Floating production installations (FPI), major types of which include floating production units (FPU), floating production, storage, and offloading (FPSO), and floating storage and offloading vessels (FSO) have been recognised for decades as an indispensable part of the offshore oil and gas production infrastructure. The operational capabilities of these easy-to-install floating installations enable their owners to monetise hydrocarbon resources in remote offshore and deepwater regions where seabed pipeline networks are not cost-effective. But, like all other commercial maritime structures and vessels, FPI operating conditions are harsh. Beyond corrosive seawater and weather, they must endure years of standard operations, all of which takes a toll on these installations. Unlike other commercial vessels that are required to dry dock for maintenance and repairs every five years, once FPI assets are anchored at a production site – many older installations are permanently anchored – they begin a period of nonstop service, often lasting 20 years. Taking them out of service is never an attractive option because of the difficulty involved in disconnecting them from well flowlines and deferred revenue while in dry dock.

More recently, with oil prices on the decline and the prospect of their operational burden increasing, most of these decades-old FPI assets have reached, or will soon reach, the end of their designed service life. And when that happens, regardless of how functional an installation is, its class service certificates will expire along with its ability to operate. That leaves FPI owners with two options: build FPI replacements or find a way to extend their service life. While the result of the first option can provide owners with a new asset that has the most modern capabilities, the price tag for building a high-production FPI installation is usually over US$700 million. Beyond the cost, the time required to plan, design, build, and put an installation into service is two or three years.

The other option is to make the necessary repairs that would extend the operational life of FPI assets. When these facilities were newly commissioned or converted for service, little thought was given to ever exercising this option. For this reason, original and conversion design documents that would provide the history of an installation’s physical condition are generally scarce, making it extremely difficult to develop a plan and budget that would result in an efficient and effective repair process. It seemed clear that owners of older FPI assets needed a programme that would enable them to accurately determine the structural integrity of their installations and outline what was needed for them to be maintained in optimal condition. Recognising this need, ABS helped develop a programme that guides baseline inspection activities and engineering reassessments for the life extension of FPI assets that helps achieve a robust integrity management programme for several years beyond original design life.

In July 2015, ABS published its first guidance notes on ‘Life Extension Methodology for Floating Production Installations’.

D avid Hua, ABS Advanced Solutions, USA, recounts how an assessment programme guides analysis of the potential life of floating production installations.

Planned Rejuvenation

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Plan for life extension assessments

Baseline inspections
The ABS life extension process begins with life extension assessments that include conducting baseline inspections, reviewing historic inspection and repair records, conducting gap analyses that compare the current condition with the original design premise and calculations, and performing additional engineering analyses.

Weight control assessments are made to evaluate a FPI's current configuration to determine if the baseline condition has been properly documented with respect to weight changes. Structural modifications that would affect the installation's weight and capacity are also identified. The information gathered during this assessment has a direct bearing on the FPI's stability. When necessary, new stability calculations, with current lightship and variable loads, should be conducted using Class Rules and USCG requirements in effect when the installations were classed.

Hull integrity is analysed with a structural reassessment according to baseline conditions, global strength, global fatigue, and major connection analyses: chain jack, chain jack connections, fairlead connection, leg hull connections, and major foundations. The dynamic loading approach (DLA) strength analyses is the basic tool for structural reassessment. Conditions of corrosion protection systems including coating, dehumidification, and cathodic protection are also evaluated.

Topside deck and truss structures are assessed by determining load condition changes since initial installation, and by quantifying the new airgap: the clearance between the water surface and the FPI's tank top. This is followed by performing strength assessments in order to determine responses to meteorological-ocean condition updates. Past fatigue damages are also identified and an estimate is made of future fatigue life.

Mooring system and piles are assessed by conducting a baseline survey to establish the condition of the mooring chains, wire rope, fairleads, and piles. Coatings and anodes are also evaluated, with special attention paid to the mooring line connectors and scour or gap around the pile heads. In addition, cathodic protection (CP) readings are taken during this survey to measure the effectiveness of existing CP systems for hull, mooring lines, mooring connectors and piles. Non-destructive evaluation (NDE) inspections of selected mooring chain components are made. This is particularly important when a chain has no active corrosion protection. Measurements are also taken to determine the thickness of selected sections of chains, including chains at chain jacks, splash zones, mud lines, and piles above mud lines.

Machinery, lifesaving, and firefighting systems are examined and generally include auxiliary machinery, pumps, piping, electrical installation in general and hazardous areas, lifesaving equipment, and fire-extinguishing apparatus. Fire mains are also pressure tested.

Engineering reassessments are crucial in determining whether a FPI can endure the latest site-specific environmental conditions for its extended service life. Beyond changes in weather at a particular site, the weight of installations are also subject to change during their service life, owing to the addition of new equipment or removal of out-of-service equipment. A gap analysis is also conducted to review original design reports and previous calculations, based on the original site-specific met-ocean data. This information can then be compared to current conditions on the FPI to determine if any additional analyses or calculations are required.

While these assessments are not intended to serve as a complete list, they are the most important parameters in an owner’s decision to undertake service life extension of an asset or decommission it.

Life extension case study: Amni’s Princess Aweni FPSO
The Princess Aweni FPSO, which is owned and operated by Amni International Petroleum Development Company Limited (Amni), started its service life as a Panamax tanker built in 1975. It was converted to a single
point turret moored FSO in 1995 and later converted to a spread moored FPSO in 1997. In 2007, the FPSO was altered for service in the Okoro field with a design life of 10 years, leaving it due to expire in March 2018. For this reason, Amni decided to select the Advanced Solutions group at ABS to initiate a life extension assessment in mid-2017.

**Solution**

Amni chose to conduct the life extension assessments using the dynamic loading analysis/spectral fatigue analysis (DLA/SFA) method instead of the total strength assessment (TSA) method according to the updated 2017, ABS Guidance Notes on Life Extension Methodology for Floating Production Installations. The more rigorous DLA/SFA approach was chosen by Amni to assure the company of asset integrity for the entire hull structure for a 15 year period. The resulting life extension assessment revealed the history of the FPSO and its physical condition, enabling inspectors to determine its structural integrity and outline what would be needed to maintain it in accordance with the applicable class service rules and standards. Due to a lack of original and conversion design documents, the life extension project began with a series of engineering assessments for the FPSO’s hull structures, mooring systems, and major hull/topsides interfaces. In addition, a baseline inspection plan was developed to guide the baseline inspection activities. The *Princess Aweni* FPSO reassessment programme included an initial scantling evaluation, the DLA/SFA analysis, the mooring system analysis, the major foundation analysis, stability analysis, and baseline inspection. As part of this effort, the ballast system – continually operated since the vessel was first commissioned as a tanker – was assessed using engineering and inspection methods to determine the suitability of the system for the FPSO’s extended service life.

**Results**

As a result of the life extension assessments, it was discovered that the original ballast system had deteriorated due to corrosion. But because FPSOs commonly use their cargo for ballasting, the ballast system would be used less frequently. Accordingly, derating the ballast system would enable it to be operated at a lower pressure requirement.

Additionally, the FPSO’s engineering reassessment yielded two important benefits: it was determined that the hull and mooring systems had a remaining fatigue life of 15 years and 5 years, respectively, beyond their original design life.

**Conclusion**

The process of a life extension assessment enables a better understanding of the technical and regulatory requirements for life extension of FPIs, enabling owners to continue their onsite production operations for several years beyond the asset’s original design life.

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**Recommended pre-life extension practices**

Start life extension assessments early, preferably two years before the end of an FPI’s design life, enabling enough time to conduct assessments, carry out repairs or retrofit, and obtain class and regulatory approval or both.

Practice rigid weight control throughout the FPI’s service life, according to class and regulatory requirements, because weight is a key parameter in assessing the impact on stability and structural capacity of a FPI.

Implement strict document control and document retention of the FPI, including original design documents, calculations, inspection reports, maintenance registry, monitoring data, repair records, and other documents that help determine the condition of a facility and assess its remaining service life.