LIFE CYCLE OF SHIPS AND OFFSHORE STRUCTURES: HULL INSPECTION AND MAINTENANCE SYSTEM

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Summary

Ship owners and managers strive to maintain a high level of structural integrity. The ship crews and shore staff perform inspections of hull structure on a regular basis to assess the hull condition. The inspection regimes require easy identification of problems. Besides owners, inspections and surveys are carried out by many agencies such as classification societies, insurers, vetting agencies, cargo surveyors, port State, coastal State and flag State authorities. All have an interest in the safe operation of the ship and its proper maintenance. The effectiveness of these inspections is being continually challenged by the ever decreasing time that these vessels remain in port. A holistic, simple and

quantifiable approach can assist all parties to carry out these functions more effectively. Such an approach employs the application of risk-based decision-making techniques. Risk-based techniques have demonstrated great potential in identifying key structural elements and focusing resources for maintenance and inspection. The proposed methodology for rationalizing the hull inspection program is via the development of a vessel-specific inspection program which includes a scoring system for identified inspection criteria and a list of target inspection areas (critical structural areas) for each compartment. The condition for each inspection criteria, depending upon the score, is displayed within the context of a simple traffic light system. This methodology can be applied by a trained and qualified owners' representative. The scoring system can be utilized and analyzed to view the condition status of compartments, vessels and fleets. The scoring system also utilizes a system to trigger anomaly list generation, which can be used to manage the damages and repairs as well as create a repair list for future repair / dry dock events.

1. Introduction

The shipping industry needs a rationalized approach to perform inspections of hull structure and a methodology on what to inspect, when to inspect, where to inspect and how much to inspect. The benefits of hull inspection are known to all the inspection agencies. Traditionally, ship owners and vessel managers have their in-house hull inspection schemes and programs to track, assess and maintain the hull structure. Inspections to assess hull condition are also performed by many agencies such as classification societies, insurers, vetting agencies, cargo surveyors, port State, coastal State and flag State authorities. All inspection data is collected in various forms, checksheets and reports. The ship owner is required in most cases to maintain a record of maintenance activities carried out on the hull structure. All the inspection data require the owner to have an effective inspection management system.

Classification societies and most of the other agencies perform inspection or surveys in a prescriptive manner or on an as-needed basis to assess the hull condition. The selected compartments are inspected based on the experience and work instructions provided to the inspector or surveyor by their respective agencies. The presence of critical areas and suspect areas in a compartment may or may not be highlighted by the inspection agencies.

Ideally, the inspection and survey results from the various agencies are to be analyzed by the owners / managers and compiled into a repair / dry dock specification list. Most of the inspection data may not be formatted to permit owners / managers to easily convert it into a repair specification as it may lack sufficient detail. This requires the owner to have a repair management system. At the time of repair there may be some unknowns and surprises as the compartment condition is not completely known.

IACS PR33 encourages ship owners to have their own hull inspection and maintenance programs and schemes. Most of the major classification societies offer some form of hull inspection to be implemented by the owners' representative.

The various stakeholders on hull condition assessment and the various inspection regimes commonly found in the marine industry are identified in the following sections of this paper.

2. Stakeholders – Hull Condition

Stakeholders for a vessel's hull condition are identified as follows:

- Owner / Operator / Manager
- Ship Crew
- Builder / Shipyard (repair yard)
- Classification Society
- Insurers / Underwriters (of cargo and vessel)
- Charterers (including vetting agencies)
- Flag State
- Port States
- Public (including competitors, prospective clients, prospective buyer)

All have a common interest in the safe operation of the ship and in properly maintaining the vessel. Among all the stakeholders, the responsibility for the inspection and maintenance management of the vessel rests with the owners and managers. Each stakeholder also has its own inspection regime, depending upon its role in the vessel's operation.

3. Drivers and Opportunities

Owners / managers need an inspection regime to help systematically examine and grade the hull structure and identify and record any defects (anomalies). A program supporting a holistic, proactive, preventative maintenance scheme for the ship addresses the following issues:

- Identification of potential problem areas, so that preventive measures can be taken in order to remain in conformance with the applicable Classification Rule requirements;
- Focused inspection and condition reporting on structurally critical areas;
- Easier development of repair dry dock specifications;
- Detection of anomalies or maintenance trends across a fleet;
- Potential to lessen disruption of normal ship operations; and,
- Improved efficiency in the use of inspection results to satisfy the inspection requirements of other stakeholders.

4. Traditional Hull Inspection

Most of the inspections involve compartment inspections carried out by the inspector or surveyor with a checklist. These checklists are designed to collect textual descriptions of the conditions found. This includes finding anomalies relative to material degradation and deformation. These inspections apply the following examination techniques:

- Overall inspection;
- Close-up visual inspections;

- Suspect areas examination;
- Critical area (fatigue hotspot) inspection;
- Coating condition assessment; and
- Anode inspection.

The inspectors or surveyors usually look for defects or assess conditions based on their work process instructions, their judgment and experience. The recording of their findings is usually textual and in some cases quantified as ‘good’, ‘fair’ or ‘poor’. There may be further quantifiable parameters reported based on the extent of the condition or damage found. The traditional inspections and surveys usually assess the compartment condition based on the entire compartment with a focus on the coating condition.

Classification societies perform surveys and record the coating condition in the compartment. Anomalies are recorded as conditions of class.

Except for Condition Assessment Program (CAP) inspections, where the grades 1 to 5 are applied for a compartment, the quantifiable attribute for all compartments on a vessel is usually the coating condition and the presence or absence of anomalies.

Most of the inspections rely on the experience of the inspectors or surveyors to identify the conditions in the compartment.

In all cases, the owners’ inspector has to gather detailed information of the compartment and send it to the shore office together with detailed specifications for any material replacement or activities that need to be carried out by a shore crew or dry dock crew.

5. Managing Hull Inspections Using Software

A new trend is to use computer software to manage data of hull inspections. Figure 1 shows the screen shot of one such software. A compartment is divided into zones similar to the ‘area of consideration’ as per IACS Recommendation 87: Coating Guidance. All compartments are divided into zones that can be inspected and graded for the inspection criteria. Six inspection criteria have been identified for each compartment. These are inspected for each zone. Critical structural areas (if any) are identified for a compartment/zone based on engineering analysis and in-service experience. The inspection criteria are graded with a score (rating) from 0 to 6. A traffic light status (red: 5 to 6, yellow: 3 to 4, green: 0 to 2) is assigned to each zone for each criterion. These scores are added for each zone and rolled up to get a normalized score for the compartment. A red signifies the presence of an anomaly which needs to be documented for resolution/rectification. Each compartment will have two checksheets, general inspection criteria and critical area.

These inspections are to be done by qualified and trained inspectors which may include ship crew.

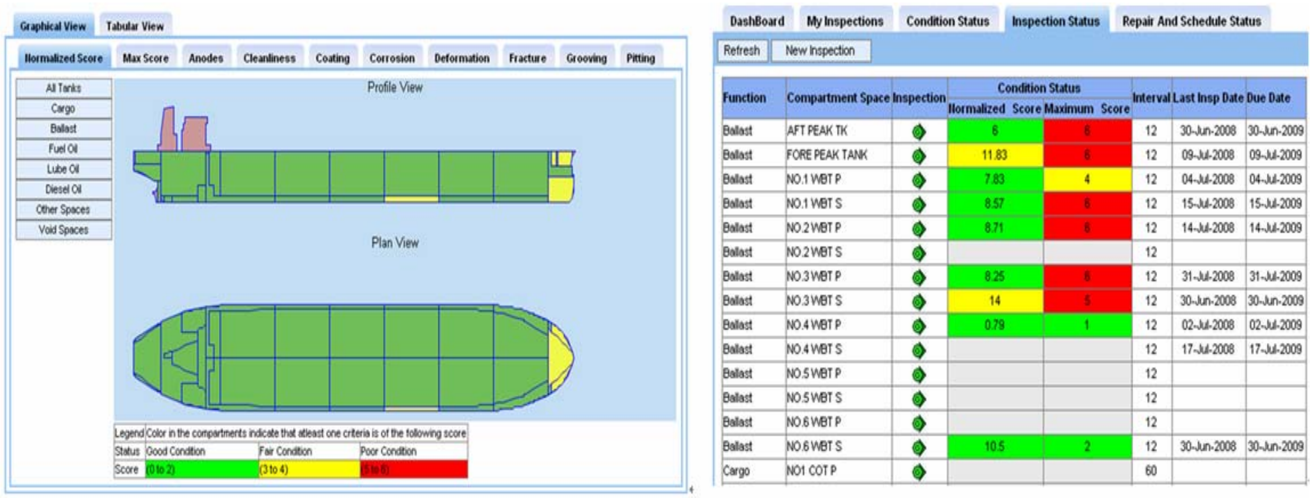

Figure 1. Managing hull inspection data

5.1. Six Inspection Criteria for Hull Structure

The six inspection criteria identified for assessing the condition of hull structure are:

- Coating condition
- General corrosion
- Pitting/grooving
- Deformation
- Fractures
- Cleanliness (housekeeping)

5.1.1. Coating

The coating condition as defined by IMO/IACS reference documents for good, fair and poor condition is subdivided and given the following scores:

Condition	Color	Score Assigned
GOOD	Green	0 to 2 both inclusive
FAIR	Yellow	3 or 4
POOR	Red	5 or 6

Table 1. Coating Score

5.1.2. General Corrosion

General or overall corrosion appears as non-protective rust which can uniformly occur on tank internal surfaces that are uncoated or where coating has totally deteriorated. This inspection criterion as defined in the referenced IMO/IACS documents is also assigned a score from 0 to 6 depending upon the amount of rust, light scale and hard scale.

5.1.3. Pitting and Grooving

Localized corrosion occurs on bottom plating and other horizontal surfaces producing deep and relatively small diameter pits that can lead to penetration of the steel member in isolated random places in the tank. Grooving is a localized, linear corrosion which occurs at structural intersections in welds or heat-affected zones. This corrosion is sometimes referred to as "in line pitting attack" and can also occur on vertical members and flush sides of bulkheads in way of flexing. Depending upon the average diameter of pits and the intensity of pitting/grooving, the scores are assigned from 0 to 6.

5.1.4. Deformation

Deformation is caused by impact loads, contact, or overloading. Deformation may be local (deformation of panel or stiffener) or global (deformation of a beam, frame, girder or floor including associated plating). Deformation is given a score from 0 to 6 depending upon its extent and severity.

5.1.5. Fractures

Fractures are categorized based on the location of the fracture and the local structure's contribution to overall hull integrity.

5.1.6. Housekeeping/Cleanliness

This criterion is used to evaluate the general condition of the compartment for cleanliness and housekeeping. This will be judged based on the following:

- Amount of sediments and dredge/sludge remaining in the tank;
- Wastage of the anodes and their perceived effectiveness;
- General cleanliness of the space;
- Condition of the piping and its supports;
- Condition of access hatches, manholes, entry spaces, ladders, and other means of access; and,
- Loose scale and plugged drainage openings in the structure (rat holes / scallops).

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Biographical Sketches

Sameer G Kalghatgi holds a Bachelor of Technology degree in Naval Architecture from the Indian Institute of Technology, Kharagpur, India and a Master of Science degree in Marine Technology from the University of Strathclyde, Glasgow, UK. He has been with ABS for 16 years, starting as a field surveyor involved with new construction, surveys after construction, and offshore installation surveys. He worked as a Senior Surveyor in the business-experts team for development of the ABS survey reporting application for 3 years. He has also worked for 4 years with the ABS Safety Analysis & Evaluation Group, the custodian of the condition database that collects, analyzes and disseminates maritime safety information. Mr. Kalghatgi has also worked on the development of the Hull Inspection module which forms a part of the Nautical System (NS) suite. He is currently in the role of Manager of Applied Innovation in Corporate Technology, working on developing data sharing and collaboration features for NS modules and survey application. He also is working on the text analytics software application for analyzing survey data and the Hull Inspection 3D application.

Chris Serratella is a graduate of Stevens Institute of Technology with a Bachelors of Science degree in Mechanical Engineering. He has over 23 years of experience related to engineering and risk assessment of marine and oil and gas production facilities both onshore and offshore. He has held several positions within both ABS and ABS Consulting. While in the role of Chief Engineer for the Marine and Offshore department within the Risk Consulting Division of ABS Consulting, he led or participated in numerous independent engineering and risk assessment services related to marine vessel and offshore oil and gas facilities, with an emphasis on floating offshore oil and gas production and storage. He is currently in the role of Director of Applied Innovation for the ABS Technology Department. His primary focus is in the lifecycle management and development of in-service inspection and maintenance regimes for marine and offshore facilities, focusing on machinery, topside production facilities and structures as well as the streamlining of the Maintenance of Class process through such regimes.

John Hagan holds a Bachelor of Science degree in Marine Engineering from the U.S. Merchant Marine Academy, a Master of Science degree in Mechanical Engineering from Manhattan College and a Master of Business Administration degree from Texas A & M University. He has been with ABS for more than 20 years and has held a number of engineering positions in New York, New Orleans, Singapore and Houston offices. Currently, he is the Director of the Applied Innovation Group in the ABS Technology Department. The primary focus is in the life cycle management developing both prescriptive and risk and reliability-based in-service inspection and maintenance regimes for machinery and systems on ships and offshore facilities.