Integrating Integrity and Class: Applying RBI to Hull Structures

Over the past decade, oil and gas operators of floating offshore installations (FOIs) such as FPSOs, FPUs, and FLNG units have been slowly pushing for a risk-based approach to be applied to these asset types in order to fit better with their operational goals.

Traditional class surveys are based on a periodic class regime, which encompasses local regulations, class society rules and industry standards and practices, however, the oil and gas industry has long applied risk-based methodologies and technology to asset integrity management.

What is Risk-based Inspection (RBI)?

The objective of the RBI process is to develop a plan for risk reduction through the application of an appropriately selected inspection strategy. A RBI plan will identify the following essential elements:

- Failure modes and degradation mechanisms
- Inspection scope including identification of critical locations
- Optimisation of inspection intervals
- Inspection processes and techniques

An RBI Scheme can be applied to:

- Floating offshore installations at a fixed location
- Existing facilities where the owner/operator can demonstrate there is sufficient technical knowledge and unit historical data to develop an RBI Plan
- New builds where the RBI plan would be developed as part of the design process.

RBI, and measuring the probability of failure, uses both semi-qualitative and quantitative risk assessment processes based on the principals of API 580. The level of risk is calculated through assessment of the consequence level (in terms of people, environment, financial and reputation) and likelihood or probability of failure. The acceptability of the risk level depends on where the hazard sits in the risk matrix and the principals of the goal setting regime such as, As Low As Reasonably Practicable (ALARP).

“Fundamentally, RBI allows operators, owners and duty holders to align the risk-based integrity approach to wider risk management activities and systems and with a safety case approach.”
Why should RBI be applied to floating units?
There is no denying that current oil and gas market conditions have pushed operators to look at achieving efficiencies across their entire operations and assets. New approaches to the inspection and maintenance of hull structures need to be considered to help optimise inspection regimes and ultimately reduce cost by eliminating unnecessary activities, enabling surveys to be carried out in line with operational activities. RBI pertaining to hull integrity management of floating units, such as FPSO and FLNG units, provides a unique flexible approach to achieving this.

RBI is an alternative to the traditional periodical classification survey scheme. It detects and monitors systems, sub-systems, equipment and component degradation and results in the application of appropriate decision making criteria to manage risk to acceptable levels.

RBI techniques may be used to provide justification for the assignment of Class, and may be systematically applied to the whole of hull structure and associated components or to individual systems, sub-systems or components.

Is there a need for RBI applied to hull structures?*

70% answered yes

Are your FPSOs / FOUs classed?*

83% answered yes

The most common degradation/deterioration mechanisms associated with hull structural components are:
- Coating failure
- General corrosion
- Localised corrosion
- Fatigue
- Overloading
- Wastage of the positional mooring system
- Stress built into the structure during new construction phase.

In order to carry out a successful RBI program, the following tasks need to be performed along with system breakdown:
- Identification and definition of functional and physical relationships, interactions and dependencies of components
- Definition of the operating conditions and loading associated with each inspectable component
- Identification of the Common Cause Failure (CCF) of components
- Identification of the failure modes and degradation mechanism associated with individual components or group of components
- Identification of possible consequences due to failure of components

“It could be argued that we are over-inspecting some FPSOs and under-inspecting others; an RBI approach can help to prioritise inspection.”

How do classification, verification and integrity fit together?
The key to understanding how classification, verification and integrity fit together is understanding if there are any differences between integrity management and classification schemes. If these two schemes can be integrated, the overall result may avoid the duplication of inspection activities.

- Classification is time-based, very detailed and establishes a minimum standard. Despite the fact that most oil and gas regions operate under a legislative regime, the UK doesn’t require operators to be Classed, however, a large proportion of FOIs are, as this provides the only real standard for the industry to work to. Internationally, Class is required as other regions are yet to adopt the safety case regime used in the UK.

In support of this, FOIs are usually designed and built to classification society rules, which set out how operators should maintain the hull and incorporate five yearly prescriptive survey regimes in addition to the annual, intermediate, special surveys and dry-docking. In addition, ship structures have other requirements to adhere to such as flag and international regulation requirements and as such, there is no provision for a RBI scheme within the relevant National Administration or IMO Conventions and Codes.

- Verification ensures compliance with the relevant performance standards and is often carried out by the class society, particularly in the UK.
- Integrity management is focused on maintaining safe asset production.

The introduction of an RBI approach aligns the requirements for class, verification and hull integrity management into a single survey and inspection programme. However, it’s noted that the Regulator has the final say on acceptance and the degree of adoption.

As previously highlighted, whilst the marine industry focuses on class, the oil and gas industry applies asset integrity management and more often than not, a risk-based approach. To overcome this disparity in maintenance and management regimes there is a requirement of the class societies to understand and appreciate what the FOI operators need and conversely the FOI operators need to understand what class ‘does’.

“The oil and gas industry has matured in a very different way from the marine industry, yet the two come head to head with FOIs.”

More recently, the class societies have recognised that they need to offer an alternative to time-based survey regimes and are looking to introduce risk-based class. The challenge though is how to implement an RBI approach, taking into consideration multi-skilled teams and the expertise and knowledge of non-destructive examination (NDE) inspectors predominantly used to applying RBI to topside structures. The remit of the class surveyor also needs to be considered – do they have to attend the offshore survey or can the information be gathered by other means and brought or relayed onshore for review? The roles and competencies must be clearly defined to realise the success of an RBI approach.

*Source: Client survey conducted at the Lloyd’s Register Energy business breakfast panel discussion titled: ‘The role of classification in managing the integrity of floating production units: A risk-based approach.’
“There is a business decision to make in relation to what standard we build this asset to.”

Building to a standard higher than the minimum
Industry feedback has highlighted that some operators chose to design and build to an enhanced standard in order to minimise operational costs and maximise life. For example, they can decide to use a better coating specification and better structural details.

However, under existing time-based survey cycles, operators don’t receive credit from the class society for these enhanced standards.

Risk Based Inspection of Hulls Process

Operator Evaluation
Operator activity
• Consider the unit’s operational environment, scope of Lloyd’s Register RBI and the investment/lifecycle costs.

Lloyd’s Register activity
• Lloyd’s Register provide consultancy at this stage.

Preparation & Planning
Operator activity
• Obtain relevant design data and operational unit records.
• Define the RBI Plan by identifying critical elements and other priority levels / risk bands, mitigation measures, audit techniques and management structure.

Lloyd’s Register activity
• Lloyd’s Register and Operator test the RBI Plan.

Inspections & Surveys
Operator activity
• Hold inspections as per the RBI plan.
• Escalate issues to Lloyd’s Register.
• Review any changes to RBI Plan.

Lloyd’s Register activity
• Hold planned surveys.
• Hold ad hoc surveys as escalated by operator
• Consider any changes to RBI Plan.

Review
Operator activity
• Maintenance of records
• Internal audit to evaluate effectiveness of RBI plan

Lloyd’s Register activity
• Annual Audit of RBI documentation and survey reports
Are class regimes an adequate standard for floating offshore installations?*

Yes  No  Don’t know  Blank

**Detail is in the data**

One of the perceived biggest challenges in adopting an RBI approach is the availability and quality of data. Knowing the probability of failures and demonstrating these in a risk-ranking matrix can be a challenge, especially when the lack of previous loading and location history can make this type of analysis difficult.

The right data is a basic prerequisite in the move to a risk-based approach. Oil and gas operators are well versed in how to gather and monitor data however, identifying what information is required to implement a RBI scheme is key to a successful outcome. A huge volume of data will have been gathered from activities such as class and integrity surveys, with assets that are sometimes 30 years old. There has to be a considerable piece of work done to identify what information will add value to the RBI process by applying a practical approach, and operators must not just be focused on reducing inspections.

In service inspection data and survey reports, as well as structural analyses including ShipRight SDA and FDA Analysis, Spectral Fatigue Analysis (SFA) and Conversion Survey reports all need to be considered when implementing a RBI programme. However, the limitations of the original design criteria and assumptions that may have been put in place during the build/conversion phase must be taken into account. Previous loading history is also a crucial element on deciding the risk profile for each asset to ensure any previous loading implications have been identified.

With this in mind, the data required for the development of the programme has to be provided via a collaboration of owner, operator and conversion/fabrication shipyards in order to build up a picture of the unit’s operational and non-operational history.

**Managing the perception of risk**

Every operator has, and works to, a different risk profile. Owner/operators manage their risk in a way to preserve the unit long-term, especially with regards for the potential of re-deployment at end of field life. Whereas operators tend to work to a risk profile dependant on field life rather that unit life. So it could be argued that unit specific class rules should be developed in relation to the operators risk profile.

**Risk profile ownership**

One of the key questions is who should take ownership of the risk profile? Traditionally, operators take responsibility for integrity and class societies take responsibility for class on behalf of the operators due to the lack of technical knowledge surrounding the class and the associated requirements. When moving to a RBI approach, the risk profile would then pass to the operator as it’s the responsibility of operators to make it work for them.

However, due to the benefits identified in moving to a risk-based regime, the owner may have a vested interest in the long term strategy and may wish to work in collaboration with the operators in establishing the longer term goals and risk profile of the unit.

“There’s no denying that there needs to be consistency in how risk is quantified; ‘Class’ gives operators a common standard set to a maximum risk level however, risk is very much dependant on where the unit is located and not just build standards. When adopting an RBI approach, it must be taken into consideration that units built to the same standards, but located in different regions, will perform in a very different way. In addition, site specific assessments and environmental factors must be taken into account.

**Inspection techniques, parameters and limitations**

When looking at hull structures, it’s less obvious in terms of how you conduct asset structure breakdowns as they don’t fall into component breakdown as found in process plant and topside equipment.

There are a number of inspection techniques available to determine the condition of the hull and its associated components. Despite this the complexity and variety of the hull structure configuration has led to challenges in areas such as the submerged hull, cargo and ballast tanks where the main driver for operators is to ensure uninterrupted continuous production.

Remote inspection techniques, for example remote cameras and drones, can reduce the need for activities such as confined space entry and unnecessary thickness measurements.

To date there is a lack of guidance available to operators on applying existing inspection technologies in order to assure the integrity of the hull structure. Going forward, this needs to be addressed in order to fully realise the benefits of moving to a risk-based approach.
Reaping the benefits
It has already been established that RBI offers a more concentrated approach to inspection than the current fixed frequency inspections, focussing inspection efforts where it can provide the most benefit, but how does this explicitly benefit operators?
• When implemented at the design phase, RBI can identify areas, which can be easily re-designed, thus creating a more reliable unit with less inspection and intervention at the operational stage.
• RBI provides an opportunity to group components with similar materials and service parameters together and conduct sampling inspections instead of inspecting 100% of components in a group. This method is commonly used for low risk components.
• A risk profile is generated for each key equipment item and structural element showing where the risk of failure lies. This allows priorities for remedial work to be forecast. Risk profiling provides knowledge of the physical status of the unit to all stakeholders.
• Non-intrusive inspection methods can be used instead of intrusive inspections, with the benefit of a reduction in the potential for human error and limiting the need for tank and confined space entry.
• Identification of risks to the operation are known, and where they exceed a threshold level, may then be subject to remedial action prior to a significant business impact occurring (e.g. safety, financial, environmental etc.).

From design through to asset life extension
Operators need to consider when to implement RBI – whether it’s at the design stage or part way through life – experts endorse the earlier the better.

Implementing at the design stage means that the RBI programme is tailored to the asset. Risk-based design can help build a more robust structure, and at this stage the design can also be modified around the risk based inspection regime.

The possible challenge lies in if you adopt RBI part way through the life of the asset – how do you make the transition from a prescriptive, time based approach to a risk-based approach?

"At the beginning we should consider what condition we want the asset to be in at end of life."

Conclusion
It can be concluded that adopting an RBI approach requires a mind-set change for both class societies and operators. It is no longer about undertaking surveys at the intervals specified by the Class society. Rather, they are undertaken based on assessment of risk that each equipment and structural item poses.

The net is also being cast wider, RBI methodology isn’t limited to the oil and gas industry. The military and defence industry and cargo shipment sector have also started to show interest in this new approach with the realisation of the operational efficiencies and cost savings that can be achieved.

An RBI approach doesn’t remove the need to undertake inspections, in fact RBI plans usually depend upon additional resources during implementation, but it is accepted within industry that these are effectively neutralised over a five year cycle. In addition, inspection frequency may increase for selected equipment and structural elements where risk increases with usage, whereas for others it may decrease frequency.

Aside from this, it has been proven time and time again that the long term cost saving and operation uptime achieved, far outweigh the cost of implementation. It’s clear that RBI and class regimes can work in tandem to optimise inspection and maintenance regimes, reduce costs, minimise downtime, mitigate risk and shutdowns.

"Ultimately, the time and cost of implementing an RBI programme outweighs the cost of downtime."

This paper has been developed with input from:
• Lloyd's Register RBI experts.
• Lloyd's Register’s ‘Guidance Notes for Risk Based Inspection of Hull Structures’ which can be downloaded by clicking here.
• Insight gathered at the Lloyd's Register Energy business breakfast panel discussion titled: 'The role of classification in managing the integrity of floating production units: A risk based approach'.
The event was attended by over 50 industry professionals. The panellists included: Alwyn McLeary, Regional Technical Authority – Floating Systems, BP; Tomasz Burnos, Head of Maintenance and Integrity, Bluewater; Rebecca Allison, Asset Integrity Product Manager LR and Raymond Caldwell, Naval Architect and Marine Consultant.

To find out more about how we can support you in moving to a RBI approach, please visit www.lr.org/energy, contact us at energy@lr.org or call +44 (0)1224 267550.