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On the operator action analysis to reduce operational risk in research reactors

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ABSTRACT

Human errors during operation and the resulting increase in operational risk are major concerns for nuclear reactors, just as they are for all industries. Additionally, human reliability analysis together with probabilistic risk analysis is a key element in reducing operational risk. The purpose of this paper is to analyze human reliability using appropriate methods for the probabilistic representation and calculation of human error to be used alongside probabilistic risk analysis in order to reduce the operational risk of the reactor operation. We present a technique for human error rate prediction and standardized plant analysis risk. Human reliability methods have been utilized to quantify different categories of human errors, which have been applied extensively to nuclear power plants. The Tehran research reactor is selected here as a case study, and after consultation with reactor operators and engineers human errors have been identified and adequate performance shaping factors assigned in order to calculate accurate probabilities of human failure.

Keywords: Operational risk; Human reliability analysis; SPAR-H method; Tehran research reactor; Probabilistic risk assessment

1. Introduction

Human actions are necessary parts of the operation and maintenance of a nuclear power plant, in both normal and abnormal operating situations. The Reactor Safety Study of the US Nuclear Regulatory Commission (1975) revealed that more than 60% of the potential accidents in the nuclear industry are related to human error. Also, some references have reported that the contribution of human error to probabilistic risk analysis (PRA) results can be as high as 88% (see, for example, Hirschberg, 1990). (The accidents at Three Mile Island in 1979 and at Chernobyl in 1986 have given us additional information about the importance of human reliability; see Bello and Colombari, 1980 and Drogaris, 1993.) So, human reliability analysis (HRA) is a key element in trying to enhance the safety of nuclear power plants, but it can be more useful in operational safety if it is used alongside PRA.

Although nuclear reactors are claimed to be very safe, there have been significant failures in the nuclear industry, the most infamous of which are Three Mile Island, Chernobyl and Fukushima. Disasters clearly can and do happen, therefore, and complacency must be avoided. Lessons have been learned by risk experts from these and other major disasters such as the NASA Challenger and Columbia events. Probabilistic risk analysis has been used as a powerful method for surveying and reducing the operational risk of nuclear reactors. In PRA we usually take the pessimistic view and use more conservative values in order to avoid the problems associated with taking the optimistic view, thereby avoiding the "elephant in the room". An example of applying PRA to an accident in the aviation industry is shown in Fig. 1 in a simple and realizable way; this demonstrates how this method can be used in a wide range of industries to enhance safety and reduce risk. In addition, any meaningful PRA needs to account for human

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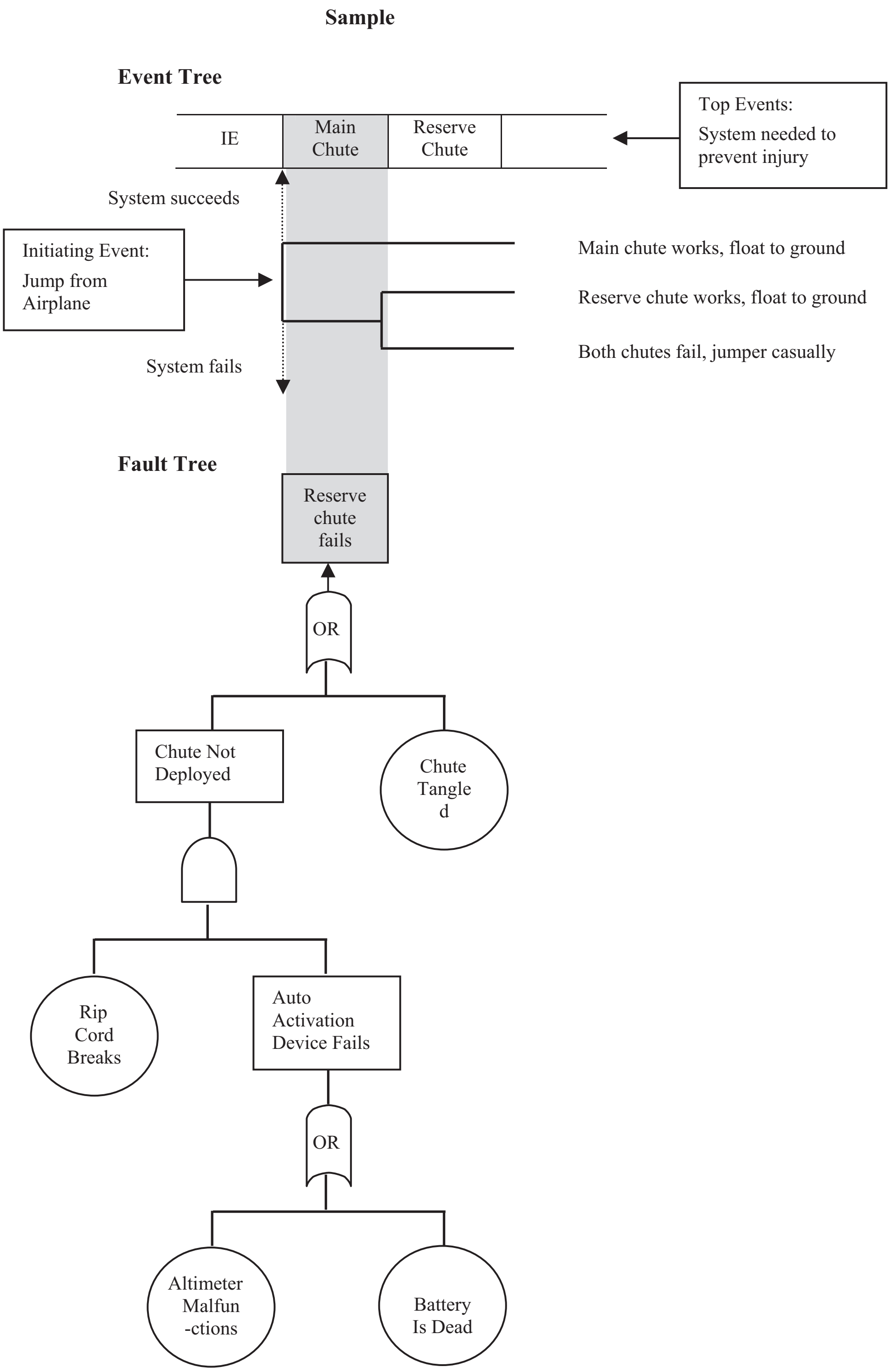

Fig. 1 – Sample event tree and fault tree.

actions (HAs) and their effects on both the probability of significant risk events and their consequences. In fact, PRA can show us how HAs can be used to prevent accidents, and in the case of the occurrence of accidents it can show us how they can be used to mitigate the consequences and reduce operational risk. Conversely, if HAs are not analyzed correctly and are assigned based on incorrect analyses, the situation can be made worse.

The nuclear industry has a reputation for high standards of safety and reliability and it is often said that there are checks upon checks. If reactors are designed properly (including using parallel controls or system redundancy and diversity), this can result in the efficiency of the system being higher than that of any single component or person. But because of the nature of the industry, in many situations operators must diagnose the situation based on symptoms and decide what they should do in a reasoned manner. This means that, whether or not the safety systems and protections that are in place are strong and redundancy and diversity are taken into account, the need for operators to take the most appropriate actions under duress is still necessary in nuclear industries. We are able to gather data and process it to generate information and design instrumentation and control systems that work efficiently. But we are still not able to design a controller that performs based

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