Platform Life Extension by Inspection

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ABSTRACT

Fatigue test data are used to quantify the bias and uncertainty in total fatigue life and the interval between detectable crack initiation and member failure. Sources of additional “hidden” bias in fatigue life calculation are also considered: e.g. characteristic wave steepness, hydrodynamic coefficients, stress concentration factors, joint flexibility, S-N curves, and the interval between first member failure and structural collapse. Using the example of an actual 40-year-old platform with a calculated life of four years, various levels of inspection are examined for their relative credibility vis-a-vis the calculation. Targeted MPI of a limited number of joints, selected using the fatigue analysis, is examined for its ability to provide fatigue life extension of up to 20 years, with periodic inspection at shorter intervals providing the same level of safety as a new design at a damage ratio D=0.5 and no inspections beyond Level II fly-by.

KEY WORDS: Jackets; fatigue; risk based inspection.

INTRODUCTION

Considering the uncertainties associated with numerous parameters affecting fatigue life, such as weld profile, stress concentration factor and an applicable S-N curve, it is not realistic to assume that calculated fatigue lives will accurately predict actual fatigue crack propagation and failure. The primary objective for performing fatigue analysis of the platform is to determine the relative sensitivity of platform components to fatigue damage so that future inspection programs will put more emphasis on those components that are more susceptible to fatigue damage.

In the late 1960s, prior to the adoption of API RP 2X, a new offshore platform was condemned because UT found “cracks” at the weld root. This provided full size specimens for fatigue testing at the University of California. External weld profiles merged smoothly with the adjoining base metal, and low cycle fatigue tests gave excellent results. The “cracks” were welding discontinuities at the root of single-sided tubular joint welds, now considered to be benign.

Subsequent large scale European tests with less desirable weld profiles showed lower results, prompting API to draw a second, lower S-N curve for this case. The European interpretation is that this is entirely attributable to a thickness effect, and that weld profile notches do not matter. API now considers both effects.

SYSTEM RELIABILITY CONSIDERATIONS IN DESIGN

Calibration of the safety factor to be applied in fatigue design may be considered in reference to examples like this 1976 North Sea structure, Figure 1. It is still in service today, despite having a calculated fatigue life of only 20 years at D=1.0, using the upper S-N curve “X” and the optimistic Alpha Kellogg stress concentration factors (Marshall & Luyties, 1982). The detailed fatigue analysis indicated the distribution of member lives shown in the histogram.

Figure 1. North Sea example

Statistical analysis allows us to deal rationally with the scatter and uncertainty inherent in the fatigue problem. Scatter in the basic fatigue S-N data is approximately log normal, with the AWS-X modified design curve corresponding to 97% survival. The median fatigue life is 5 to 8 times that given by the curve, and the 2-sigma scatter band