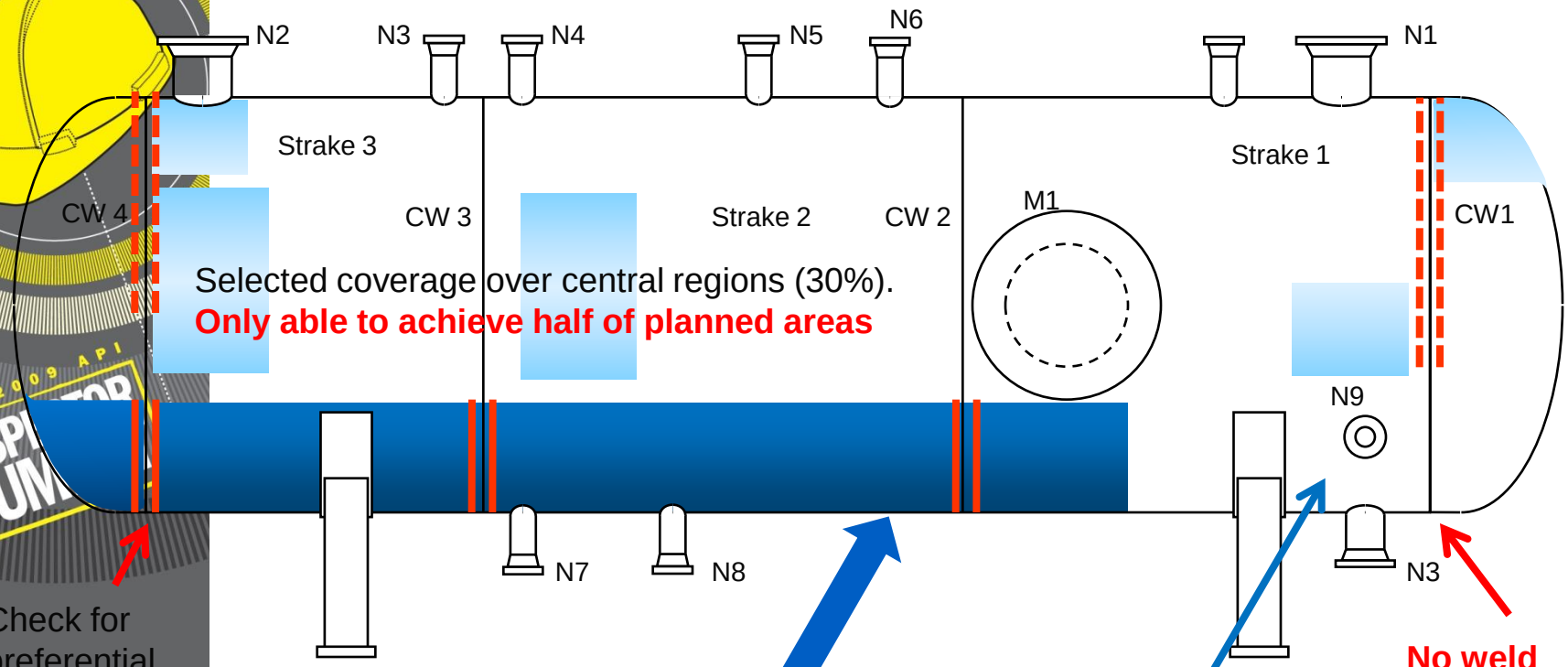
The vessel in reality…





How does this affect our NII?

Selected coverage (20%) over regions near top of vessel to identify if condensation related corrosion is active. **Mostly unable to achieve**



Check for preferential weld attack, particularly in lower regions

Lower region – 100% coverage using technique with high POD for local and general wall loss. **Unable to achieve over 30% due to poor surface**

No weld inspection in lower region

Can we achieve a meaningful NII?

- Are we really able to achieve the objectives of the inspection?
- Are there some areas where we do not get sufficient information to establish confidence in condition?
- To what extent is extrapolation (statistical or otherwise) valid when a limited amount of data is available?
- Should we recommend blast cleaning of some of the nozzles and other areas of poor surface?
- To what extent can we take the results of NII in these circumstances as being a replacement for IVI, e.g. Should we look at a reduced interval to the next inspection, can we use the results for re-grading?

Questions ???

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