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REMOTE INSPECTION TECHNIQUES

NI693 - MAY 2025

GUIDANCE NOTE

BUREAU VERITAS

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RULES, RULE NOTES AND GUIDANCE NOTES

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These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

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REMOTE INSPECTION TECHNIQUES

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Section 1 General

1 General

1.1 Introduction

1.1.1 Remote inspection techniques are a means of survey that enables external and internal examination of any part of the structure without the need for direct physical access by the Surveyor.

1.1.2 Remote inspection techniques may include the use of:
- Unmanned Aerial Vehicles (UAV) / drones
- Remote Operated Vehicles (ROV)
- unmanned robot arms
- climbers
- divers
- other means acceptable to the Society.

They are equipped with various payloads such as, but not limited to, imaging device, illumination equipment, LiDAR, SONAR, ultrasonic thickness probe to gather data including photos, videos, thickness measurement, point cloud data etc.

1.1.3 The use of remote inspection techniques may offer improved safety, greater efficiency, and higher flexibility.

1.2 Scope of the document

1.2.1 This Guidance Note sets out recommendations for using remote inspection techniques both within and outside the scope of classification surveys. The Guidance Note provides information to the marine and offshore industry on:
- application and challenges of Remote Inspection Techniques
- guidance to service supplier
- guidance to risk assessment
- guidance to survey process
- guidance for data management and reporting.

1.2.2 Some commonly used robotic inspection platforms, refer to [1.3], UAV, ROV, crawlers, unmanned robot arm, poles, are detailed in this document.

1.2.3 In this Guidance Note, the term ''Structure'' is used as a generic term to indicate any part of the structure of ships or offshore units.

1.3 Remotely operated platforms

1.3.1 Some remotely operated platforms commonly used to perform inspections using remote inspection techniques are described in this Article. It should be noted that while climbers are not remotely controlled, they are a type of remote inspection technique.

1.3.2 Unmanned Aerial Vehicle (UAV) - Aerial Drone

A UAV (aerial drone) is a rotary type of small aerial vehicle with no on-board pilot. They may either be piloted remotely from a control station or be autonomous. An autonomous UAV is programmed to follow a pre-mapped path based on previously acquired information (e.g. identified hot spot areas, areas of interest from previous inspection campaigns, etc.) of the asset. These are typically powered either by battery or tethered connection, providing varying flying time ranging from a few minutes to hours.

UAVs are used in normally inaccessible areas to collect images, videos, point cloud data, and to perform thickness measurements and other non-destructive tests.

Inspection UAVs are generally purpose-built based on deployment zone and payload needs. Drones designed for external hull inspection, may differ from those intended for GPS denied confined space environments in terms of dimensions, hardware, and software capabilities.

1.3.3 Remote Operated Vehicle (ROV) - Underwater drone

A ROV (underwater drone) is a remotely operated submersible craft designed to carry out inspection and physical tasks like an UAV but in an underwater environment. It is typically battery powered with tethered communication to provide uninterrupted live feed. A ROV (underwater drone) may also have an umbilical cable for power provision and control as well. It may be deployed for both underwater external hull examination and flooded confined spaces examination (such as ballast tanks). There are ROVs with varying degrees of autonomy, from remotely operated to fully autonomous.

1.3.4 Crawlers

Crawlers are remotely operated vehicles that attach themselves to the hull using magnets. Using their magnetic wheels or tracks, Marine Hull Crawlers (MHC) can crawl along the hull structure in various orientations, whether horizontal, vertical, or inclined, in air or in subsea environment. Depending on the payload, MHC can perform diverse tasks such as cleaning, visual inspection, thickness measurement, crack detection, Cathodic Protection (CP) measurement etc.

There are various types and designs of crawlers including wheeled crawlers that do not use magnets.

1.3.5 Robot arm

There are various types of robot arms, offering diverse applications. These arms can function independently or be mounted onto other robotic vehicles like crawlers. Commonly attached payloads are imaging device, illumination equipment, NDT sensors.

1.3.6 Poles

Telescopic poles, tripods equipped with illumination equipment and imaging device may provide solution for accessing difficult-to-reach areas. Additionally, UTM or other NDT sensors can be fitted onto these platforms for enhanced functionality.

2 References, Definitions and Acronyms

2.1 References

2.1.1 The Society Classification Rules

- NR467, Rules for the classification of steel ships
- NR445, Rules for the classification of offshore units
- NR533, Approval of service suppliers.

2.1.2 Recommendations and Guidelines

- IACS Rec. 42, Guidelines for Use of Remote Inspection Techniques for surveys
- IACS Rec.72, Confined Space Safe Practice
- IACS Rec.90, Ship Structure Access Manual
- IMO MSC-Guidelines on Maritime cyber risk management, MSC-FAL.1/Circ.3/Rev.2, 7 June 2022
- Easy Access Rules for Unmanned Aircraft Systems (Regulation (EU) 2019/947 and Regulation (EU) 2019/945).

2.1.3 International Standards

ISO/IEC 27001:2022 standard on Information technology - Security techniques - Information security management systems - Requirements. Published jointly by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

2.2 Terms and definitions

2.2.1 Artificial Intelligence (AI)

Artificial Intelligence (AI) is the ability of a machine to mimic and automate human intelligence processes such as rule-based reasoning, problem-solving, learning, and decision-making.

2.2.2 Machine Learning

Machine Learning is a subset of AI enabling systems to learn from data by automatically discovering patterns and handling complex, non-linear relationships without being explicitly programmed with rules.

2.2.3 F1 Score

F1 score is a machine learning evaluation metric that measures a model's accuracy. It combines the precision and recall scores of a model using their harmonic mean.

2.2.4 Overall survey

An overall survey is a survey intended to report on the overall condition of the hull structure and determine the extent of additional close-up surveys.

2.2.5 Close-up survey

A close-up survey is a survey where the details of structural components are within the close visual inspection range of the Surveyor, i.e. normally within reach of hand. The purpose of a close-up survey is to obtain a detailed understanding of the condition of a structural item or for identifying, quantifying, and documenting any anomalies detected during overall survey. Close-up survey is generally directed towards a well-defined location.

2.2.6 Photogrammetry

Photogrammetry is a technique to construct a 3D model by obtaining surface measurements from non-contact photos/videos of a structure.

2.2.7 Point-Cloud

A point cloud is a collection of points plotted in the 3D space. Each point has X, Y, Z co-ordinates, that represent a real point on the structure in the scene.

2.2.8 Digital twin

Digital twin is a virtual representation of a physical object or a system.

2.2.9 Remotely operated platform (ROP)

Remotely operated platform (ROP) is the technology platform or vehicle or hardware that carries the inspection payload, such as UAV, ROV, crawlers, rollers, robot arm, telescopic pole etc.

2.2.10 Payload

Payload means instrument, mechanism, part, apparatus, appurtenance, or accessory that is installed or attached to the remotely operated platform and is not used or intended to be used in operating or controlling the remote platform (e.g. flying, diving, crawling) but dedicated to performing inspection tasks.

2.2.11 Service supplier

Service supplier (a service supplier or category of service supplier may be referred to here after simply as supplier) means a person or company not employed by the Society who, at the request of an equipment manufacturer, a shipyard, a vessel's Owner or other client acts in connection with inspection work and provides services for a ship or a mobile offshore unit such as measurements, tests or maintenance of safety systems and equipment, the results of which are used by surveyors, in making decisions affecting classification or statutory certifications and services.

2.2.12 Surveyor

Surveyor means technical staff acting on behalf of the Society to perform tasks in relation to classification and survey duties.

2.2.13 Operator

Operator means a technician, an inspector, or a supervisor employed by the service supplier.

2.2.14 Owner

Owner means the Registered Owner or the Disponent Owner or the Manager or any other party having the responsibility to keep the unit seaworthy, having particular regards to the provisions relating to the maintenance of class laid down in Society's rules.

2.2.15 The Society

The Society means Bureau Veritas Marine & Offshore SAS.

2.3 Acronyms

2.3.1

AI : Artificial Intelligence
BVLOS : Beyond Visual Line Of Sight
CAP : Condition Assessment Programme
CP : Cathodic Protection
ESP : Enhanced Survey Program
GPS : Global Positioning System
LiDAR : Light Detection And Ranging
ML : Machine Learning
MHC : Magnetic Hull Crawler
NDT : Non-Destructive Test
OE : Operating Environment
RIT : Remote Inspection Technique
ROP : Remotely Operated Platform
ROV : Remote Operated Vehicle
SONAR : Sound Navigation and Ranging
UAS : Unmanned Aircraft System
UAV : Unmanned Aerial Vehicle
UT/UTM: Ultrasonic Thickness Measurement
VLOS : Visual Line Of Sight.

Section 2 Application and Challenges

1 Application

1.1 General

1.1.1 RIT may be used to perform a variety of inspection tasks in different operating environments depending on the deployment platform and payload.

RIT continues to evolve, and the range of application could expand in future. It should be noted that being an emerging technology, there may be some limitations in effective implementation of remote inspection technique.

1.2 Application of RIT based on operating environment

1.2.1 Confined space

RIT may be utilised to inspect internal hull structures in enclosed spaces or tanks normally with limited openings for entry and exit.

1.2.2 Pipeline inspection

Internal visual inspection and other non-destructive examination of oil & gas pipeline may be done using RIT such as a crawler.

1.2.3 Underwater inspection

Remote inspection techniques may be utilized to carry out tasks (inspection, examination, and interventions) in underwater environment such as underwater external hull and its appurtenances, mooring system for permanent and mobile offshore units, flooded tanks without exposing human divers to risk.

1.2.4 Inspection at height

Where it is required to perform an inspection at a height (difficult-to-reach), use of RIT may be considered.

1.3 Application of RIT based on scope

1.3.1 Visual inspection

Visual inspection is the most usual method of inspection. Remotely operated platform fitted with imaging devices and/or illumination equipment may be utilized as an extension of surveyor's vision range. It may perform an overall assessment of the hull structure using overall survey method and then a close-up survey as required in areas normally difficult to reach. The visual data can be live streamed or recorded for post-analysis. The close-up surveys intended for classification purposes should be performed in accordance with the Society's Rules.

1.3.2 Thickness gauging

Deployment of a remotely operated platform fitted with an UT probe to measure thickness of plates, stiffeners in difficult-to-reach areas may provide efficient and flexible solution.

1.3.3 NDT and CP measurement

It may be possible to perform NDT and CP measurements using suitable sensors mounted on a remotely operated platform.

Note 1: Remotely Operated Platform (ROP) performing TM/NDT should be equipped with an imaging device to capture visual information, simultaneously, of the location where TM/NDT is being conducted.

1.3.4 Digital twin

Remotely operated platforms may be used to collect point cloud or photogrammetry data to create a digital twin of the asset.

1.4 Use of RIT for Classification Surveys

1.4.1 General

Requirements for the use of RIT within the scope of Classification Surveys are given in the applicable Rules.

1.4.2 Risk Based Inspection

RIT may serve as a data collecting or monitoring tool to support risk-based inspection for the hull structure of floating offshore units.

1.5 Use of RIT outside the scope of Classification

1.5.1 Condition Assessment Programme (CAP) surveys

Consideration may be given by the Surveyor to allow the use of RIT in CAP surveys, provided prior agreement on the utilisation and scope of RIT has been obtained from the Society. As this technology is relatively new, further expansion of RIT scope into CAP survey is subjected to technology maturity and Society agreement.

1.5.2 Self-inspections by owners, shipyards

a) Condition assessment and monitoring:

Asset Owner may deploy RIT to collect data utilised in assessing the condition of the asset. RIT may also facilitate monitoring of known condition and mapping of anomaly progression. The collected data may be further analysed, aided by AI, to gain insight into the asset integrity management.

b) Dry-Dock and maintenance planning:

RIT may be used to carry out an overall survey of the asset to locate any new damages or to assess the conditions of previously identified anomalies prior going to dry-dock. These collected data may provide valuable insight into planning maintenance, preparing work specifications, or negotiating with shipyard.

c) Emergency damage survey:

RIT may be leveraged in emergency conditions such as collision, grounding, pollution, or fire for a quick assessment of the situation or damage extent. They may facilitate collaboration with subject matter experts from remote locations to define and execute a response plan.

d) Shipyards:

Shipyards may deploy RIT for new construction. Periodic scan of under-construction units, aided by AI, can track work progression. Thereby, RIT enables the shipyard to analyse scheduled against real work progress, and provides assistance in project management.

2 Challenges

2.1 General

2.1.1 Being an emerging technology RIT may face several challenges due to the complexity of structures and operating environment. As the technology advances, these challenges continue to evolve. Some potential challenges are compiled to aid the stakeholders in preparing and reviewing an RIT inspection plan.

2.2 Hull arrangement

2.2.1 Any proposed remote inspection technique should be able to inspect all locations of a tank to the satisfaction of the attending Surveyor. The intricate design of the hull structure can present physical challenges to the ROP regarding accessibility. For instances, in way of ballast tank double bottom area, the inner bottom manholes can be as small as 400 mm x 400 mm. The longitudinal stiffeners can be of a size which may require access between stiffeners to realise a close-up survey. Bracket toes can be facing either direction in all three planes, posing challenges to ensure line of sight from both sides of such brackets. Cage ladders, stairs can restrict the access of a ROP into a tank.

The class inspection requirements relate to specific structural design detail and age of units. While drafting the RIT inspection plan, it is advisable to analyse the design specification thoroughly. For instance, the dimension of ROP such as drones should be verified against that of the access holes to ensure complete coverage.

2.3 Tank condition

2.3.1 Accumulation of water, scale, dirt, oil residues, etc. inside tanks may obstruct meaningful inspection using RIT.

2.4 Surface condition and reflection

2.4.1 The presence of corrosion on the structural surface may restrict the use of UT probe mounted on a drone unless the selected surface has been sufficiently cleaned beforehand.

2.4.2 Depending on the coating type, coating condition, presence of oil film, remote imaging device, and illumination equipment specifications, glare from the surface may hinder meaningful identification, detection, and examination of anomalies.

2.5 Environment

2.5.1 Dark environment

Confined space or tank's operating environment is dark and may have light absorbing surfaces, making visible spectrum photography difficult. Powerful artificial illumination is necessary for ROPs. As they are moving, the level of illumination needs to be relatively high (compared to still photography mounted on a stationary platform) to allow high definition and acuity photography.

2.5.2 ATEX zone

Operating environment where explosive atmosphere may exist, RIT should not be deployed unless the RIT is ATEX certified, or the environment is made safe in accordance with IACS Rec. 72 or other recognized recommendations or standards.

2.6 Batteries

2.6.1 For battery powered remote vehicle, the single operating time (flying time, diving time) is limited by its battery capacity.

2.6.2 A damaged unhealthy battery may reduce anticipated operating time or even pose potential fire hazards. Battery health should be monitored, and manufacturers recommendations should be taken into account.

2.7 Others

2.7.1 Biofouling

Underwater hull & appurtenances and mooring systems acquires biological depositions over time. Build-up of such depositions compromises meaningful examination unless the RIT is equipped with an additional cleaning module, or the structure has been cleaned beforehand by some other means.

2.7.2 Tethered connection

Tethered drone or ROVs could encounter issues such as entanglement with structure, friction, snagging, or travelling distance limitation by finite length of the tether. Additionally, the maximum height the drone or ROV can attain may be constrained by the weight of the umbilical it should pull.

Section 3 Service Supplier

1 Application

1.1 General

1.1.1

Where required by the applicable Classification Rules, the company who operates the RIT is to be approved by the Society as a service supplier in accordance with the requirements of Society's Rule Note NR533, Approval of service suppliers.

Owner or shipyards conducting self-inspection outside the scope of classification may allow a competent person to carry out the survey however, it is recommended to engage a Society's approved service supplier.

2 Scope of approval

2.1 General

2.1.1 The requirements for approval of service suppliers vary depending on operating environment and scope of service. The different combination of services and applicable scope is summarised in Tab 1.

Table 1 : Applicable scope for service supplier using RIT for one service or a combination of services.

Operating Environment (OE)	Remotely operated platform (ROP)	Performed via a remotely operated platform (ROP)	
		Overall survey and close-up survey **(1)**	Close-up survey including TM **(2)**
In-Air	UAV (Aerial Drone) Climbers Unmanned Robot Arm Poles Crawlers	RIT	RIT, TM
In-Water (external Hull & appurtenances)	Crawlers ROV (Underwater drone)	IW	IW, TM
In-Water (Internal Hull/Flooded Tanks)	Crawlers ROV (Underwater drone)	RIT, IW	RIT, IW, TM

Note 1:
RIT: Certification of a Firm engaged in Survey using Remote Inspection Technique as an alternative means to close-up survey
IW: Certification of a firm engaged in In-Water Surveys
TM: Certification of a Firm engaged in Thickness Measurements of Hull Structures

(1) In any kind of survey, i.e. class renewal, intermediate, annual or other surveys having the same scope, thickness measurements of structure in areas where close-up surveys are required, are to be carried out simultaneously with close-up surveys. When RIT is used for a close-up survey, temporary means of access for the corresponding thickness measurements is to be provided unless such RIT is also able to carry out the required thickness measurements.

(2) Where the thickness measurement is performed via remotely operated platform, the same service supplier company should be approved for RIT and TM.

3 Additional regulations

3.1 General

3.1.1 The service supplier and/or the pilot of remote inspection techniques may have to comply with local, national, or regional regulations. The service supplier should ensure that the assigned pilot is in possession of all applicable licenses and operational authorisations.

3.1.2 Where the proposed ROP is subjected to additional regional, national, or local regulations, references of these regulations and the corresponding license, permit, or authorisation should be included in the RIT inspection plan.

3.1.3 For example, European Union Aviation Safety Agency (EASA) regulations (EU) 2019/947 and 2019/945 mandate registration for both an operator (service supplier) and the unmanned aircraft system when operating in open category with maximum take of mass greater than 250 g, or, which in case of an impact can transfer to a human kinetic energy above 80 Joules. Additionally, an UAS pilot is required to acquire a certificate of competency based on applicable category.

However, it is to be noted that EASA UAS regulation does not apply to any indoor UAS operation. Indoor operations are operations that occur into a closed space (enclosed compartment of a hull structure such as a cargo hold, cargo tank, ballast tank, etc.).

Section 4 Risk Assessment

1 General

1.1 Application

1.1.1 This Section provides a basis to the Owner and service supplier to develop a risk management plan.

1.2 Risk assessment

1.2.1 A case specific risk assessment containing identification of hazards, likelihoods, severity (unmitigated and mitigated) and control measures should be carried out prior conducting the inspection.

1.2.2 The risk assessment should be adjusted as needed considering the actual conditions on the day of inspection.

1.2.3 Each stakeholder i.e. the owner's representative, the operator, and the attending Surveyor, as applicable, should acknowledge the risks associated with the inspection and corresponding control measures during pre-inspection meeting.

1.2.4 Where the RIT is used for class surveys, the risk assessment should be included in the RIT inspection plan.

2 Risks identification

2.1 General

2.1.1 In addition to the challenges described in the Sec 2, [2], the identification of risks should account for the aspects given in [2.1.2] to [2.1.11], as applicable.

2.1.2 Conditions of operation

The operational risks pertain to the conditions in which the inspection takes place, including at least the following:

- VLOS or BVLOS
- proximity of people during operation
- proximity of critical structures other than the asset on which the inspection is being carried out. (e.g., proximity of other vessels in port)
- meteorological conditions such as wind speed, sea current when RIT is utilised for the inspection of external structure. This should be assessed and amended on the day of the inspection
- effects due to asset's motion i.e., vessels motion such as rolling, pitching, etc.

2.1.3 Equipment calibration

Inspection with an uncalibrated equipment may produce unreliable data. Specific time should be allocated prior inspection to calibrate the equipment properly.

2.1.4 Glare from sunlight

Glare from direct sunlight on the control station (screen) may cause difficulty to pilot or detect anomalies.

2.1.5 Dropped object risks

Inspection robots can turn into a falling object due to:

- loss of power
- loss of propeller
- loss of signal
- loss of adhesion for a magnetic crawler.

Or in scenarios where a part of the ROP is detached from the platform.

2.1.6 Collision

Inspection robots may collide with human, other safety critical equipment or third-party assets due to various factors:

- loss of signal
- sudden change in meteorological conditions (winds, rain, sea current)
- pilot error
- autonomy failure e.g., collision with other drones where autonomous swarm of drones is deployed.

2.1.7 Inappropriate human resource management

Where the service is provided by a supplier, it is recommended that the inspection team comprises a minimum of 2 persons, excluding the attending Surveyor.

Where the inspection is being carried out using multiple homogeneous or heterogeneous platforms, such as a swarm of UAVs or a combination of UAV, ROV, crawler, an additional designated team leader is needed to oversee multiple teams. The team leader should act as a coordinator between the attending Surveyor and the teams.

The role of each member of the team should be well defined, key members should be identified and communicated to the attending Surveyor.

It should be noted that inefficient allocation of human resources may contribute to accidents and incidents.

2.1.8 Human performance limitation

At present scenario most of the remotely operated platforms are operated and controlled by remote pilots, the human factor is implicit in the risk analysis process. The human performance limitation factors may include the following:

- perception (situational awareness when operating BVLOS)
- fatigue
- stress
- time constrains
- commercial pressure
- distraction
- medical fitness.

2.1.9 Loss of signal

There may be instances where the command-and-control link between inspection robot and the control station is lost due to factors such as:

- interference with the radio frequency because of the presence of other electronic devices or radio signals, heavy steel structures, high voltage power source that emits electromagnetic signals etc.
- design signal range of the drone when going too far from the control station
- low battery power can lead to loss of signal.

In any case, signal strength indicator should be monitored. In addition, there should be a reliable and predictable method to recover the command-and-control link, or if that fails, the operation should be terminated in such a way that reduces the effect.

2.1.10 Hijacking of ROP

Malicious attempt could be made to acquire unauthorised control over a ROP via its remote ID link and use it for nefarious purposes.

2.1.11 Unforeseen breakdown

In the event of a serious malfunction or an unforeseen breakdown of the ROP, and absence of a redundancy, the inspection schedule may experience delays, leading to operational and financial strains.

Section 5 Guidelines to Engage RIT in a Survey

1 General

1.1 Application

1.1.1 This Section outlines general guidance for conducting a survey using RIT.

2 Survey planning

2.1 General

2.1.1 A detailed RIT inspection plan should be developed in consultation with all stakeholders - Owner, service supplier, yard, and the Society, as applicable. Tab 1 outlines the roles and responsibilities of each stakeholder along the survey process.

Table 1 : Survey planning using RIT

Step	Owner	Service supplier	The Society
1	Considering the applicable requirements for the asset, determine the eligibility of using RIT for the envisaged survey		Review eligibility for agreement if applicable
2	Select a service supplier approved by the Society, as applicable		
3	Provide following information to the contracted supplier - • Type of survey • Scope of survey • Relevant drawings	Review documentation provided by Owner	
4		• Select appropriate ROP. • Develop detailed RIT inspection plan	
5	Review and approve RIT inspection plan prepared by service supplier.		
6	Submit the RIT inspection plan to the Society, as applicable		
7			Review the RIT inspection plan for agreement

2.2 Selection of service supplier

2.2.1 It is the responsibility of the Owner to select the appropriate service supplier for the intended survey. The following factors should be considered while selecting the supplier:

- geographic location and time of inspection
- method of survey envisaged (overall survey, close-up survey, thickness measurement, non-destructive testing)
- operating environment (in air, in-water, external structure, confined space)
- illumination needs, particularly for confined spaces where no supplementary illumination is intended to be provided
- data requirement (photo, video, LiDAR, SONAR, UTM)
- structure cleaning requirement in order to allow a meaningful inspection
- data security
- certification requirements for the service supplier.

Note 1: Owner may identify, locate, and contact approved service supplier through https://approvalexplorer.bureauveritas.com.

2.3 Selection of appropriate RIT

2.3.1 The service supplier should select the appropriate remote inspection technique after thorough analysis of the documentation and requirements provided by the Owner.

- operating area, external structure or confined space
- intended inspection for in-water or in-air
- in case of confined space, the inspection to be carried out from outside BVLOS or from within the confined space itself
- the dimension of ROP is compatible with access hole dimension to allow comprehensive coverage
- data requirement
- design signal strength when operating in complex internal spaces
- suitability in the use of tether or battery powered.

2.4 RIT inspection plan

2.4.1 The RIT inspection plan should be developed by the assigned recognised service supplier based on the information provided by the owner's representative. It should be validated by the representative of Owner prior sending it to the Society for review.

The RIT inspection plan should be comprehensive, containing pertinent details tailored specifically for the intended survey.

The RIT inspection plan should include, but not limited to, the following:

- information of asset Owner and service supplier
- asset name, type, operational details, and other general information
- geographical location of inspection
- expected timeframe for inspection
- selected remotely operated platform: make, model, technical specification
- scope of inspection
  - type of survey (periodical, occasional)
  - inspection area (tank id in case of confined space inspection)
  - inspection method (overall survey, close-up survey, UTM, NDT)
  - overall survey scope, close-up survey scope, UTM, and NDT scope including schematics
  - where the RIT is to be applied on ESP vessels, after receiving confirmation from Flag, the RIT Inspection Plan should clearly refer to the scope of survey as defined in the ESP Planning Document. Also, in such cases the ESP Plan (structures access section) should reflect the parts intended to be surveyed using RIT.
- inspection navigation plan for example flight plan for an aerial drone
- risk assessment comprising an emergency recovery plan and redundancy measures in case of primary ROP malfunctions or lost, should be included
- applicable certification such as class recognition certificate, national and/or local certification, if applicable, is to be attached to the appendix of the RIT inspection plan
- mechanism to allow attending Surveyor to witness inspection results (video, a-scan, etc.) on real time and replay, such as the establishment of secondary screen
- provision to allow attending Surveyor to perform confirmatory inspection by traditional method if deemed necessary
- video, image resolution and quality
- report Format, an example of data presentation including pictorial presentation should be attached to the appendix of the RIT inspection plan
- time frame for submitting the results to the Society.

3 Before inspection

3.1 General

3.1.1 On the day of survey prior to the commencement of the inspection, a pre-inspection meeting should be conducted involving all participating parties - the attending Surveyor(s), the master of the ship or an appropriately qualified representative appointed by the master or the Owner, yard representative(s), representative(s) of service supplier. This meeting should aim to address the followings:

- understanding of the inspection plan (including ESP requirements where applicable) by all actors
- requirements for any surface cleaning to allow thickness measurement
- requirements of any confirmatory survey
- identification of all key personnel associated with the inspection
- operator's qualifications as may be requested by the Surveyor
- means of communication
- assessment of the prevailing field conditions, meteorological conditions and adjust inspection plan as deemed necessary
- review of the risk assessment with all participating personnel and amend as necessary, and acknowledgment of the risk assessment by all parties
- review of emergency recovery and evacuation plan
- review and acknowledgement of any relevant work permits, entry permits
- confirmation that all personnel are in possession of all required personal protective equipment.

3.1.2 It is the responsibility of the Owner to verify that all relevant documentations and checklists are completed, and all necessary permissions are obtained prior authorising the commencement of the inspection process.

3.1.3 When RIT is used in scope of a class survey, the survey report should indicate where and when the meeting took place and who participated.

4 During inspection

4.1 General

4.1.1 The service supplier should develop a standard operating procedure, which may include but should not be limited to:

- Checklist: It should contain, at a minimum, visual checks of equipment and accessories, Operation check (e.g. test flight), communication check between control station and ROP.
- Identification of launch and recovery zone. The identified zone should be well marked and restricted from unauthorised entry.
- Calibration: Where applicable the attending Surveyor should carry out visual inspection of the equipment, sight calibration certificate, and may perform calibration block verification against thickness to be measured and material grade.
- Personnel assignment: Designating one person to operate the ROP and another to aid which may include tasks such as battery handling, tether management. Where a swamp of drones or a combination of ROP is deployed, each drone or ROP should be operated or monitored in case of autonomous system by one person and one additional person overseeing the whole operation.
- Any technical adjustment or maintenance carried out during inspection should be recorded.
- Documentation: All the inspection data should be well identified, spatially attributed, and documented for final reporting.
- Operator of the ROP should maintain a constant line of communication with the attending Surveyor during the survey for any findings.
- The operator of the ROP should always follow the direction of the attending Surveyor.

5 After inspection

5.1 General

5.1.1 Upon conclusion of the inspection, it should be ensured that the complete survey scope have been achieved to the satisfaction of the attending Surveyor. Any incomplete scope or part thereof should be clearly identified, communicated, and documented within the report.

5.1.2 All gathered data should be of sufficient quality, spatially attributed and appropriately presented to perform a meaningful examination, particularly where the RIT inspection is utilised in association with class periodical, and occasional surveys. Refer to Sec 6, [2].

5.1.3 Service supplier should provide an RIT inspection report in accordance with Sec 6, [5]. The inspection report should be delivered to the Society within the timeframe as agreed in the RIT inspection plan.

Section 6 Data Management and Reporting

1 Application

1.1 General

1.1.1 While the new inspection method using RIT provides numerous advantages, it also generates a substantial volume of data.

1.1.2 This Section provides recommendations related to data acquisition, data processing, data management and reporting in order to fully harness the RIT capabilities.

2 Data acquisition

2.1 General

2.1.1 Where the collected data using RIT is intended for class survey, it should be of sufficient quality to allow for a meaningful examination.

2.1.2 Imaging devices used for videos and photographs should be able to obtain at a minimum high-definition colour digital image. The image should maintain the afore mentioned quality when submitted to the Society. Imaging devices should be capable of date and time stamping the photographs, videos or capture this information in the digital file. The recorded videos should be uninterrupted.

2.1.3 The quality of other sensor data such as LiDAR, SONAR, UTM, NDT should be to the satisfaction of the Society and agreed upon in the RIT inspection plan when they are part of class survey scope.

2.1.4 Where the survey is performed outside the scope of class survey, the data quality should satisfy the owner's requirements.

3 Data Processing

3.1 General

3.1.1 Data collected by an RIT may undergo further processing using artificial intelligence and machine learning for additional evaluation. This processing may be performed either in real time during data acquisition or after the inspection on recorded data.

3.2 Image processing

3.2.1 Many ROP manufacturers and service suppliers utilize real time advanced image processing techniques to improve the collected photographs/videos especially in underwater environment. In such cases, any enhancement or adjustment of image colour should not hinder the understanding of the true condition of the structure.

3.2.2 Machine Learning (ML) based image recognition tool may be used for anomaly detection and measurements such as corrosion, fractures, indentation, coating breakdown on acquired images and videos. This may serve as an initial screening aid for the Surveyor during the inspection process. Where such ML based tool is employed during inspection, the Society should be informed during the planning stage, and it should be included in the RIT inspection plan. The inclusion should encompass any certification and/or performance metrics such as confidence score of prediction, accuracy, precision, F1 score of such model.

3.3 3D digital model and localisation

3.3.1 A 3D digital model can be generated using LiDAR, SONAR, or photogrammetry either in real time during inspection or afterward. Additional colourisation of the point cloud from images provides a representation that closely resembles to the real-life condition of the asset.

3.3.2 Localization of inspection findings is a crucial part of an inspection. 3D digital model may be utilized to localise any detected anomaly. This can be further populated with spatially tagged information such as annotation, links to images, reports, thickness measurements, NDT, CP measurement data, or any other relevant meta information.

3.3.3 A 3D digital model containing spatially attributed meta data has the potential to track evolution of anomalies between inspection campaigns throughout an asset's life cycle, enhancing asset integrity management capabilities.

4 Data management and data security

4.1 General

4.1.1 Inspection data acquired using RIT may provide valuable insight into asset integrity management. All collected data should be properly documented, marked with type, asset identification, date of generation, confidentiality for easy future access by both human and machine.

4.1.2 Service suppliers should comply with Owner's cyber security policy, recommended best practices when sharing RIT data with the asset manager, asset Owner and/or the Society via portable storage devices or remote data access portals.

5 Reporting

5.1 General

5.1.1 At the completion of an inspection using RIT, the service supplier should provide an inspection report containing general information of the asset, information pertaining to the inspection, photographic evidence.

5.1.2 The inspection report should be validated by all stake holders.

5.1.3 The inspection report which is submitted to the Society should contain:

- General particulars of the asset inspected, such as name of the unit, IMO number, the Society registration number, flag, ship manager.
- Information related to the inspection, such as class survey type, class survey report number, date of pre-inspection meeting, date(s) of inspection, service supplier details, equipment details.
- An inspection summary with all items mentioned in RIT inspection plan, plus any additional areas inspected by the attending Surveyor at the time of inspection. The summary should identify items inspected to the satisfaction of the Surveyor, items that require confirmatory inspection without the use of RIT, items where confirmatory TM or NDT is required to be performed and items with remarks.
- All findings should be spatially attributed and presented with photographic evidence.
- Applicable Class recognition certificate and any other permits and/or license required by the national and/or local authority should be attached to the annex of the inspection report.
- In addition, digital files of photographs, videos should be provided to the Society in a mutually acceptable format for the Society's internal records and the transfer should be recorded in this report.

An example of an RIT inspection report as an alternative means to close-up survey is provided in App 1.

5.1.4 Where UTM measurements are performed, a dedicated UTM report in accordance with the Society's rules should be submitted to the Society in addition to the RIT inspection report.

Appendix 1 RIT Inspection Report

1 General

1.1

1.1.1 An example of an RIT inspection report provided by the service supplier is shown in Tab 1.

Table 1 : RIT Inspection Report

Name of ship:.. Flag:...
IMO Number:... Ship Manager:..
The Society Registration number:.. Ship Owner:...

INSPECTION INFORMATION

Class survey type, if applicable	
Class job/report number	
Date of pre-inspection meeting	
Start date of inspection	
End date of inspection	
Place of Inspection	
Service supplier name	
Service supplier certificate number	
Service supplier certificate expiration date	
RIT equipment details	

REPORT SIGNATURE

Report Number:	Issued on:
Name: (Operator 1) Signature: Date:	Name: (Supervisor/Operator 2) Signature: Date:
Name: (Owner's representative) Signature: Date:	Name: (Class Surveyor) Signature: Date:

SUMMARY TABLE

Item number	Hull region/ compartment/ Tank ID	Location	Inspection results				
			WR **(1)**	CI **(2)**	TM **(3)**	NDT **(4)**	Comments **(5)**
1	No 1 WBT PS	FR 46		X	X		
2	No 1 COT S		X				
3	No 3 COT C		X				X
4	Hull underwater PS	Bilge Keel					X

(1) Without Remarks (WR) completion of survey using RIT, no confirmatory inspection, TM, or NDT required.
(2) Confirmatory Inspection without use of RIT required
(3) Thickness Measurement performed
(4) Non-destructive Testing
(5) See annex pages for comments
Note 1: Summary table should include all items from RIT inspection plan.
In case additional area was inspected (not included in RIT inspection plan), it should be included in the summary table.
Photographic evidence with spatial attribution of representative inspection areas should be included in the annex.
Class recognition certificate, any other applicable permit and/or license required by regional, national and/or local authority should be attached to the annex of this report.
Operator's qualification records where applicable should be attached to the annex.
Equipment calibration certificate is to be included in the annex of this report.

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