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Evaluation of the Risk OMT model for maintenance work on major offshore process equipment

B.A. Gran [a,*], R. Bye [b], O.M. Nyheim [a], E.H. Okstad [c], J. Seljelid [a], S. Sklet [d], J. Vatn [c], J.E. Vinnem [e]

[a] Safetec Nordic AS, Norway
[b] Studio Apertura, NTNU, Trondheim, Norway
[c] SINTEF Technology & Society, Trondheim, Norway
[d] Statoil, Stavanger, Norway
[e] University of Stavanger, Norway

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ABSTRACT

Operational safety is receiving more and more attention in the Norwegian offshore industry. Almost two thirds of all leaks on offshore installations in the period 2001–2005, according to the Risk Level Project by the Petroleum Safety Authority in Norway, resulted from manual operations and interventions, as well as shut-down and start-up. The intention with the Risk OMT (risk modelling – integration of organisational, human and technical factors) program has been to develop more representative models for calculation of leak frequencies as a function of the volume of manual operations and interventions. In the Risk OMT project a generic risk model has been developed and is adapted to use for specific failure scenarios. The model considers the operational barriers in event trees and fault trees, as well as risk influencing factors that determine the basic event probabilities in the fault trees. The full model, which applies Bayesian belief networks, is presented more thoroughly in a separate paper. This paper presents the evaluation of the model. The model has been evaluated through some case studies, and one important aspect is the evaluation of the importance of each risk influencing factor. In addition some risk-reducing measures have been proposed, and the paper presents how the effect of these measures has been evaluated by using the model. Finally, possible applications and recommendations for further work are discussed.

1. Introduction

1.1. Background

Operational safety is receiving more and more attention in the Norwegian offshore industry. One reason for this is that the focus in the future for the industry is on operation of existing installations, extending the operational life of some of these installations as well as tying in new sub-sea installations. Authorities are also more focused on risk reduction in the operational phase. When installations have substantial extension of their operational life, it implies also that the technical capabilities with which the installations were constructed may be significantly different from the corresponding technical requirements of new installations. Reference to large scale accidents like Piper Alpha (UK, 1988) and Texas City (US, 2005) may also be used in order to substantiate this. Almost two thirds of all hydrocarbon leaks on offshore installations in the period 2001–2005, according to the Risk Level Project by the Petroleum Safety Authority in Norway (PSA; see Vinnem, Aven, Husebø, Seljelid, & Tveit, 2006), resulted from manual operations and interventions, as well as shut-down and start-up, confirming what is considered common knowledge; that incidents and accidents are often caused by the failure of operational barriers.

Another reason for having a focus on operational safety is that the trends in the last ten years with respect to several aspects of major hazard risk for existing production installations in the Norwegian sector, according to the Risk Level Project by PSA (Vinnem, 2010; Vinnem et al., 2006), have been either constant or slightly increasing. The industry may need a new initiative in order to turn the trends in the right direction.

The intention with the "Risk OMT" (risk modelling – integration of organisational, human and technical factors) program has been to develop more representative models for calculation of leak frequencies as a function of the volume of manual operations and

* Corresponding author.
E-mail address: bag@safetec.no (B.A. Gran).

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interventions. The Risk OMT program represents a further development of the work in the barrier and operational risk analysis (BORA, Vinnem et al., 2003) and Operational Condition Safety (OTS, Sklet et al., 2010) projects. The emphasis is on a more comprehensive modelling of risk influencing factors (RIFs) and how these affect the performance of operational barriers. One of the main aspects of the BORA project was to address the barrier situation in detail when operational activities are carried out. A list of ten suitably defined activities and conditions that are associated with risk of hydrocarbon leaks was established during the work with activity indicators (Vinnem, Veire, Heide, & Aven, 2004), and this is also used in the BORA project. The BORA project was concluded in 2006 with a generalised, but relatively coarse, methodology based on the initial methodology formulation as well as the experience from the case studies. One of the main aspects of the BORA project was to address the barrier situation in detail, introducing risk influencing factors. The basic approach is the same, but the intention with the Risk OMT program has been to develop further the models used in BORA and OTS. The Risk OMT program is built on analysis of questionnaire survey data and leaks (Kongsvik, Johnsen, & Sklet, 2011) as well as in depth analysis of investigation reports from the most critical hydrocarbon leaks in the past. In a companion paper by Vinnem et al. (in press), the full generic RIF model and its implementations are presented. In that paper a particular focus is put on the generic RIF model that has been developed and how it is adapted to be used for specific failure scenarios. The paper also presents the full Bayesian belief network (BBN) model.

1.2. The BORA and OTS projects

The RIF structure used in the BORA modelling was a one level structure, where all RIFs were given the same structural importance (Aven, Sklet, & Vinnem, 2006). The general groups of RIFs used were: personal characteristics, task characteristics, characteristics of the technical system, administrative control and organisational factors/operational philosophy. The specific RIFs for a specific basic event in a fault tree for barrier failure were chosen from this general list.

The objective of OTS was to have a system for assessment of the operational safety condition on an offshore installation/onshore plant, with particular emphasis on how operational barriers contribute to prevention of major hazard risk and the effect of human and organisational factors (HOFs) on the barrier performance. The OTS project was based on the modelling in the BORA project, and has given the opportunity to study the human and organisational factors in a more detailed manner. The objective of the OTS project was reached through a development process with the following targets:

1. Identify and describe human and operational barriers for selected accident scenarios, with major hazard risk potential.
2. Identify those tasks that are most critical from a risk point of view, either through initiation of failures (initiating events) or failures of important barrier functions.
3. Establish an overview of the factors that influence the initiating events and the operational barrier performance and define Performance Standards (PS).
4. Define performance requirements for these PS that are suitable for measurement of the condition and establish methods for how to measure the status.

The OTS project has developed a dedicated questionnaire survey in order to focus on work practice in the performance of interventions in the process systems, as well as an extensive interview guide for the interviews of various employee groups associated with interventions in the process systems. This may be used as the main basis for the scoring of the RIFs. The OTS method comprises 7 performance standards: work practice, competence, procedures and documentation, communication, workload and physical working environment, management and management of change.

1.3. The Risk OMT program

The emphasis in the Risk OMT (risk modelling – integration of organisational, human and technical factors) program has been on a more comprehensive modelling of risk influencing factors and how these affect the performance of operational barriers. The objective of the Risk OMT program was to provide new knowledge and tools for major hazard risk management for installations and plants, based on improved understanding of the influence of organisational, human and technical factors. These challenges are addressed explicitly and the main objectives are achieved through meeting the sub-goals of the project:

- Identify and describe organisational and operational barriers for risk control.
- Provide new knowledge about the effectiveness of organisational, human and technical factors for the performance of operational barriers.
- Define indicators for these factors that are suitable for measurement of barrier performance and establish methods for how to measure the status of these factors.
- Develop new models for barrier performance reflecting organisational and operational management factors.
- Demonstrate use through case studies and proposed risk reduction measures.
- Analyse experience data in order to identify those risk management regimes that are most effective.

1.4. Research purpose

One particular objective of the Risk OMT program, as listed above, is to demonstrate the use of new knowledge and models through case studies and proposed risk reduction measures. The main intention of this paper is therefore to demonstrate and evaluate the use of the Risk OMT model through applying it in a set of case studies. The case studies include applying the model to evaluate the effect of different strategies to reduce the leakage rates.

The result is that the paper demonstrates that the Risk OMT model provides a good basis for ranking a set of proposed risk reduction measures. When the model is used for ranking of the risk-reducing measures, the effect of the use of human error probabilities is limited, whereas this is the weakest element when the model is used in an absolute sense (Vinnem et al., in press).

1.5. Structure of paper

Section 2 summarises the RIF structure that has been developed. The generic RIF model is presented first, followed by how this generic model is used for specific scenarios. Then the BBN model, including fault trees, event trees and RIFs, is presented. The implementation in a BBN software tool is also briefly explained, including the simplifications that have been adopted. Section 3 presents the case studies and their evaluation. One important aspect is the evaluation of the importance of each RIF. Section 4 presents some risk-reducing measures and how the effect of these measures has been evaluated by using the model. In Section 5