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Minimization of Variability in Risk-based Winterization Analysis: Asset Integrity Assurance in Arctic Environments

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Asset Integrity (AI) assurance poses significant challenges for petroleum asset operations, especially in Arctic environments. In the context of AI assurance, winterization plays a significant role in harsh cold environments, and physical assets operate at or close to their design limits. Although the risk-based winterization (RBW) approach provides a rational way of determining the need for winterization and its levels, the inherent ad hoc nature of the RBW level analysis increases the variability in the assessments and recommendations. This manuscript proposes an approach for minimizing the assessment and recommendation-related variability in the RBW level analysis tasks.

INTRODUCTION

Asset Integrity (AI) assurance in Arctic and harsh environments with low temperatures, extreme ice features, icebergs, permafrost and icing, extreme winds, and storms requires a holistic approach (Khan et al., 2014b; Surveyor, 2015). This is due to challenges such as “scarce information and lack of knowledge of degradation mechanisms and their impact” (related to operational and technical integrity); the “stochastic nature of degradation and [its] consideration in design” (related to operational and design integrity); the “determination of [the] winterization requirement” (related to operational integrity); the “effect of unpredictable climate changes on design and operational integrity”; and the “ineffectiveness of conventional load monitoring and load characterization methods” (related to technical integrity). These challenges influence sustaining the performance at the anticipated levels in Arctic and harsh environments (Khan et al., 2014a). Especially, the “complex degradation rates, unpredictable climate changes, and high uncertainty due to lack of knowledge and data” exacerbate the challenges for assuring the AI at an anticipated level (Khan et al., 2014a).

In the context of AI assurance in Arctic environments, winterization plays a significantly important role. The winterization addresses the risks associated with air temperatures and ice accretion (Surveyor, 2015). In this context, Yang et al. (2013) proposed a risk-based approach to determine appropriate winterization levels (e.g., ice repellent coatings, chemical seals, and heat tracing). In the Arctic environments, low temperatures create negative effects on the material behavior and increase the viscosity of liquids and/or lubricants whilst freezing certain fluids that are essential for normal operations. Apart from that, low air temperature impairs the exposed machinery and electronic systems, causing hazards to health, safety and environment (HSE) (Surveyor, 2015). For instance, it is possible for ice accretion (i.e., the combined effect of wind and wave action) to increase risks related to “escape route accessibility, blockage of air ducts, and mechanical interference of deck machinery and equipment,” which causes the degradation of the AI of the operating assets in the Arctic and harsh environments (Surveyor, 2015). Hence, the implementation of effective winterization approaches is vital to minimize the risk of potential failures in order to enhance and maintain AI at an acceptable level.

Inherently, AI declines over time (Ratnayake, 2012) due to hardware-related challenges (the design, construction, and operation of facilities), organizational and human factors (the ability of personnel to perform in harsh environments), and the changing nature of degradation mechanisms due to changes in the product and operational conditions (see Fig. 1). Although RBW approaches have been developed to assure AI, the RBW analysis itself creates a certain level of variability (see Fig. 1). Hence, it is vital to minimize the potential uncertainty and variability. Khan et al. (2014a) suggested potential sources of information and data, such as “expert knowledge and experience,” “input from local residents in the Arctic and sub-Arctic regions,” and “data and information shared across industries,” as well as regulatory authorities, which have operations and responsibility in Arctic and harsh environments, to address the lack of data and information. Although the aforementioned data sources enable minimizing uncertainty, it is vital to have methodologies to enhance currently existing analysis approaches. For instance, if there is high variability in the analysis performed by experts, then the increased variability in turn increases the variability in the assets’ performance (see Fig. 1).

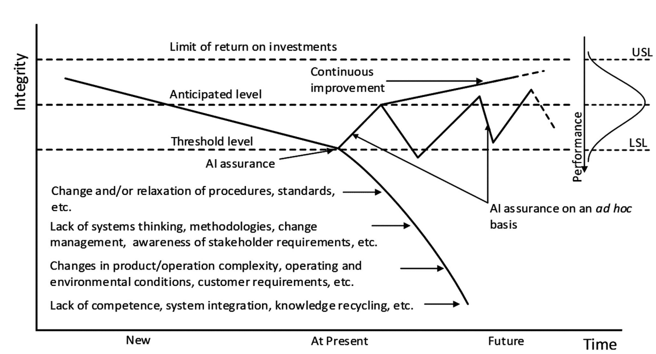

Fig. 1 AI degradation and performance variability (adapted from Ratnayake, 2012)

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KEY WORDS: Asset integrity assurance, Arctic environment, variability, asset performance, risk-based winterization.