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Using a task-based risk assessment process (EDEEP) to improve equipment design safety: A case study of an exploration drill rig.

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Introduction

Diverse and considerable energies are associated with mobile equipment operated and maintained on mine sites. Loss of control of these energies is a common cause of injury. In 2006, four multi-national mining companies formed the Earth Moving Equipment Safety Round Table (EMERST – emesrt.org). The aim of EMESRT is to engage with the manufacturers of equipment to accelerate improvements in mining equipment design. Since then, EMESRT has maintained a program of regular visits and other engagements with a steadily increasing number of manufacturers. The membership has also increased, with fifteen companies being members in 2012. An early task undertaken by EMERST was the development of "Design Philosophies" which collated the experience of mining companies in identifying the common unwanted events which cause equipment related injuries and illness. These potential unwanted events are grouped into eight categories in the current version of the Design Philosophies - Access & Working at Heights; Tires & Rims; Exposure to harmful energies; Fire; Machine operation and controls; Health impacting factors; Manual tasks; and Confined spaces & Restricted work areas. The complete Design Philosophies are available at emesrt.org.

A technique for analysing risks associated with operation and maintenance tasks, the Operability and Maintainability Analysis Technique, was subsequently developed and trialed [1-3]. OMAT involves the use of a task-oriented risk assessment process to identify, analyse and evaluate risks associated with the operation and maintenance of mobile mining equipment. This technique encourages the implementation of design control measures to eliminate or reduce the risks, rather than reliance on administrative controls such as warnings and training.

OMAT was developed based on the recognition that the behaviour of the operators and maintainer is largely shaped by their tasks which are, in turn, partly shaped by the

equipment's design. Therefore, in order to create safer equipment, designers must predict how their designs will shape the behaviours of miners in the context of the different sites around the world. OMAT was consequently designed to provide a user-engagement processes to identify and assess the risks in the design of mining equipment.

In 2011, the EMERST members resolved to propose a common form of safe design information to be requested by all members companies during procurement. A draft EMERST Design Evaluation for Equipment Procurement process was developed through which the outcomes of OMAT risk assessment and control activities are integrated into a common "Safe Design Information" template. This draft process was presented to seven major mining equipment manufacturers during an international tour undertaken in February and March 2012. The manufacturers were requested to consider and trial the proposal and provide feedback. A number of changes and clarifications were consequently incorporated into the final version that was launched in September 2012.

The process involves identifying priority tasks based on frequency and the severity of the consequences of potential unwanted events identified in the EMESRT Design Philosophies; undertaking a task-based risk assessment of priority tasks in conjunction with site-based personnel; evaluating the effectiveness of control measures; and providing information about safe design features in a standardised format. Burgess-Limerick, Joy, Cooke & Horberry[4] describe the process in detail including supplementary files with examples and a template spreadsheet.

Sandvik Mining supports the EDEEP process, which was recently applied to a drill rig. The outcome of the activity shows that is a process with many levels of complexity, however if it can be further simplified and streamlined it can be more cost beneficial and have the potential to add to the EHS value of the industry.

Sandvik Mining

Sandvik Group is a global engineering group with advanced products and world-leading positions in key areas. Sandvik Mining is a business area within the Sandvik Group and a leading global supplier of equipment and tools, service and technical solutions for the mining industry. The offering covers rock drilling, rock cutting, rock crushing, loading and hauling and materials handling.

Sandvik Mining's ambition is to provide the safest machines on the market. A safe product is one which under normal and reasonably foreseeable conditions of its intended use, including foreseeable misuse, presents acceptable risk for operators and people working with or in the near vicinity of the machine or equipment. Sandvik Mining aims to achieve this through implementing a Product Environment Health and Safety (Product EHS) Process for Product Development for all new and upgraded products.

Product EHS deals with how Sandvik Mining's products are designed, assembled, transported, operated, maintained and supported. It is also about how to further implement EHS in new and upgraded products and communicate this to our customers. Our products, services and technical solutions aim to deliver acceptable EHS risk, high quality, long endurance and lifetime, energy efficiency, environmentally sound and as far as possible recyclable.

Sandvik Mining works in a structured way to identify potential hazards and being innovative to find solutions on how to mitigate the risks.

Sandvik Mining strongly supports the EDEEP process; however it is complex and requires time and resources. Therefore as Sandvik has applied the process in practice, a number of suggestions have been made with the intention of making the process more practical without compromising on the end result; increasing the EHS of the mining industry.

Sandvik Mining EDEEP Process

During 2011, Sandvik Mining Product EHS engineers were trained in the OMAT process. The aim of OMAT is to eliminate design-related operability and maintainability health and safety issues through strategic hazard identification, risk ranking and risk control identification to be used by designers to become more aware of ergonomic and human factors and incorporating these ideas into their designs.

In 2012 Sandvik Mining engaged in the EDEEP process. To fit existing internal 'ways of working', Sandvik has attempted to simplify and adapt the process, however additional activities have also been added to the original EDEEP process.

The Sandvik Mining EDEEP process (Figure 1) consists of four steps:

- Priority task identification
- Task Based Risk Assessment
- Sales Design Information
- Sandvik Mining Follow-up Actions

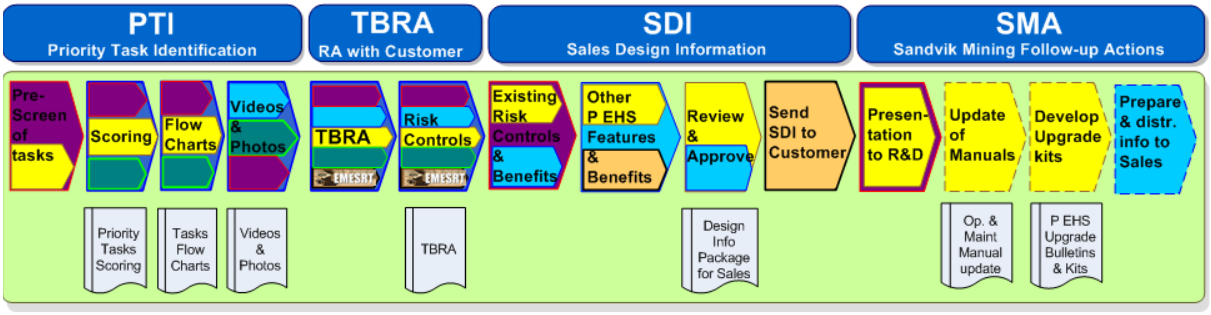

Figure 1. Sandvik Mining EDEEP Process

Sandvik Mining acknowledges the importance of conducting the process in interdisciplinary teams. The colors in the process above represent different functions and their place of participation in the process. The functions represented in the process are customer, Product EHS/ Product Safety, Market and Communication, Product Line Management and Sales. The entire process is coordinated by a minimum of two facilitators. The following sections describe in detail how the EDEEP process was applied and which obstacles and opportunities were encountered. These are also further discussed and suggestions for improvements and streamlining of the process are made.

The Application of Sandvik Mining EDEEP Process

During 2012/2013, Sandvik Mining initiated an EDEEP process to a new Drill Rig together with the RockTech USA. RockTech USA is a supplier of mining equipment, especially focusing on core drill rigs and excavator mounted percussive drill assemblies. Although this customer is not an EMESRT member company, the inclusion of experienced drill rig operators satisfies EMESRT's requirements to involve users in the design evaluation process.

Priority task identification

The priority task identification is a substantial undertaking. First of all, the selection of tasks is complex. Participants have different opinions regarding the definitions of tasks. The number of tasks to be studied can vary depending on the decisions made at this stage. Secondly, the number of tasks that may be taken into account is not restricted and can be 1000 or even more, depending on the product and EDEEP assessment team. To control this issue a decision was made to conduct a pre-screening and selection of tasks to be included in the priority task identification. The pre-screening was based on previous documentation, for example manuals and experience and background of the participants. The number of participants was limited to four, representing the Product Line, Engineering and Product EHS. 25 tasks were selected in this process, which were then transferred to the priority task identification section of the template to be assessed in relation to the potential unwanted events.

For the priority task identification the team was extended to include functions such as Quality, Market, Sales and technical professionals within design, service, maintenance and operations; this despite the recommendations of EMESRT. The diversity of the team was crucial to the exercise; however it was also of highest importance that the team understood the intention of the activity, EMESRT, the process and shared definitions. Therefore much emphasis was put into the introduction.

Early in the process it became obvious that a number of definitions had to be made such as the scope and framework for the environment in which the equipment was perceived to be operated.

The complexity of the categorization of potential unwanted events was an obstacle in the process. The potential unwanted events had to be further defined, a couple of examples are; 'fall from heights', 'respirable dust exposure' or other health impacting factors that are more or less constant in an mining environment. Different standards define 'height' differently and the decision was made to consider all work above ground level as 'height'. The team also decided to consider dust exposure, vibration and noise only if these were caused directly by the task or if performing the task meant a higher direct level of exposure. Potential unwanted events were often found to be difficult to differentiate because categories overlapped and/or are not clearly defined.

As stated earlier, a large amount of time was put into describing the task and its start and end points prior to the scoring. Although, it became clear that the perception of each task is highly related to the individual and it was difficult to maintain a shared picture of the specific task.

The work flow was continuously interrupted by efforts to establish which part of the task was currently assessed.

It is also important to study the design philosophies during the priority task identification session. A document containing the potential unwanted events and the connection to the design philosophies was created in order for the participants to easily access this information without skipping back and forth in the EDEEP excel template.

All tasks that were scored as having Serious, Major, or Catastrophic Maximum Reasonable Consequences associated with any potential unwanted event were then selected for further assessment in the task-based risk assessment. The total number of tasks selected was 10.

Having identified the priority tasks for which detailed risk assessment is required, the next step was to create flowcharts of the tasks (Figure 2). This was done with the help of operations technical professionals and the support of manuals.

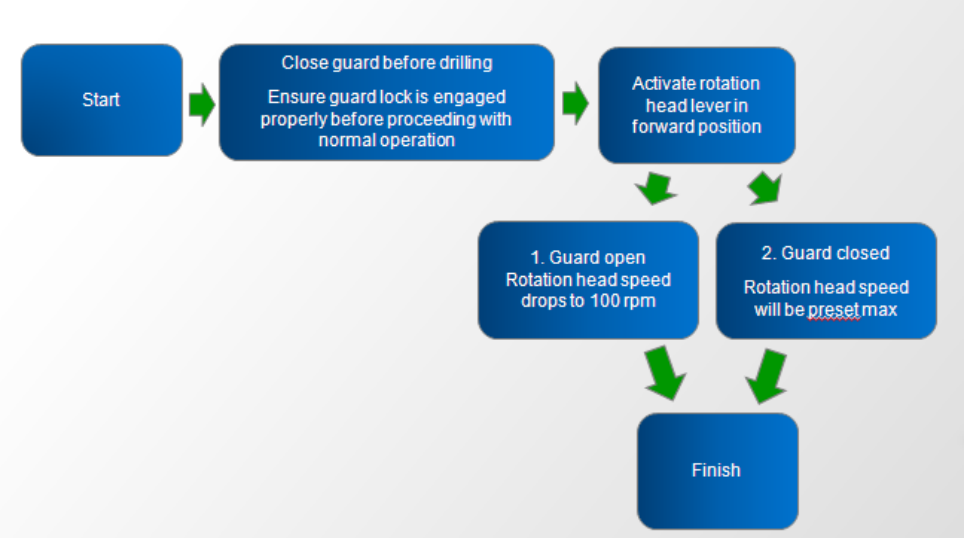

Figure 2. Example flow chart of task

Video recording

The team decided to record the task in collaboration with a professional videographer because the intention was to also use the recorded material in training and marketing. The personnel filming must be informed about the risks connected to being around the equipment and it is recommended to make the recording together with EHS professionals. The recording took almost 3 days. There were many learning outcomes from participating in the filming because tasks had to be repeated and in some cases corrected. Although Sandvik Mining acknowledge that this is a normal part of the EDEEP process we recommend to do it because of the value it adds to the understanding of the tasks and the discussion as well as activities post- EDEEP.

Task-Based Risk Assessment

The team assembled to perform the task-based risk assessment included a customer (RockTech USA), mining company-based operation and maintenance personnel, OEM service personnel, Product EHS/ EHS functions, Engineering, R&D, Product Line Management and Sales.

The team used the outcomes of the priority task identification, video footage, 3D models, the equipment, flow charts, previous risk assessments, information about related equipment, studies such as visibility and noise assessments and other historic data to further assess the 10 selected tasks. The team received training about the EDEEP Process with focus on the task-based risk assessment.

The task-based risk assessment shared some issues with the priority task identification, such as defining tasks, scoring and functionality of the template. The scoring of probability for each task (and hence risk) took a long time and was not considered to add great value. The rationale behind this is that the tasks are already evaluated against the unwanted events in terms of exposure and potential consequence in the priority task identification stage. It is suggested that assessing probability (and risk) could be replaced by asking a number of questions, such as:

- What control measures are currently in place to reduce the probability of the unwanted events occurring?
- What measures are in place to reduce the severity of the outcomes of the unwanted events?
- Are these sufficient? How do we know?
- Are there other design control measures needed?
- What administrative control measures should be put in place by the equipment purchaser?

Further, while the connection to the design philosophies is important at the priority task identification stage, it is suggested to remove these from the task-based risk assessment. The reasoning for doing so is that the Design Philosophies are already studied during the priority task identification. Further it will reduce the administration.

Outcomes of the task-based risk assessment

The task-based risk assessment was successful in identifying the key design control measures for the potential unwanted events associated with the priority tasks. By using this method we can identify what people do with the machine that can hurt them and propose and suggest designs to control this. For example, it was identified that the relocation of sheave greasing points from the top of the drill mast to ground level would eliminate the need to climb the mast, and hence significant risks associated with this task. Similarly, the location of a breather filter on top of a hydraulic tank was altered to eliminate a tripping hazard. The existence of a significant crushing hazard near the jack legs for which no design control exists was also identified. The communication of this hazard to operators has been reinforced through modifications to the warning label in the vicinity of the hazard, and through recommended administrative controls provided within the safe design information.

Safe Design Information

The outcomes of the task-based risk assessment were the then transferred to the safe design information, in the Sandvik EDEEP process this is known as Sales Design Information. The safe design information is very much a tool for communicating to the customer. Therefore, how this information is presented is crucial and the question has been raised whether the excel sheet/ table is the most suitable format.

Sandvik Mining Follow- Up Actions

As a result of the Sandvik EDEEP process it is now possible to take the gained information and translate it into activities and actions. A number of changes have been made to the equipment and other potential design features are to be assessed by R&D. Manuals have been updated with improved procedures and training material has been and is being developed for Sales organization and the customer. There have also been some improvements to the EDEEP process itself and suggestions have been made to EMESRT for how the process can be streamlined.

Conclusions

The discussions within an OEM regarding the design of the equipment are often internal, especially in safety related matters as some information can be of a sensitive nature. There has to be an understanding between the customer and the OEM that this should be seen as a collaborative process that includes a structured way of communicating. Sandvik believes that if the process is done this way it can add EHS value in the industry. It is important to note that the customer may also have expectations on the outcome of the process that the OEM cannot live up to in short given the restrictions in cost and time to market. The design process is not a simple matter, it is complex, calculated, assessed and tested. It takes time to create sustainable solutions. The discussion about suggested new design controls has many levels of complexity in it. It deals with resources, knowledge, access to technology, the customer expectations and the willingness to pay. It is definitely a rewarding discussion to have, but to reduce the tension and expectations it is suggested that the outcome, i.e. the suggested new design controls, are only to be noted by the participating R&D personnel and engineers for further assessment and considerations and the relevant column in the EDEEP template to be excluded.

Overall, the process is a very good method for a structured way to discuss hazards connected to maintenance and operability of the equipment with the customer. The process is about how the machine is to be used, how thing potentially can go wrong and how to find solutions that fit in the design and business process to create a better machine. Sandvik believes it has derived significant value from the EDEEP process today and intends to pursue this as it is considered to add great value to the industry.

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