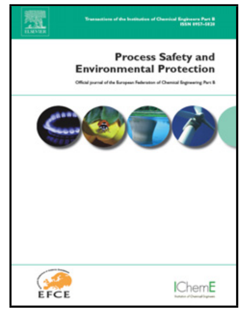
Accepted Manuscript



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PII: S0957-5820(16)30289-0
DOI: http://dx.doi.org/doi:10.1016/j.psep.2016.11.019
Reference: PSEP 922

To appear in: *Process Safety and Environment Protection*

Received date: 10-9-2016
Revised date: 20-11-2016
Accepted date: 22-11-2016

Please cite this article as: Keprate, Arvind, Chandima Ratnayake, R.M., Sankararaman, Shankar, Minimizing Hydrocarbon Release from Offshore Piping by Performing Probabilistic Fatigue Life Assessment.Process Safety and Environment Protection http://dx.doi.org/10.1016/j.psep.2016.11.019

Minimizing Hydrocarbon Release from Offshore Piping by Performing Probabilistic Fatigue Life Assessment

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Abstract

Topside piping is the major source of hydrocarbon release (HCR) on offshore oil and gas (OOG) platforms in the North Sea region. Since 21% of piping failures are caused by vibration induced fatigue (VIF), an accurate remnant fatigue life (RFL) assessment has the potential to minimize the chances of HCR from an operating piping system. BS-7910 gives two possible approaches for performing a RFL assessment: the S-N curve approach and the fracture mechanics (FM) approach. Since there are large number of uncertainties (such as uncertainty due to the crack growth model, future loading, material and geometric properties, etc.) involved in the RFL calculation process, therefore it is vital to consider the aforementioned sources of uncertainty in order to arrive at an accurate RFL estimate. Nevertheless, BS-7910 provides limited guidance on how to handle uncertainty in RFL assessment. The most common way of dealing with the aforementioned uncertainty is to evaluate RFL probabilistically. This manuscript thus explains the procedure of the probabilistic RFL assessment of offshore topside piping, with an emphasis on uncertainty quantification, propagation and management. Uncertainty quantification deals with identifying and characterizing the various sources of uncertainty that may influence the future behavior of the piping component and, in turn, the RFL estimate. Thereafter, uncertainty propagation employs the previously quantified uncertainties and uses this information to predict the RFL. Finally, uncertainty management deals with performing sensitivity analysis to find the individual contributors to uncertainty in the estimated RFL. A numerical example illustrating the deterministic and probabilistic RFL assessment of topside piping is presented. Afterwards, probabilistically predicted RFL is used to demonstrate the calculation of an inspection interval. Finally, the implications of probabilistically estimated RFL on HCR from process piping is discussed.

Keywords: HCR, RFL, VIF, Uncertainty Handling, Probabilistic Crack Growth, Offshore Piping

1. Introduction

1.1 Fitness-for-service assessment and remaining useful life prediction

On 29th April 2016, a helicopter carrying 13 personnel from Gullfaks-B offshore field crashed near the shores of Bergen, killing all onboard (Maslin, 2016). Besides the 13 fatalities, the crash also led to production shutdown on the platform, thus leading to both economic and life losses. The reason for the crash was identified as a fatigue crack in the right-hand input shaft pin (in the helicopter's main gear box), which initiated and propagated under cyclic loading imposed on the aforementioned component, leading to the catastrophic accident (Maslin, 2016). Likewise, with time, the mechanical components and process piping on an offshore oil and gas (OOG) installation are subjected to cyclic (fatigue) loading, causing the initiation and propagation of cracks. However, unlike the disastrous helicopter crash, the fatigue cracking in offshore piping rarely leads to a catastrophic