Navigating the Depths of Oil and Gas Safety

Danny Constaninis, EM&I, Malta, explains how incorporating emerging technology with a desire to mitigate safety risk, reduce impact on operations, drive efficiencies and save costs will maintain the integrity of offshore hulls.

Maintaining the integrity of offshore hulls is playing a critical role in the energy business. Hulls age and get damaged, needing maintenance and repair for their planned life on station, often over 25 years. Below the waterline, inspection and repairs once meant dry dock, extensive and expensive out of service (OOS) time. More recently, diving operations reduced the need for dry dock, at the expense of safety, unwanted extra people on board and costly DSVs (dive support vessels).

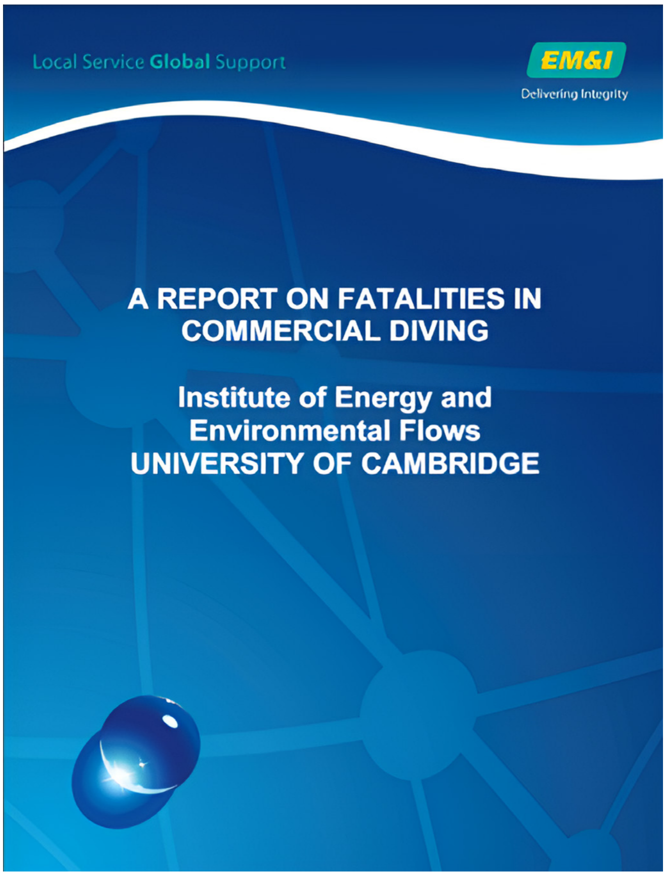
But there are better, safer and proven alternatives that minimise OOS time and expense. The industry is conservative, and while these new methods are being adopted, faster take-up will bring the safety, OOS and economic benefits more quickly.

A progressive mindset

When operators, regulators and innovators work together, the identification of commonly agreed challenges and solutions progresses faster.

HITS
HULL INSPECTION TECHNIQUES & STRATEGY

Figure 1. *The HITS JIP.*


Local Service Global Support

EM&I
Delivering Integrity

A REPORT ON FATALITIES IN COMMERCIAL DIVING

Institute of Energy and Environmental Flows
UNIVERSITY OF CAMBRIDGE

Figure 2. *A report on fatalities in commercial diving.*

Figure 3. *Launch of the integrity class ROV.*

One industry group, made up of representatives of all of these elements, is the Hull Inspection Techniques and Strategy Joint Industry Project (HITS JIP) which celebrates its tenth anniversary, and looks back with pride on the outcomes of such collaboration. HITS is one of the longest operating such projects, initially part of the Global FPSO Research Forum, which is now re-focused and re-named as the Floating Energy Research (FER) Forum.

The collaboration has benefited from leadership and engagement from Energy Majors, owners and operators, the major Classification societies, innovative services providers, and representatives from academia and technical research.

At the outset, the JIP members agreed a series of objectives which would benefit the sector, mainly to mitigate the safety risk to humans. The first of these was to reduce the requirement for diver intervention, noting the inherent risk, and the significant financial impact of diving operations to inspect and repair FPSOs, particularly in hostile metocean conditions around the world.

The benefits of that collaboration, and the resulting technology and techniques have now expanded into asset integrity management of mobile offshore drilling units (MODU), floating gas production units including FLNG and FSRUs, and early engagement with floating renewable energy production stakeholders, particularly in floating offshore wind (FOW).

But do we really need to replace diving as a capability for asset integrity management in the floating energy production sector?

Understanding the risk

Professor Andy Woods, of the Institute of Energy and Environmental Flows at Cambridge University, in his 2022 work, 'A Report on Fatalities in Commercial Diving', presented sobering statistics, not just on the frequency of such fatalities, but also the human and commercial cost.

The outcome of that work must be that as alternative, diverless options for asset integrity management are available, owners and operators of floating energy production assets have an obligation, both moral and commercial, to their employees, subcontractors, shareholders and the public, to implement safer alternatives.

Complex problems with simple solutions

Maintaining hull integrity below the waterline, with minimal diving intervention, presents a number of challenges. For example, carrying out hull and critical sea valve and sea chest inspections that satisfy Class and regulatory requirements is no mean feat. Maintaining coatings and corrosion protection systems underwater is a further challenge, and that is without mentioning repair and replacement of essential equipment.

One challenge has been to provide an answer to 'so what?' from owners and operators who pointed out that a diverless inspection solution still needed diver intervention if repair or maintenance was required. This point meant that industry had to come up with diverless solutions for inspection, repair and maintenance. ODIN® diverless technology has been developed over the last decade as a means of reducing diver intervention, much of the innovations being in response to the direction of the HITS JIP.

Diverless UWILDs

UWILDs (underwater inspection in lieu of dry dock) have traditionally been carried out by divers, mostly in sheltered waters. There has been an unacceptable level of injury and fatalities particularly when these methods have been used on assets located offshore. Furthermore, weather related downtime and failure to complete workscope is an inevitable feature of diver-based solutions in areas of high currents, swell and strong winds.

Replacing divers with ‘integrity class’ ROVs that can operate from the deck of the asset with a 3-person team, is proven and efficient. These ROVs are capable of ‘cavi cleaning’ surfaces for inspection and indeed maintenance, and carry NDT tools for thickness measurement, mooring chain measurement and cathodic protection readings.

Sea valves and sea chests are inspected from inside the hull using an ODIN Port. This device allows cameras and other tools to be inserted through a pipe so that the valve can be inspected during operation, with no OOS time; a more reliable inspection than a diver or ROV poking a camera through a grating some distance away from the valve or using a small diameter borescope through a strainer. A safer, more productive and lower cost solution that can operate in conditions that divers cannot.

Diverless sea valve and sea chest, inspection and repairs

The early diverless inspection benefit left operators hungry for more. Inspection and repair were just two elements of an underwater campaign, and if more of the underwater scope could be fulfilled, the safety, operational and commercial benefits increased.

With this feedback and encouragement, ODIN diverless services were expanded to include blanking of the hull discharge lines (PLUG™) and sea chests to enable diverless repair or replacement of sea valves (LIMPET™).

PLUG technology is based on a double block seal created by an inflatable plug pushed inside the discharge line, backed up a secondary seal comprising a metal plate with a rubber faced seal.

LIMPET blanks are sealing plates, designed to fit and seal sea chest intakes. An integrity class ROV cleans the sealing surfaces of the sea chest and surrounds, then attaches lines to the LIMPET blank which is fitted with ‘intelligent’ remotely operated, proprietary winches, designed to draw the blank into place, and reinforce the hydrostatic pressure once the sea chest is internally drained. Once sealed by either PLUG or LIMPET, the lines are available for the safe removal and repair or replacement of the sea valves.

CLAM™ are custom made cofferdams, remotely attached and sealed to the hull to enable replacement of corroded, cracked or otherwise damaged steel hull plating. The design and installation of CLAMs (which can be as large as 5 m x 3 m to date), requires a new and higher level of engineering to ensure safe and effective deployment.

The hydrostatic and operating loads are significant and depth and swell dependent. Full finite element modelling is used to ensure adequate strength with a good safety margin, whilst keeping the weight of the cofferdam low.

Hull surfaces are far from flat, so laser scans are used to ensure the CLAM sealing face is a perfect match to the hull. Lowering a CLAM over the side and through the splash zone involves numerical modelling to define the weather and hull movement limitations.

All these things have to be taken into account for a successful project but the rewards are huge: no dry dock, continued production and safety.

Malaysian CLAMs

The operator of an FPSO offshore Malaysia faced a significant challenge with leaks in the hull, in locations that were below the water line during normal operations, and therefore critical to the asset’s integrity. Several temporary repairs had been implemented, using cement boxes to stem the leak – these had been proven ineffective.

In addition to these temporary repairs, more permanent options were sought, and the traditional route of diver repair was explored. This led to unsuccessful campaigns and tragically, the death of another diver.

Following a series of mandatory surveys, a condition of class was imposed, and a permanent solution was urgently sought. For a sister vessel, this meant coming off-station, moving to a drydock to repair similar damage, and with that came significant financial penalties.

The owner was far sighted and searched for new options, including the CLAM diverless repair technology.

Figure 4. *An ODIN access port.*

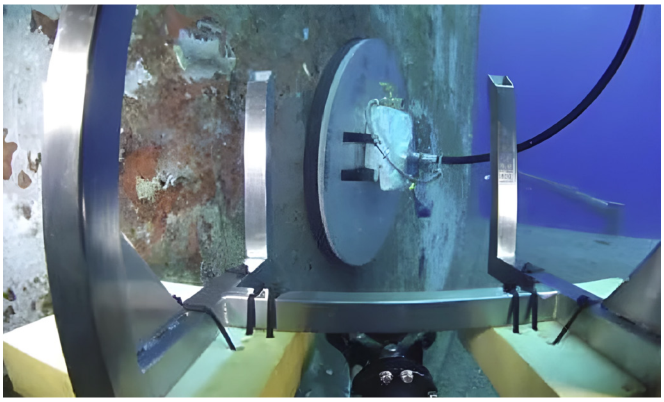


Figure 5. *PLUG overboard discharge isolation.*

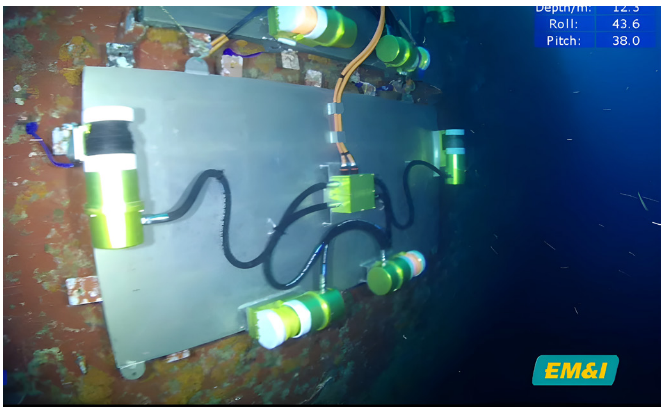


Figure 6. *LIMPET blank in place.*

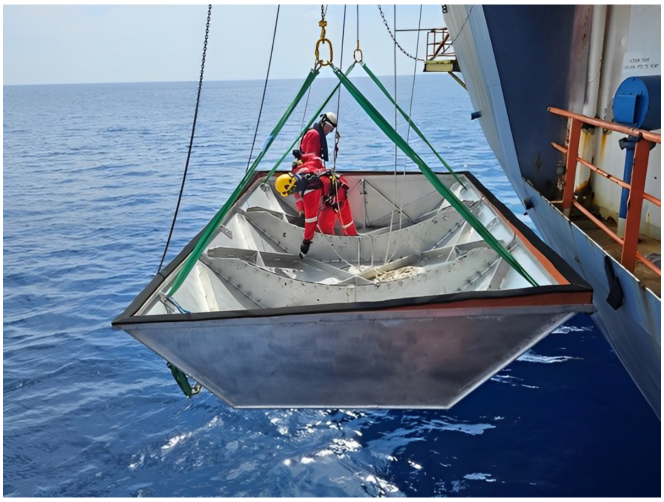


Figure 7. *CLAM cofferdam preparation.*

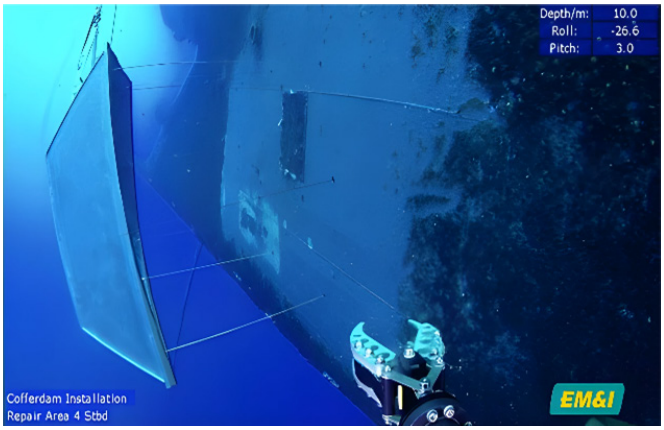


Figure 8. *CLAM cofferdam attachment.*

This led to detailed discussions, review of previous projects and a contract to do the first of a number of repairs. A strong bond and technical understanding were developed between the client, the service provider, and critically, the Classification Society which had imposed the requirement for the repair. This collaboration and understanding included:

- An early site survey, including the laser scanning of the hull around the repair site to ensure the precise design of the cofferdam for optimal seal.
- Engineering liaison for the finite element analysis and numerical modelling.
- Design of the cofferdam (at 5 x 3 m, one of the largest deployed for such work on an FPSO globally).
- Approval of the engineering plan.
- Fabrication in South Africa, where the client visited once for progress, and secondly to witness the factory acceptance test, before approving the work plan for submission to Class.
- Both the service provider and the client liaising with Class for approval of that work plan.

Despite it being cyclone season, the repair team deployed to complete the repair within the deadline for condition of class. CLAM specialists, supported by local Malaysian technicians worked with the FPSO's operator and attending class surveyor.

The first task was the removal of the temporary concrete repairs, followed by the installation of internal ODIN winches through ODIN ports for the cables to draw the cofferdam in to place, giving the double assurance of hydrostatic pressure to create the seal.

With the cofferdam travelling in two parts due to the size, first task on board was to assemble the CLAM cofferdam. With work continuing inboard, the cofferdam was deployed from the deck above the repair site which had been previously cavi cleaned by the ROV. Meanwhile, cables deployed through the ODIN access ports were attached to the cofferdam on the deck.

The team were able to monitor and guide the cofferdam installation using the integrity class ROV deployed for that purpose. The cofferdam was lowered into the area of repair, winched into place, drained and tested to confirm a complete seal.

Once the seal was assured the cropping and replacing of damaged plating was completed to the satisfaction of both the FPSO's operator and the attending surveyor.

On completion of the steel renewal, the process was reversed, and the external face of the repair coated later, by rope access, when offloading brought the repair site above the water line.

The outcome of the successful project resulted in these comments from the vessel operator: "The crop and renew steel repairs were conducted behind the largest cofferdam ever built using marine grade Aluminium material, secured by ODIN technology, efficiently, effectively, and safely throughout. This was a first for underwater repairs in Malaysian waters, which was carried out based on precise engineering design, delivered on schedule, during rough weather in monsoon season…. As the operator, we understood the progress every step of the way; there was no impact to operations and production; and the integrity of the hull has been regained."

Critically, all of the project on board was completed while the FPSO was conducting normal operations, therefore saving the significant cost and production implication of coming off station to go to drydock.

Where to now?

Building on the direction of the members of the HITS JIP, feedback from the market and a parallel exploration of technology available in neighbouring sectors, the scope of diverless services is expanding beyond the initial inspection, through CLAM, PLUG, and LIMPET.

New opportunities being explored include deeper inspection and cleaning of mooring systems with integrity class (as opposed to work class) ROVs; the replacement of depleted anodes on floating production units; and larger scale hull cleaning for asset integrity, all under the ODIN diverless technology 'umbrella'.

So far, we have discussed diverless methodologies and their benefits. HITS however also mandates methods to be developed to avoid manned entry into confined spaces for inspection because traditional strategies create risks of confined space and working at height, a double jeopardy also the subject of a safety study by Professor Andy Woods of Cambridge University.

NoMan® methods combine remotely operated cameras, laser imaging, remotely operated UAV, to provide integrity data on the condition of tanks and other confined spaces.

Conclusion

Incorporating emerging technology with a desire to mitigate safety risk, reduce impact on operations, drive efficiencies and save costs will improve outcomes all round.

In the current context of the energy transition equation, reducing team size and improving that efficiency will reduce carbon emissions and play a noticeable part in the route to Net Zero.

Will the moral and commercial obligations be approached in a realistic, honest and effective way? The technology is available to support.