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Rational Reliability Analysis in Nuclear Power Plant

Vedant Rajesh Rasal

Abstract: The growing interest in nuclear power from the past few years has led to an increased number of concerns of the power plant utilities and the general public about the safety of the power plant and its operational reliability. Reliability analysis is completely essential in modern-day science where complex devices are used for scientific purposes. Reliability monitoring will help in nuclear safety in many ways as it will not only tell the cause of the failure but also tell how the cause can be eliminated. Also, Nuclear power brings numerous hazards which may create a huge impact and as nuclear power plant uses radioactive material the exposure to radiation increases the chances of various diseases and all the waste generated by the reactors remains radioactive for thousands of years which badly affects the environment. Nuclear power plants were even stigmatized by two very severe accidents the Chernobyl and the Fukushima accidents and studies confirmed that humans are the major contributors for such incidents to take place. To avoid such disaster's Human reliability analysis (HRA) can be applied to identify and judge human error. It mainly helps to improve the human-machine interface and reliability. The main purpose of HRA is the identification of human error, human error modeling, and error probability quantification. There are various approaches implemented for HRA which are different from each other in some of the other ways. The main motive of the study is to look over the various ways which have been implemented to gauge the human errors influencing the safety operation of nuclear power plants.

Keywords: Human Reliability Analysis, Human Error, Nuclear Power plant, Probabilistic Safety Assessment, Resilience Engineering, Nuclear accidents.

1. INTRODUCTION

The energy from fission has provided a primal technique of generating a clean form of energy from a very little source. This form of energy is very well known as Nuclear power and now the increasing interest in this form of energy, made it extremely important to check how reliable are the nuclear power plants producing this energy in order to generate electricity. also there has been a strong awareness of the potential hazard from various nuclear gases. the design and operation of the power plants mainly focus on minimizing the probability of accidents, but no industry is immune to accidents rather they learn from these accidents.

Body part	Occupational exposure	Public exposure
Whole body	20	1
Lens of eye	150	15
skin	500	50
Hand and feet	500	-

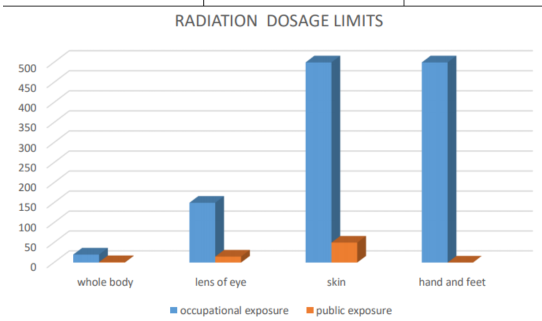

Figure 1: - Radiation Dosage Limits

Few nuclear accidents were significant, but it posed very little consequence in terms of human fatalities mainly due to resilience engineering. it is about securing the well-being of people way of thinking that allows us to properly manage all kinds of adverse events Resilience Engineering means preserving critical functionality, guaranteeing a graceful degradation and allowing the rapid recovery of complex systems with the help of generic designed capabilities as well as customized technological solutions when systems witness problems, unexpected interruptions or unprecedented events. But since some incidents have significant impact reliability analysis was important to be carried out.

Place of Accident	Error
Greifswald,East Germany	fire due to electrical error
Athens, Albama, USA	safety violations and operator error
Chernobyl, Soviet Union	flawed reactor design
Sosnovy Bor, Russia	leakage through ruptured fuel channel
Fukui, Japan	steam explosion in reactor
Surry,Virginia, USA	feed water pipe break
Ibaraki, Japan	exposure to radiation above permissible limits

Table 1: - List of Some Nuclear Accidents

2. METHODOLOGY

Three various accidents were critically analyzed which include Chernobyl, Three Mile Island and Browns Ferry incident. The Chernobyl accident took place when the safety test was carried out, with all safety systems kept off. Also, it was found that the reactor design had some flaws too. Similarly, in the Three Mile Island accident, there was an instrumentation failure; the relief valve was not close, and the system failed to reveal the fact as in what led to such cooling malfunction and due to which the reactor was destroyed. Moreover, the Browns Ferry accident took place due to the very careless behavior of the engineers who were trying to seal the air leak with spongy rubber using candles, which was put so close to the rubber that it burst into flames and the situation worsened as fire disabled the safety system. Even after this, operators continued to run the reactors despite the fire and surprisingly there was a confusion in the number to be used to report the fire.

Type	Proportions
Work Preparations	9.50%
File Management	15.80%
Work Practice	18.80%
Operation Error	6.70%
Procedure Performing	6.10%
Communication Error	10.70%
Panel Surviellance	4.20%
Human Machine Interface	5.80%
Input Error	1.20%
Alarm Response	2.10%
Others	19.10%

Table 2: - Types and Proportion Of Human Error (Yanhua Zou,2017)

Critically analyzing these accidents, it was evident that all the accidents had involvement of human error. Not only in these accidents, but overall humans are the major contributors towards such disasters taking place in the power plant. The main objective was to understand and study the human contribution towards the nuclear power plants, which will help in minimizing the human error probabilities and enhancing human performance and increasing plant safety which was possible with the techniques of Human Reliability Analysis (HRA) which is an essential part of every Probabilistic Safety Assessment (PSA) and is used to identify human errors. Human Reliability Analysis can be simply defined as the assessment concentrating on the human errors liable to be committed by the operator having a mission to fulfil on a system. Three different methods were considered under Human Reliability Analysis. They are **THERP**- Technique for Human Error Rate Prediction, **HEART**- Human Error Assessment and Reduction Technique, **ATHENA**- A Technique for Human Error Analysis.

2.1 THERP Method

THERP method is based on performing a task analysis that describes the tasks to be performed by the operators or maintenance crew. It starts by performing a task analysis and by identifying all the significantinteractions involving all personnel, after which potential problems areas are identified w.r.t procedures, equipment design, plant policies etc. which may lead to human error. Then comes the step of determining the problems which have potential impact, and which necessitate changes in equipment or extant practices. After these solutions are developed to the problem, they are implemented withproper training. All this is done with the help of an event tree. Event tree is unique to THERP. Here we have also explained the accident of Chernobyl using an event tree.

2.2 HEART Method

HEART method works on the principle that every time a task is performed, there is a possibility of failure and that the probability of this is affected by one or more Error Producing Conditions (EPCs). These conditions can then be applied to a "best-case-scenario" estimate of the failure probability under ideal conditions to then finally obtain a final error. There are totally 8 generic task types(A-H): each with a nominal Human Error Potential (HEP) and 38 Error Producing Conditions. First the task is classified according to which a HEP is assigned and then the EPCs are identified and then the effect of each EPCs is assessed in proportion to nominal HEP after which the final HEP is calculated.

TASK E	GENERIC ERROR PROBABILITY=0.02		
Error producing condition	max effect	assessed proportion effect	calculation
Inexperience	X 3	0.4	((3-1)0.4)+1=1.8
Low Moralw	X 1.2	0.6	((1.2-1)0.6)+1=1.12
	HEP= 0.02 X 1.8 X 1.12=0.04		

Table 3: -Calculation of HEP through HEART method

2.3 ATHEANA Method

ATHEANA method mainly focuses on the human system interaction, but by representing the accident sequence and provides recommendations for improving human performance based on possible causes. It begins with identifying the human failure events described in PSA event tree. The next step is to consider the Error Forcing Contexts (EFCs), which are defined as combinations of PSFs and plant conditions that make human erroneous actions likely. EFCs are provided as verbal descriptions rather than as a set of predefined categories. This method incorporates two important loops. The first is from characterization of EFCs (Error Forcing Conditions) to the identification of HFEs. The second is from characterization of EFCs to the PSA (Probabilistic Safety Assessment) model. This suggests that the outcome from the qualitative part of HRA may be used to modify the underlying PSA model, for instance by pointing to conditions of the human interactions that have been missed in the first place.

3. CONCLUSION

These methods not only helped in improving the safety of the plant, but also minimizing the risk and provided a range of suggestions on how the reliability can be improved. It also suggested how to reduce the occurrence of errors majorly the human errors as observed previously. Therefore, using these methods not only helped to reduce the human errors but also ensured the safety of the power plant and hence the public safety too. This will surely help the nuclear plants to work more efficiently by reducing errors and hence becoming more reliable.

4. REFERENCES

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- *Vedant Rajesh Rasal is currently pursuing B.Tech degree program in Mechanical engineering in Vellore Institute Of Technology, Vellore, India, PH-+91-9820681035. E-mail: vedantrasal9@gmail.com*