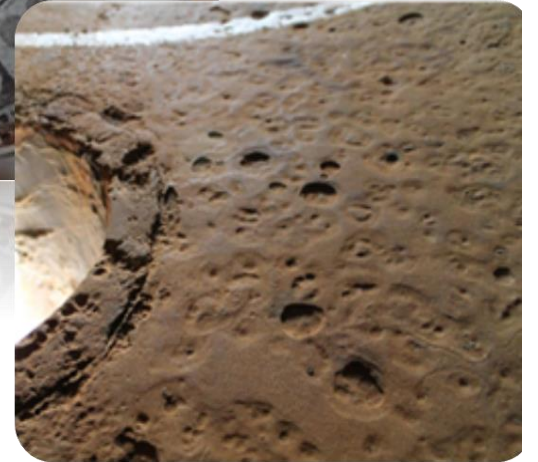


Highlights of HOIS-RP-058 Recommended Practice for remote internal inspection of pressure vessels

HOIS Symposium
January 2024

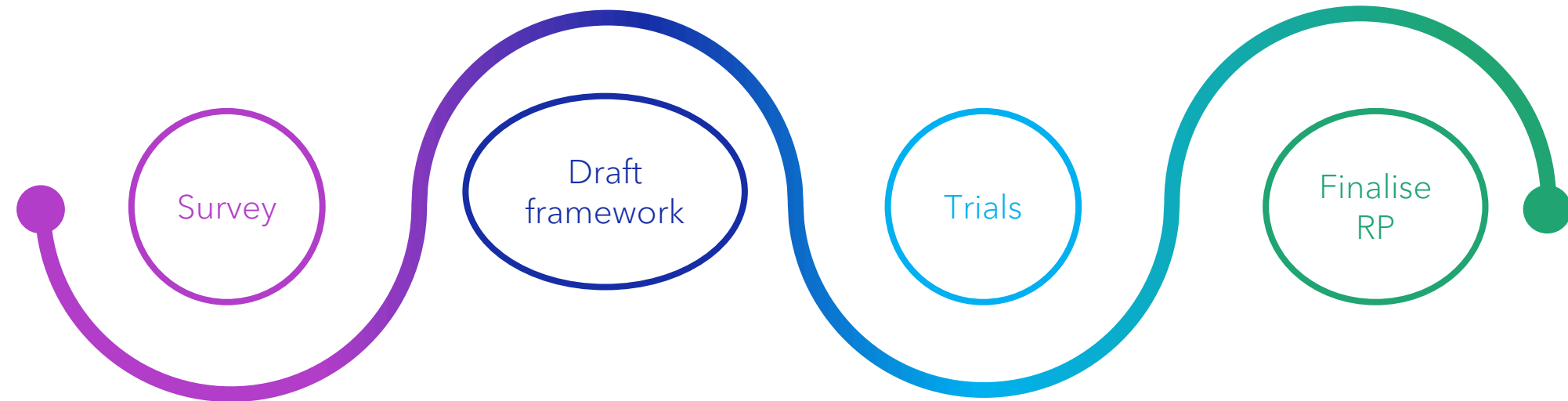
Dr Helen Peramatzis



Motivation

- Pressure vessels and pressure systems represent high hazard items.
- Safe operation relies on assessment of their condition which requires inspection for internal degradation.
- Internal visual inspection (IVI) is widely accepted and understood by asset operators and regulators.
- Remote internal inspection (RII) provides operators with key benefits.
- HOIS members report that RII is increasingly used to replace or supplement IVI where externally applied NII is not a viable alternative.
- Up to now there has been no structured framework to ensure that the application of RII is performed such that the risks are effectively managed.

Development of HOIS RP



Information gathering

Completed June 2020.

RP Framework for discussion

Draft RP issued March 2022.

Scope of practical and desktop trials developed.

Trials

Practical trials
Desktop trials

Finalise RP

Issued to HOIS members June 2023

Scope of HOIS RP

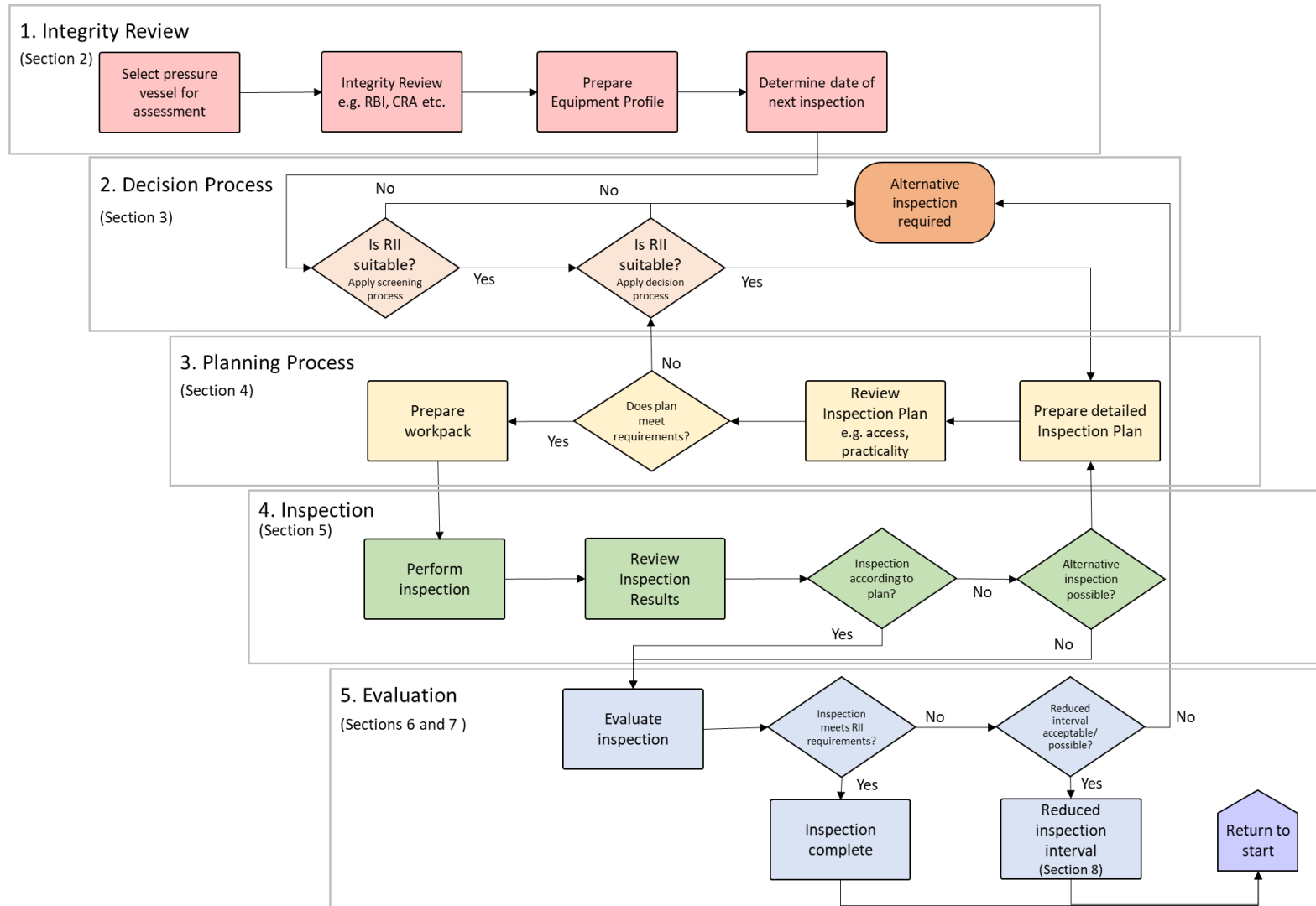
HOIS-RP-058 will...

- Determine when RII is appropriate in principle as an alternative to IVI, or as a means of deferment of IVI, or as a complementary inspection to NII.
- Define information requirements to plan for RII.
- Define the inspection requirements, e.g. visual inspection performance and coverage, for the RII method(s) to be selected.
- Selects methods that meet the requirements.
- Provide framework for evaluating the results of the inspection.
- Provide recommendations on documentation requirements.

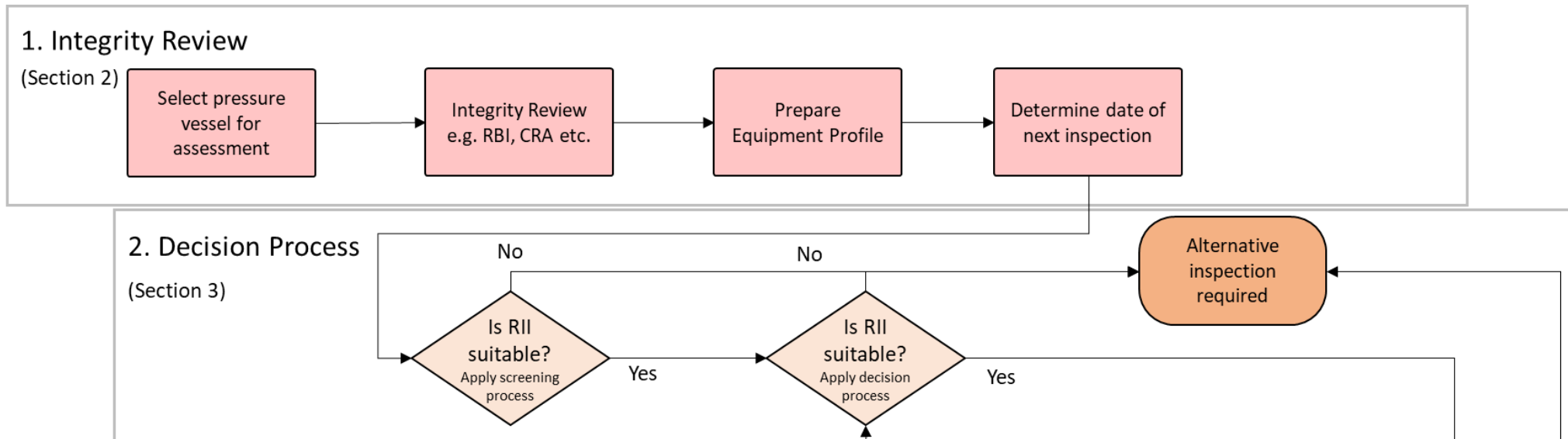
HOIS-RP-058 will not...

- Set POD requirements
- Set strict camera performance requirements e.g. colour performance
- Provide details on how to measure camera performance [available elsewhere in extensive detail]
- Provide recommendations specific to in-service inspection of tanks full of product.

Structure of the RP

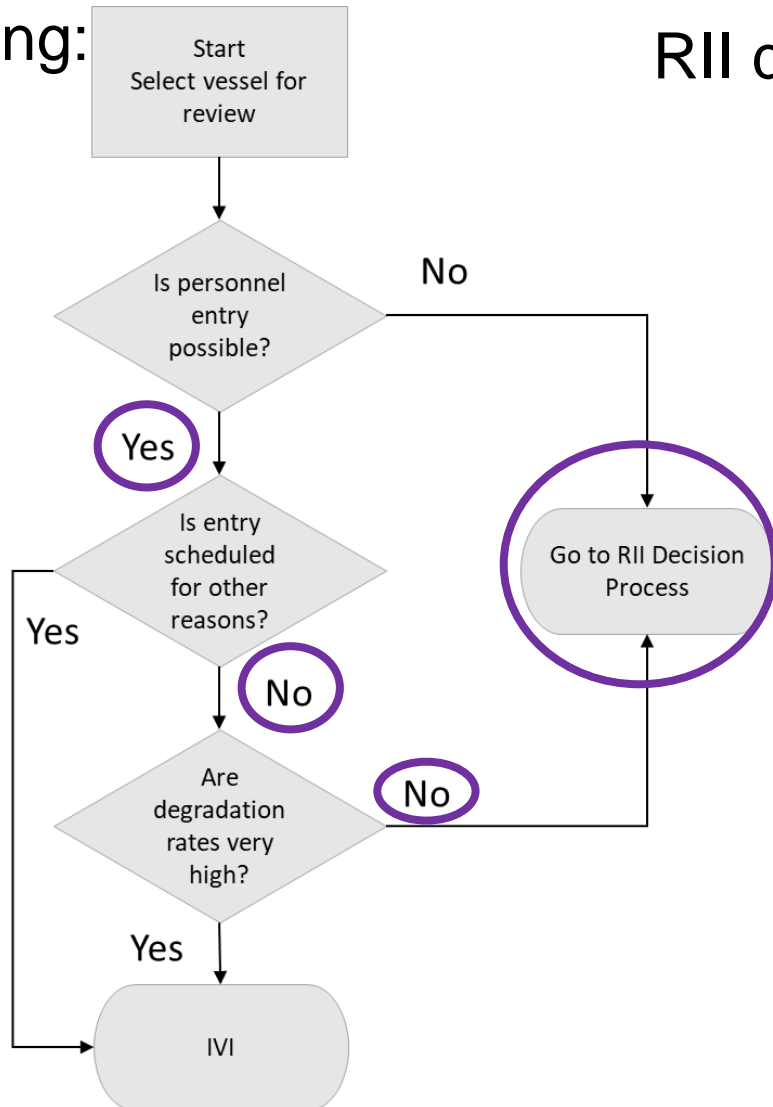


Structure of the RP

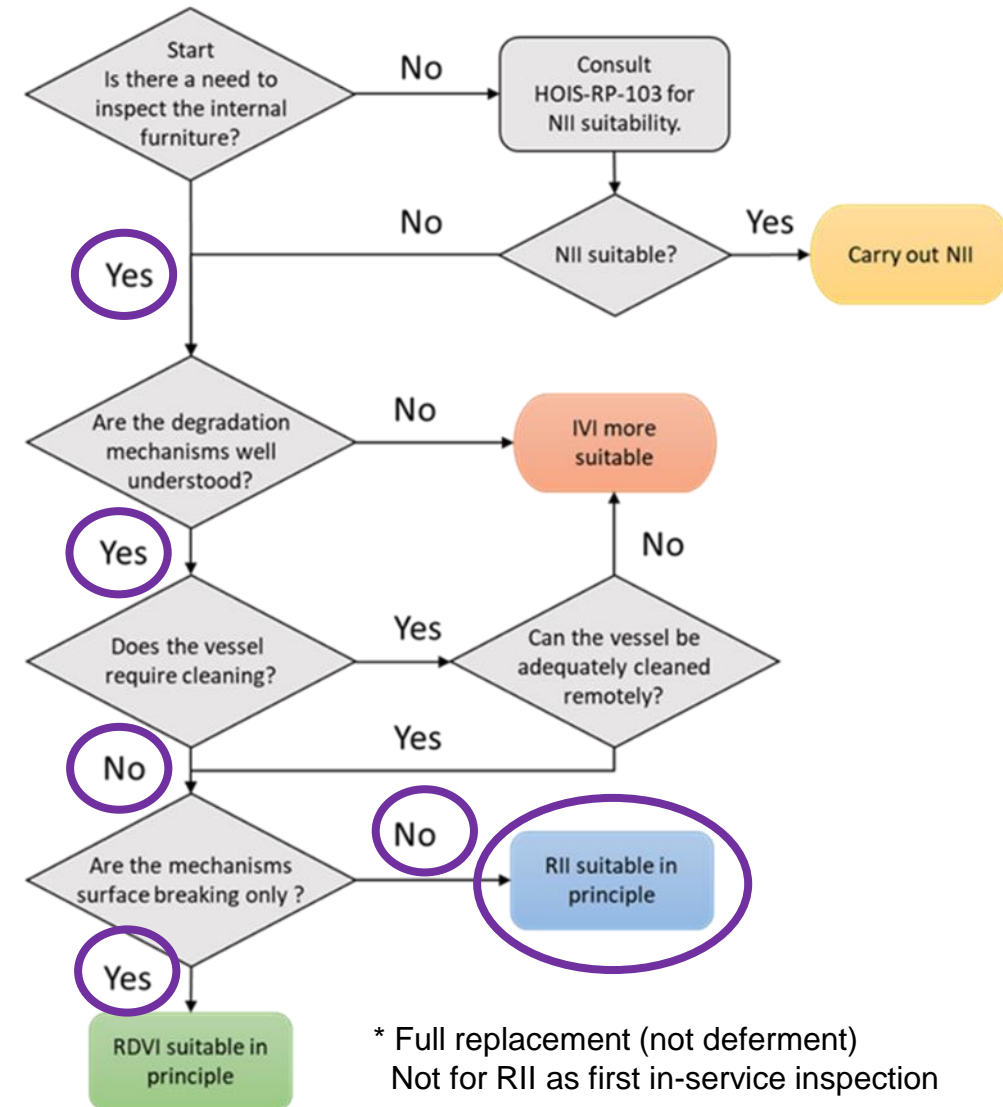


Decision guidance

Screening:

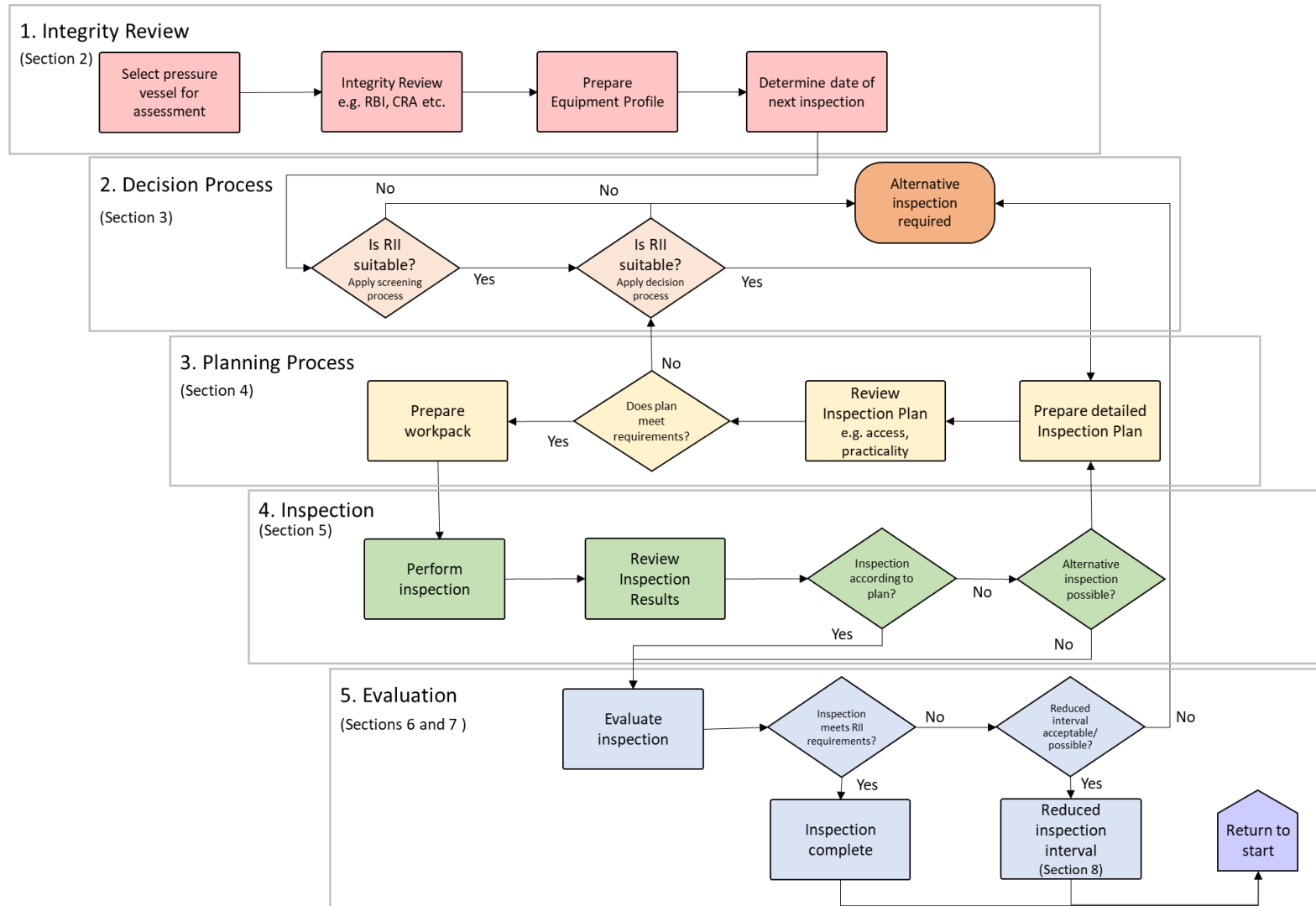


RII decision Process*:

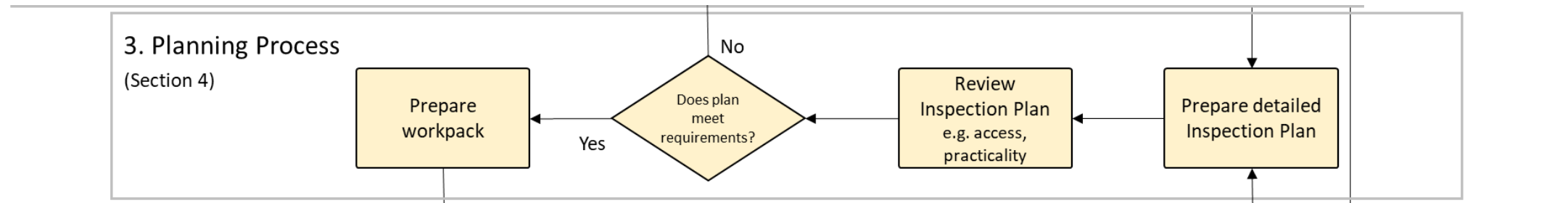


* Full replacement (not deferment)
Not for RII as first in-service inspection

Structure of the RP: Planning



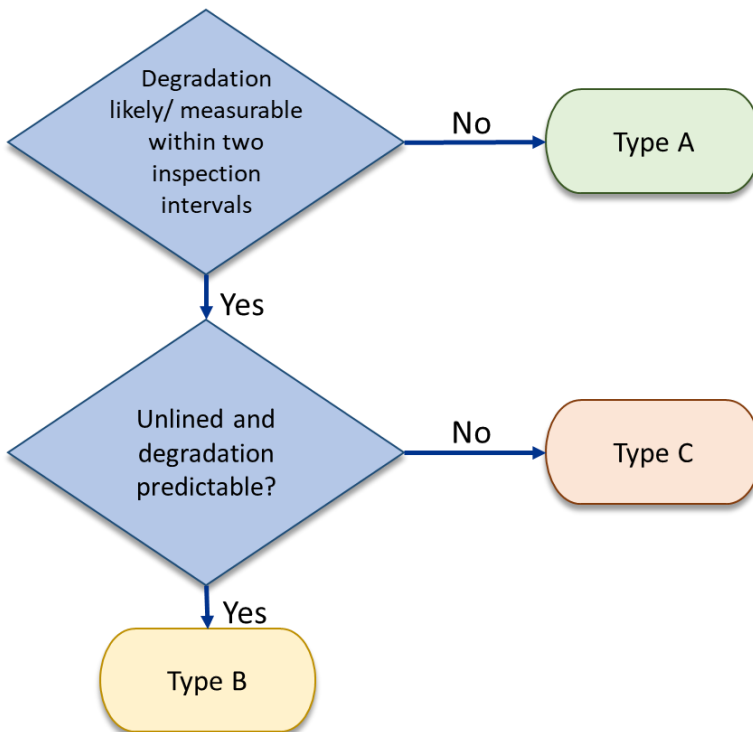
Structure of the RP: Planning



Workscope development

- Identification of the planning team
- Definition of vessel zones
 - Common degradation threats (c.f. corrosion loop) e.g. welds/vessel shell
 - Access zones
- Inspection strategy for each zone
 - Satisfactory level of confidence in vessel's safe and reliable operation until the next inspection.
 - Provide information on vessel condition that improves efficiency of integrity management
 - Presence/absence of degradation mechanism(s)
 - Accurate estimate of corrosion rates

Inspection strategy definitions



Type	Definition	Purpose of inspection	Example
A	Degradation mechanism is NOT expected to occur. Inspection is required to confirm there is no onset of the degradation mechanism.	Detection; confirmation no degradation is present	CRA vessel or CRA clad carbon steel vessel
B	Degradation mechanism expected, with low/medium progression. Location of degradation can be predicted. Degradation mechanisms are wall loss only, i.e. not cracking. Not anticipated to impact on vessel integrity in the medium term (typically at least 2 outage periods). Inspection required to confirm DTA predictions.	Identify and measure degradation in predictable locations. Coverage of 100% of susceptible areas.	Carbon steel vessel with reasonable likelihood of corrosion.
C	Degradation expected with medium/high progression. Locations of degradation cannot be predicted, or the vessel is lined with a polymeric type coating (unpredictable breakdown) May impact on vessel integrity in the medium term (two-outage timeframe). Inspection required to confirm absence of flaws of defined limiting sizes.	Identify and measure corrosion in unpredictable locations	Carbon steel vessel internally lined with polymer based material

Inspection requirements

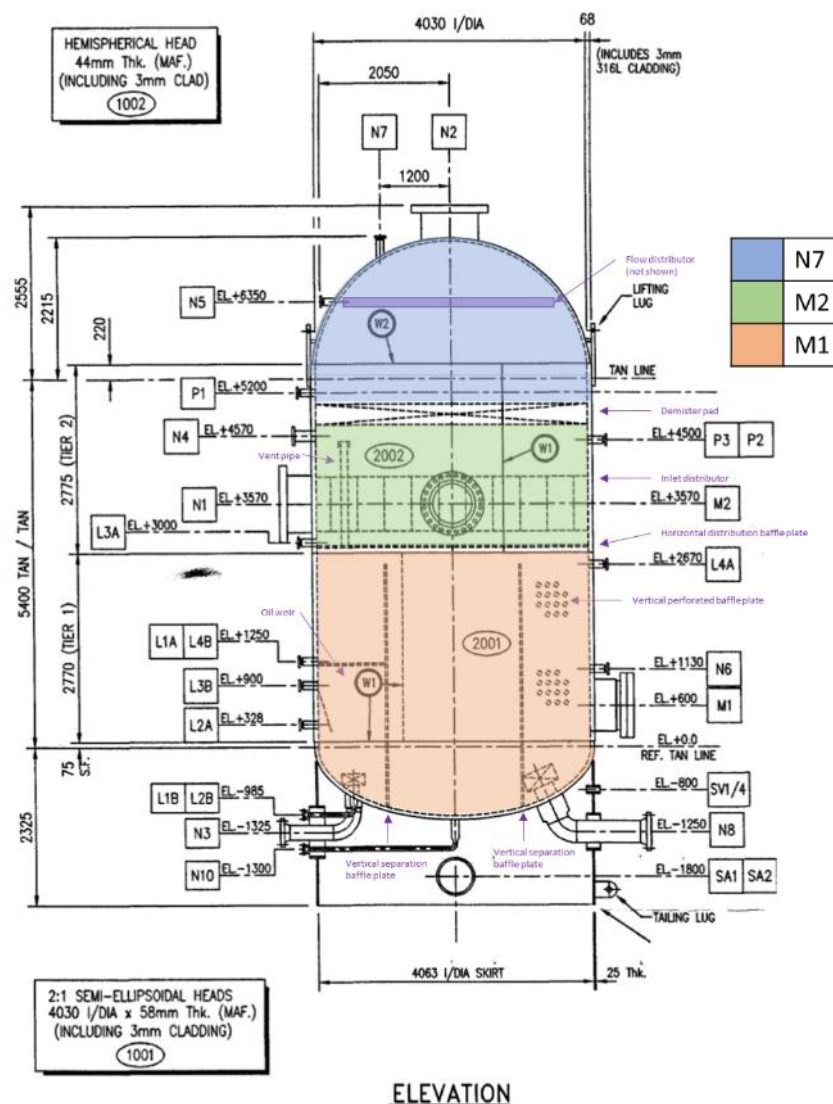
Consequence of failure drives specification of inspection requirements, including:

- **Coverage** — usual aim for 100% but for type A&B there can be less as long as areas are representative
- **NDT performance requirements** – again driven by strategy type
- **Location/navigation**
- **Cleaning and preparation**
- **Lighting**
- **Visual inspection performance (CVI equivalence)**
 - Environmental conditions
 - Camera set-up: spatial resolution, spatial distortion and scale, SNR, colour.
- **Reporting requirements**



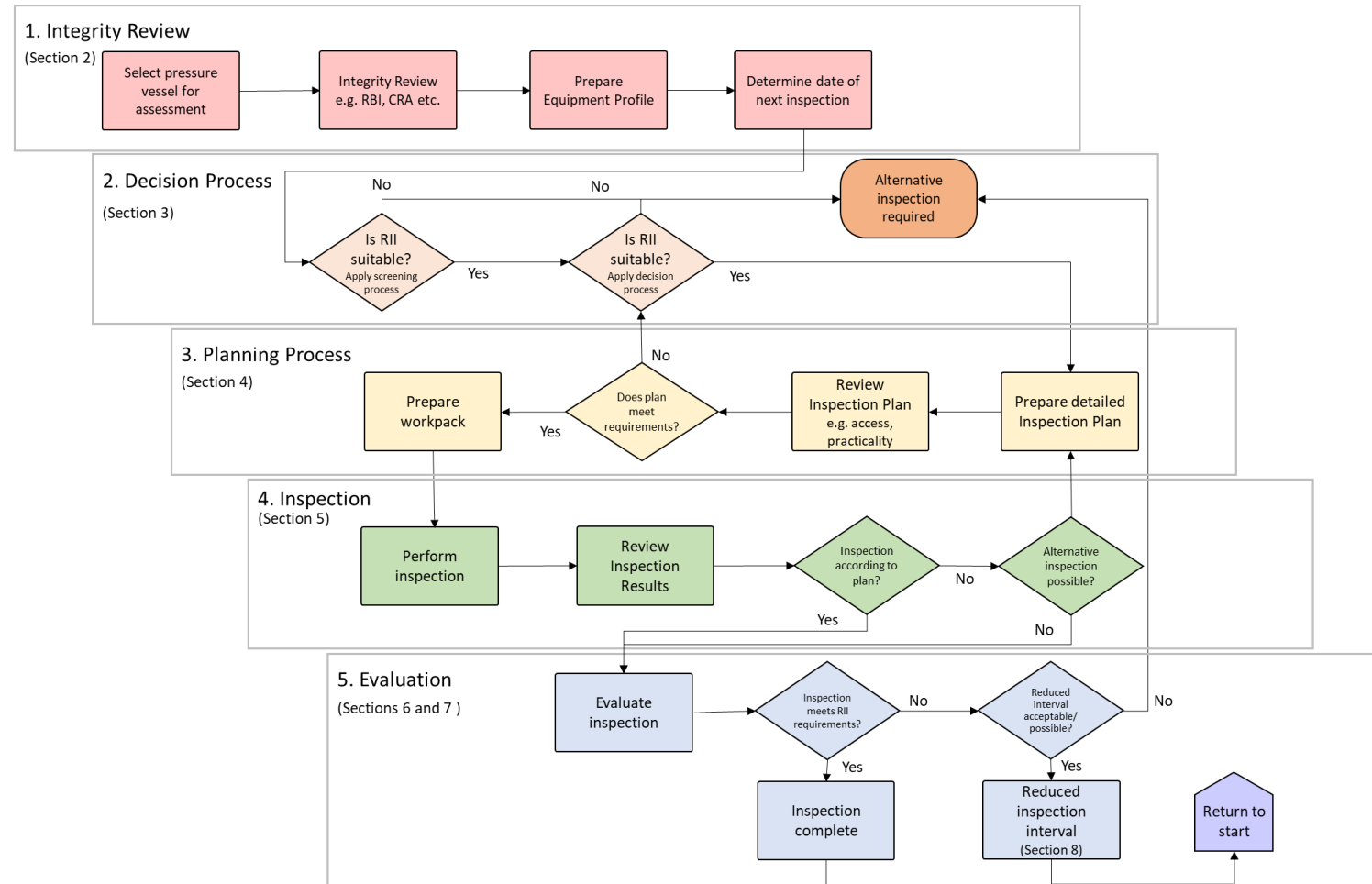
Selection of inspection and deployment method(s)

Case study: Inspection plan

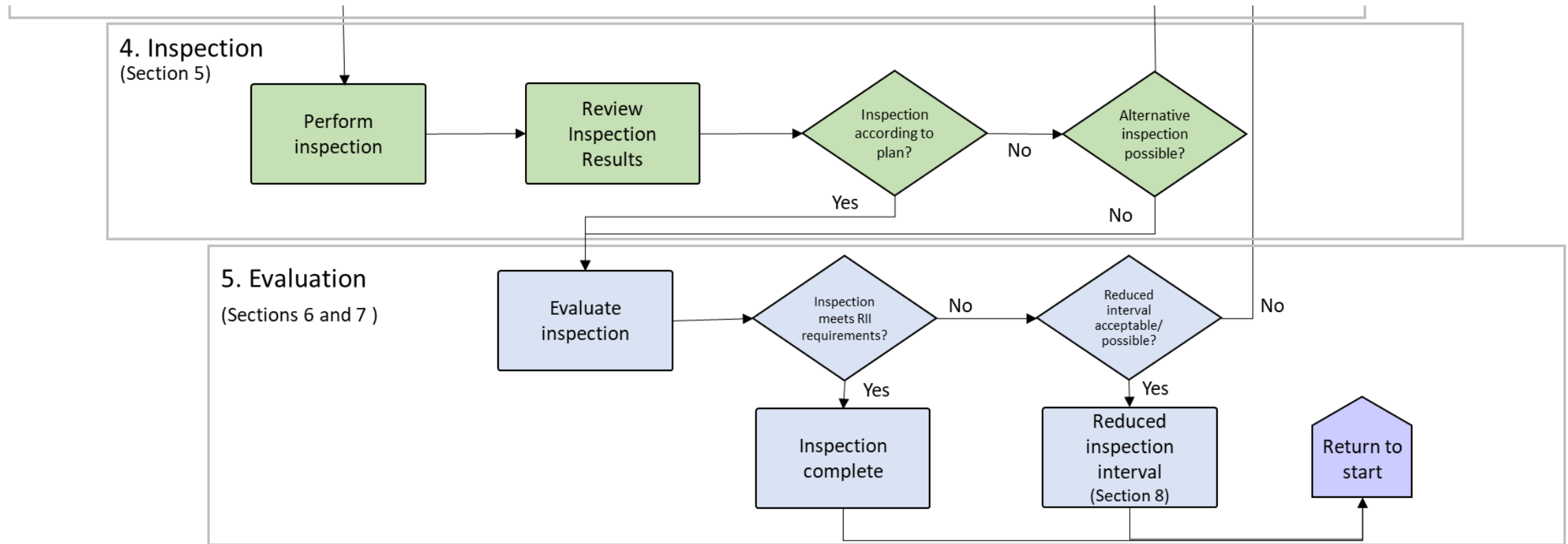


Items/locations to inspect	M1 - Lower dome, shell, liquid compartment bulkheads/baffle plates, shell attachments points, nozzle penetrations, vortex breakers, baffle plate, M2 – Shell, baffle plate, inlet device, nozzle penetrations, demister pad, internal piping N7 – Upper dome, shell, demister pad, flow distributor, nozzle penetrations.
Coverage required	90% or better of shell and domes,
Inspection method(s)	RDVI Eddy current of 25% of welds
Deployment method	RDVI via telescopic pole and PTZ camera for main areas, Digital Videoscope and tooling to access internal areas of liquid and oil compartments. Magnetic crawler not suitable due to non-ferrous cladding.
Access requirements (nozzles for access)	M1, M2 and N7. Easier to break flange and remove piping from a smaller nozzle rather than e.g. N2

Structure of the RP: Inspection & Evaluation



Structure of the RP: Inspection & Evaluation



On-site inspection

Factors affecting the performance of an inspection might include:

- Access issues
- Insufficient cleaning
- Lighting
- Poor sensitivity or excess noise due to material condition/lighting

.....how these are addressed will depend on inspection strategy type.

Reporting requirements



Reporting of results to

- Provide a basis for repeatability of the inspection and comparison between past, current and future inspection results
- Facilitate evaluation of the RII and any integrity assessment.

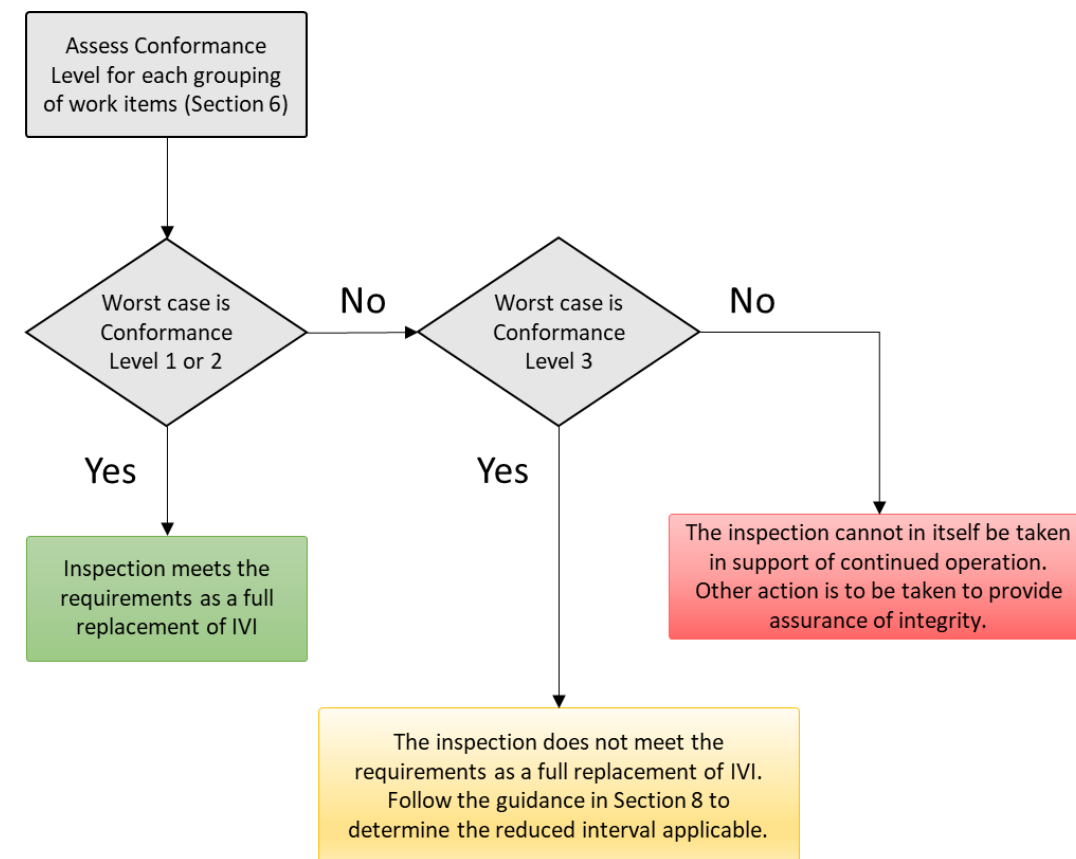
Requires:

- Detailed and accurate record of locations of inspection relative to features on the vessel.
- A clear and accessible record of the data collected.

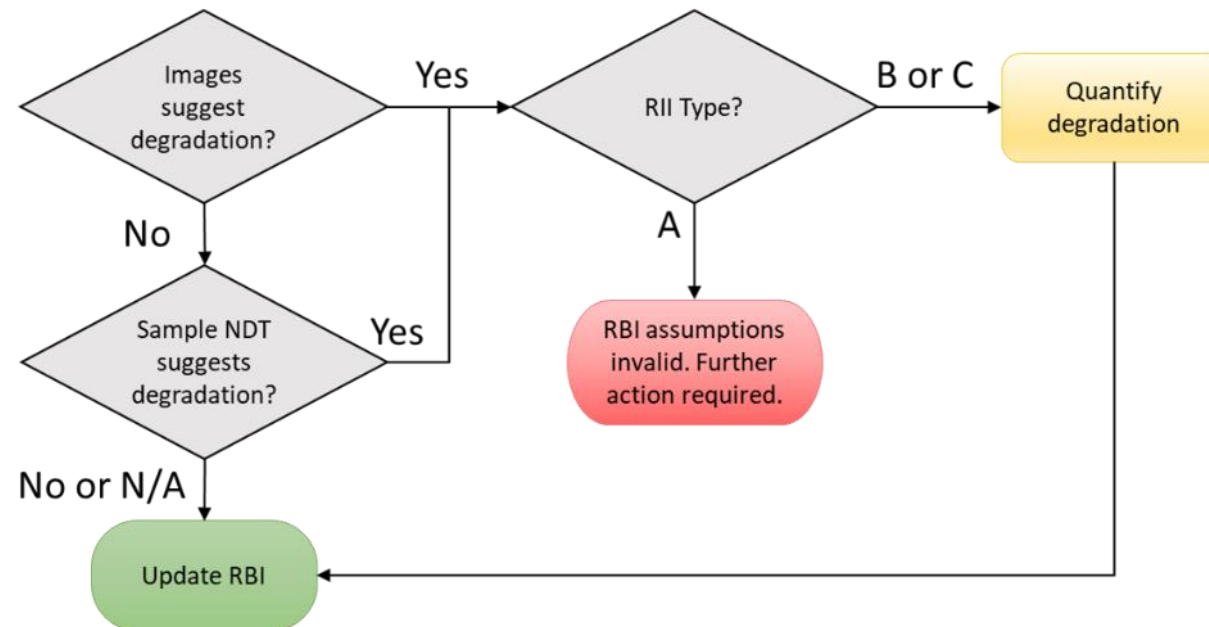
Completion of the report for the inspection phase does not represent the conclusion of the RII. RII can only be justified as a replacement or deferment of the IVI following an evaluation of the inspection results.

Evaluation - conformance

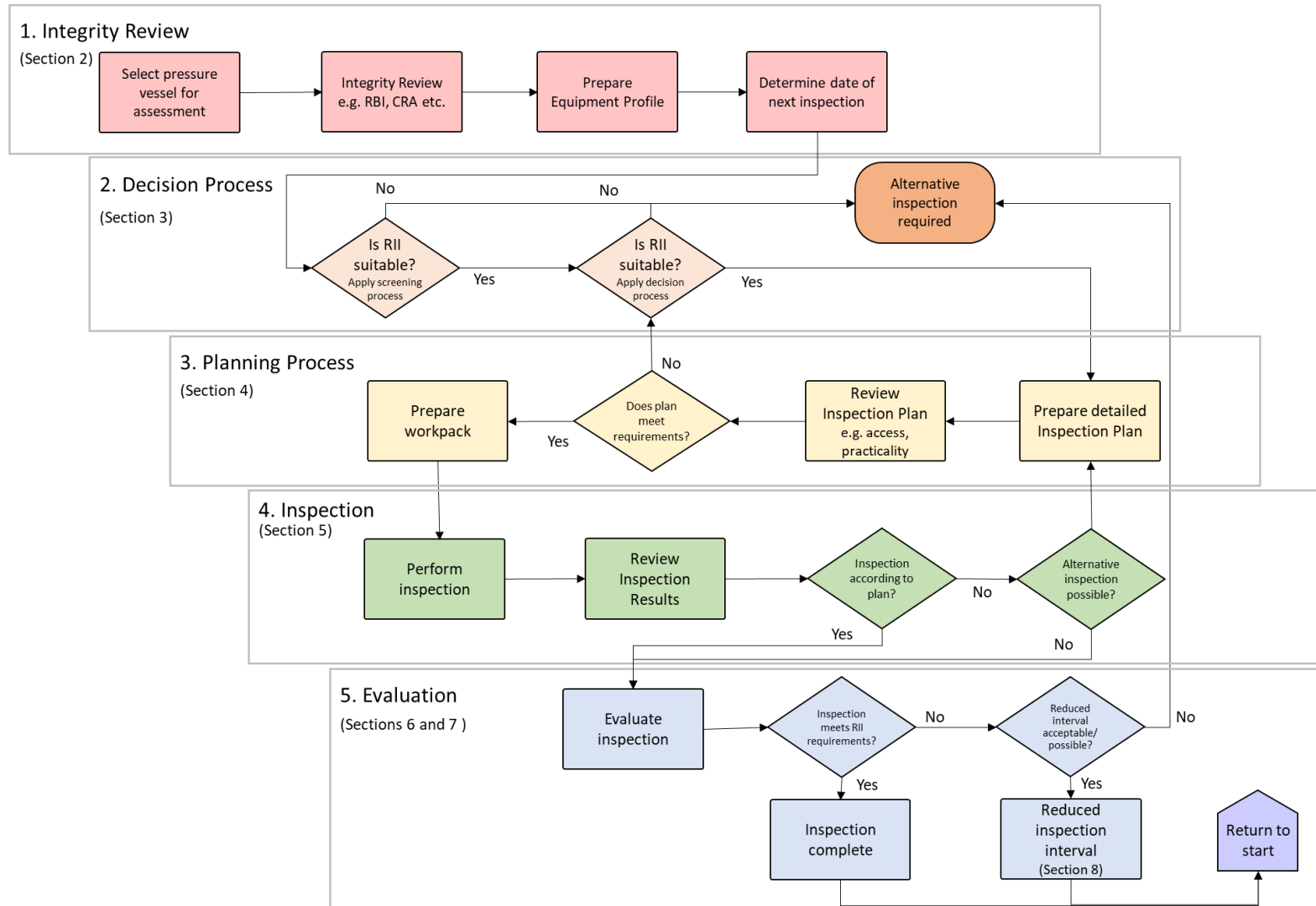
	Image quality	Location	Coverage
L1	Images appear reasonably noise free, and surfaces and features are discernible.	All locations and features in plan were inspected.	As per plan.
L2	All images show some level of noise, but surfaces and features are still discernible.	Some locations or features were missed but these are considered either non-critical or represented by the areas inspected.	A & B: $\geq 75\%$ of planned. C: $\geq 90\%$ of planned.
L3	The image quality is poor (noisy or blurred) such that some features are not discernible.	One critical feature or location was missed.	A & B: between 50% and 75% of planned C: between 50% and 90% of planned
L4	The image quality is poor (noisy or blurred) such that features are not discernible.	More than one critical feature or location was missed.	<50% of expected



Evaluation - analysis



Structure of the RP



Summary

- Remote internal inspection requires a different approach to human entry internal inspections (IVI)
- The RP develops a systematic assessment of each item of equipment to be inspected using RII.
- Will require changes in administration, planning, execution and evaluation of inspection.
- RP is not currently publicly available, confidential to HOIS members.
Builds on knowledge within other HOIS documents in the public domain:
 - HOIS-G-005 Guidance on image quality for UAV/UAS based external RVI in the oil and gas industry
 - HOIS-RP-103 Recommended practice for non-intrusive inspection of pressure vessels

Acknowledgements

- We would like to extend our thanks to:
 - Susan Osbeck – principal author of the RP.
 - Mark Stone & Steve Burch – contributing authors.
 - Billy MacKay and Kris Kydd Project Champions.
 - Ash Peters and Sean Peters for their very useful input to the RP.
 - Waygate, Inspectahire, and Eddyfi for completing the trials and providing further feedback.
 - All volunteers for the table top trials.
 - All members who have attended working group and other meetings.