www.scandoil.com

SCANDINAVIAN

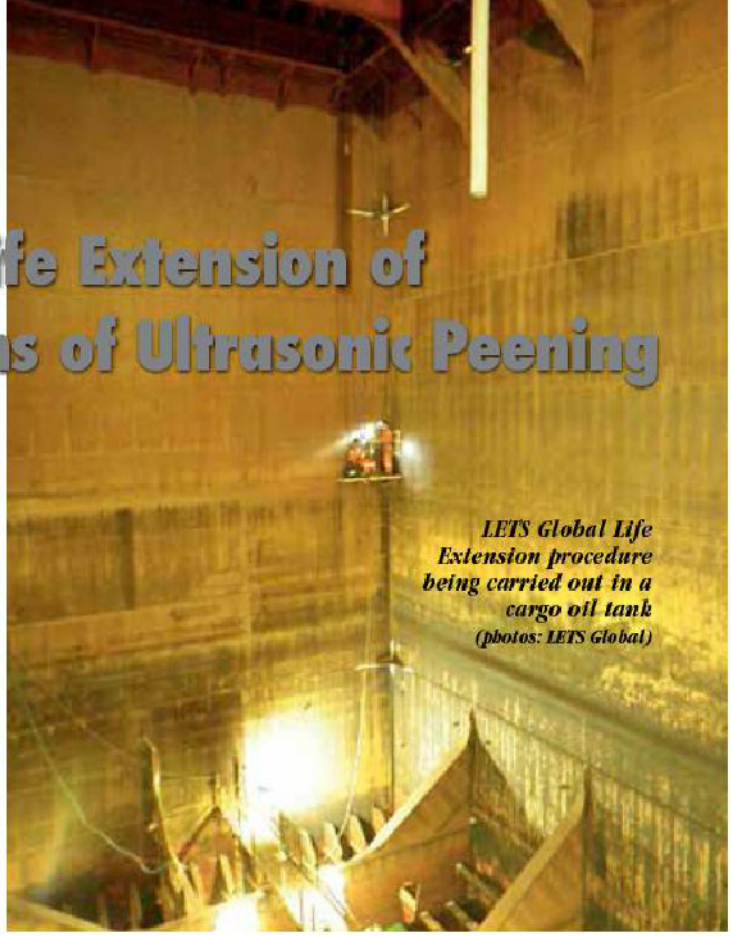
OIL·GAS

MAGAZINE

NO. 5/6 2012 VOL. 40

Operators' Struggle Against Age –

Structural Fatigue and Life Extension of Offshore FPSOs by Means of Ultrasonic Peening



LETS Global Life Extension procedure being carried out in a cargo oil tank (photos: LETS Global)

Life extension of offshore installations is becoming a popular topic, and it ought to be, one thing man cannot stop is time, and with time comes aging. More and more offshore installations are reaching their original intended service life. All rigs are designed for a certain amount of time out on the open sea, and with all the elements against them, at a certain point all rigs will start to show signs of structural fatigue.

BY MALCOLM HEDMAR

The structural integrity of offshore installations is very important because without the body keeping the production equipment and oil afloat, there is not much of an installation to talk about. So operators have to make sure that the structural integrity of their aging rigs are kept intact, and safeguard it.

Structural fatigue cracks tend to initiate at the welded joints, the Life Extension concept is built around the possibility of considerably increasing the strength of the welded joints. The technique, ultrasonic peening, was originally developed in the Soviet Union during the Cold War for use on submarine hulls.

Ultrasonic Peening

Ultrasonic peening, might sounds a lot like ultrasonic testing, which can mislead someone into thinking that it is some kind of inspection method. But ultrasonic reefers to the utilised frequency, which happens to be in the ultrasonic spectrum which starts at 20 KHz, and the verb peening is derived from the hardened steel peen which works the steel surface.

So when performing ultrasonic peening, a hardened steel peen is oscillated, or hammered, against a weld-toe or steel surface at approximately 20,000 times per second, with a amplitude of only 0.05 mm. As the peen hammers the weld toe, a couple of things happen: first of all, all non-geometrical features and crack-like flaws are removed, and left is a smooth groove. As the peen's amplitude is small, the created groove consists of a compressive layer that has high resistance against fatigue cracking.

Numerous projects has been carried out together with among others DNV, IIW, SSAB, NTNU and The Royal Institute of Technology (KTH) in order to measure the benefit of the LETS Global Ultrasonic Peening Procedure on offshore installations. The benefit that ultrasonic peening will have on a given welded joint on an offshore installation is dependent on the stress range that the detail is under. Therefore it is actually difficult to give a constant of how much of a difference the treatment will make. However, as a rule of thumb, the fatigue life of a welded attachment on an offshore installation, under high cycle fatigue with stresses of 200 MPa, will be increased fivefold.

A weld toe treated with LETS Ultrasonic Peening Procedure

Previously, when fatigue hot-spots were located and classed as a threat to the structural integrity, the common approach was to add steel in order to reinforce the area. The downside of this is that you end up changing the stiffness of the vessel at this specific area, making nearby areas prone for fatigue hot-spot development. The ideal solution is to strengthen the area of concern without altering the stiffness, keeping the dynamics of the vessel in the same. This is one of the reasons why ultrasonic peening is being used by operators around the world as the ideal solution for structural integrity challenges deriving from high cycle fatigue.

Achilles Heel of Ultrasonic Peening

The procedure will only be significantly beneficial if the welded joints selected for treatment are of full penetration. As only the surface of the weld can be treated, the root of the weld is left untouched,

Bracket treated with LETS Global Ultrasonic Peening Procedure

making it an "Achilles heel". This is because, even if the weld toe and surface is greatly strengthened, the crack initiation can still take place at the root of the weld, limiting the possible gain in fatigue life.

Ultrasonic Peening and FPSOs, a Perfect Match?

As you might expect, ultrasonic peening can be applied on any structure suffering from structural fatigue. But FPSO operators in particular are finding the concept appealing.

The first reason for this is the fact that FPSO operators want to avoid their assets being forced to stop production and head to a dock for structural repairs, so naturally they will do their outmost to avoid this scenario. Secondly and related to the first, the contracts that FPSOs tend to enter are relatively long compared with, for example, drilling rigs, so at times structural maintenance must be done whilst out on sea.

The third reason is that ultrasonic peening does not produce any heat when applied, so it is a relatively easy procedure to host for an oil and gas producing FPSO. Fourth but not least; the fatigue life extension that is accomplished by using Ultrasonic Peening is so great that it is the only real option against structural fatigue.

FPSO P-37 and FPSO Triton, an Ocean Apart, a Challenge Alike

Petrobras realises that in order to reach the production goal it has set for 2020; it needs to safeguard the structural integrity of its already existing fleet of production platforms. Otherwise downtime due to unforeseen structural failures will put the production goal in jeopardy.

During the third quarter of 2012, Petrobras' *FPSO P-37* will be its first in line to undergo life extension by means of ultrasonic peening. The first phase of the project is identical to that of the *FPSO Triton*, once owned by HESS, namely ultrasonic peening of fatigue hot-spots found at pallet stools.

This specific issue arises because both *FPSO Triton* and *FPSO P-37* originates from conversions. The production deck, resting on the pallet stools is much stiffer than the less-rigid hull of a tanker that is built for sailing. So as the hull moves with the sea, the pallet stools supporting the stiff production deck will place immense stresses against the vessel's deck, which often leads to fatigue cracks.

The primary project on the *P-37*, encompasses Life Extension of 30 pallet stool fatigue hot-spots. This case high-lights the fact that ultrasonic peening is a proactive method to ensure structural fitness rather than a reactive method. If a crack has had time to develop, it will first need to undergo weld repair before Ultrasonic Peening can be applied.

So, is it necessary to use Ultrasonic Peening after a conventional weld repair?

The simple answer to this question is yes. But one must take into account that conventional weld repair only restores what once was, which means that the relatively high stresses still remain, the material is unchanged, the only thing which has changed is that there has been a considerable increase of harmful residual stresses in the heat affected zone (HAZ).

LETS Global Ultrasonic Peening Technicians working on the FPSO Schiehallion

All this combined, means that the crack will re-initiate sooner rather than later if ultrasonic peening is not applied.

FPSO Triton was ahead of the *P-37* applying ultrasonic peening on her pallet stools already in 2005/2006. But since she has a planned service life up to year 2022, a more extensive Life Extension program has been put into place. In total, eight ballast tanks will undergo ultrasonic peening, treating a total of 640 fatigue hot-spots. The aim with this is to avoid fatigue cracks developing in the water ballast tanks, and making sure that she gets a repair free service life.

After the first Ultrasonic Peening campaign on *P-37*, Petrobras is likely to use it on all of its floating platforms which shows similar characteristics as *P-37*, following HESS's serious approach of safeguarding its installation's structural integrity.

Different FPSOs, Identical Issues

Engineers working with structural integrity of FPSOs often seem to work isolated from colleagues from other companies. FPSOs, and especially FPSOs originating from conversions, all tend to encounter the same structural problems. To some extent it is understandable that operators do not want the short comings of their rigs to become known to everyone, but if they would, downtime and cost could be saved.

It is very likely that the neighbouring rig may face the same problem, or maybe the same problem has just recently solved. We are now entering an era where FPSOs no longer are a new phenomenon. Today there are FPSOs whose working life is close to an end, but headstrong operators will make sure they do everything in their power to keep them producing. Much can be learned from these rigs, as it becomes obvious how much time and money can be saved if a more proactive approach towards structural integrity is taken.

FPSO Triton was ahead if its time, but because of her, other operators are catching on. ■

The Author:

Malcolm Hedmar is currently Ultrasonic Peening Quality Assurance and Quality Control Manager at LETS Global, which specialises in Offshore Life Extension. Mr. Hedmar graduated as a Maritime Officer from the Maritime University of Applied Science in Rotterdam, the Netherlands.