# Assessment of the Risk Impact of an Event Misdiagnosis

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## 1. Introduction

In emergency situations of nuclear power plants (NPPs), the diagnosis of occurred events is crucial to managing or controlling the plant to a safe and stable state. If the operators fail to diagnose (or misdiagnose) the occurred event(s), their responses to a given event eventually can be inappropriate or inadequate, i.e. they may fail to perform required actions or they may perform inappropriate and unrequired actions [1]. This paper presents a procedure and technique for assessing the probabilities of diagnosis failure (or misdiagnoses) of the occurring event(s) and the risk impact of their misdiagnosis which have not been incorporated into the probabilistic safety assessment (PSA).

## 2. Approach

The approach to the assessment of the impact of diagnosis failure on PSA is composed of three parts: 1) analysis of the potential for diagnosis failure, 2) identification of the probable human failure events (HFEs) that could be induced from the diagnosis failure, and 3) estimation of the probabilities of the identified HFEs and assessment of their impacts on PSA.

### *2.1. Analysis of the potential for diagnosis failure*

As an aid for analysing the diagnosis failure in a systematic way, the misdiagnosis tree analysis (MDTA) technique is suggested in this study [2]. The MDTA is constructed to represent all the possible misdiagnosis paths with their contributors. The three groups of causes to misdiagnosis are used in the study, i.e. (1) plant dynamics (PD), (2) operator errors (OE), and (3) instrumentation failures (IF).

MDTA is constructed according to the following steps:

(1) Represent the decision rules for an event diagnosis or situation assessment in a chronological order in the heading of an MDTA.
(2) At each decision rule, draw up the upper branch and the lower branch as representing respectively the correct decision and the wrong decision, and again for the lower branch, split it into three branches to represent the corresponding causes contributing to choosing the wrong path or decision.
(3) For each decision rule, check the possible causes that are applicable to the current decision rule, i.e. the causes that may contribute to the operators' wrong situation assessment or choosing the wrong decision path, and represent the identified causes on the corresponding branches.
(4) Continue steps (2) and (3) for all the decision rules until the final diagnosis is made. Finally, the analyst can obtain the final diagnosis results (including both correct and wrong diagnosis), and the possible misdiagnosis paths and their causes.

### *2.2. Identification of human failure events (HFEs)*

After analysing the potential for diagnosis failure, the analysts identify the probable human unsafe actions or human failure events for modeling into PSA that could be induced from the diagnosis failure. For such human actions, it may include both types of error of omission (EOO) and error of commission (EOC). The human unsafe actions from diagnosis failure could be induced from the inadequate plant model and the wrongly selected response procedure. Such human actions include the following ones:

- Omission of required actions
- Inappropriate actions or operation of unrequired systems/components
- Inappropriate termination of automatically operating systems

### *2.3. Quantification and modeling into PSA*

Quantification of the identified HFEs is performed by three steps: 1) the estimation of the diagnosis failure probability, 2) the estimation of the conditional probability of human unsafe actions under the diagnosis failure, 3) the estimation of the probability of the diagnosis failure recovery.

The estimation of the diagnosis failure probability is performed by three cause factors: plant dynamics (PD), operator error (OE) and instrumentation failure (IF). The probability of taking a wrong path in a decision point due to PD can be calculated by the probabilistic comparison of the probability density functions of two variables, i.e. the timepoint that the decision parameter satisfies the decision criteria and the operator's entry time to the diagnosis procedure. Secondly, the diagnosis failure probability due to OE is estimated using the CBDT method [3]. Lastly, the probability of instrumentation failure (IF) is assigned an approximate value of 1.0E-3 based on the study of reference [4].

The identified HFEs can be modeled into PSA through event trees or fault trees. New event or fault trees can be generated.

### 3. Application & Results

The proposed approach has been applied to the small loss of coolant event (SLOCA). The analysis of diagnosis failure (or misdiagnosis) and the estimation of its probability are provided in Figure 1. As shown in Figure 1, the paths and causes leading to final misdiagnoses are represented with their estimated probabilities. The most dominant causes are described in boldface. According to the MDTA results, the SLOCA event has the potential for misdiagnosing as the excess steam demand event (ESDE) with a probability of 2.2E-02 and as the general transient event (GTRN) with a probability of 1.2E-02. In total, the diagnosis failure probability for the SLOCA event is estimated to be about 3.4E-02.

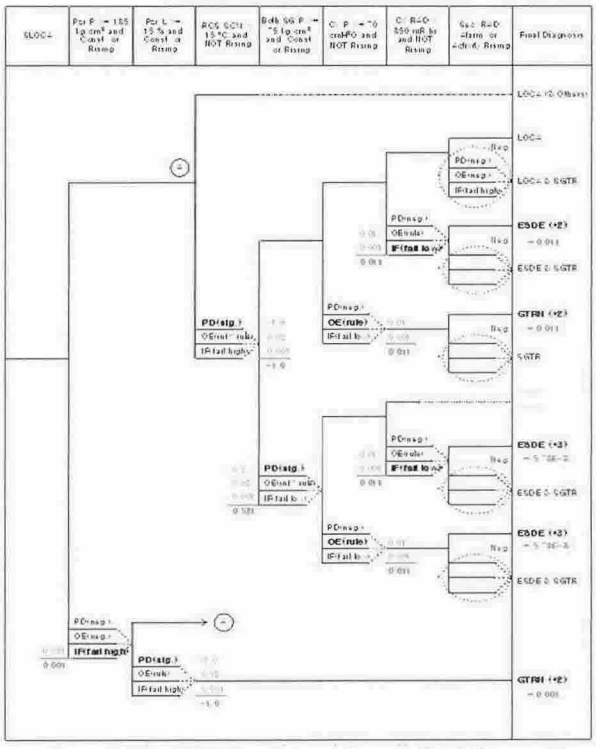

Figure 1. The MDTA result on the small LOCA event

As the probable HFEs that could be induced by the misdiagnosis of SLOCA as ESDE or GTRN, the following two HFEs are considered representatively.

1) Inappropriate termination of HPSI
2) Failure to perform aggressive cooldown for LPSI operation (in case of HPSI failure)

The two HFEs are modeled in PSA event tree as seen in Figure 2. The conditional probability that the operators perform such unsafe actions under the diagnosis failure is assumed to be nearly 1.0. And, for the first HFE the possibility of recovery is considered. Table 1 shows the estimated impact of the diagnosis failure of SLOCA on the plant PSA result according to the variation of the recovery probability of HPSI.

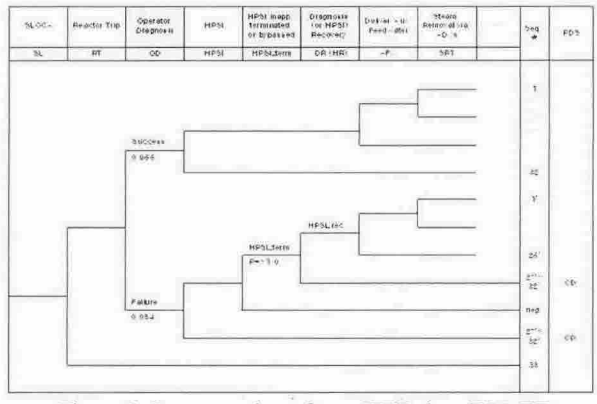

Figure 2. Incorporation of new HFEs into PSA ET

Table 1. The impact of the misdiagnosis of SLOCA on PSA

| $P_{non\_rec}$(HPSI) | Risk Impact | CDF(old:new) | CDF increase |
|---|---|---|---|
| 1.00E-03 | 1.02E-07 | 7.43E-6 : 7.63E-6 | 2.7 % |
| 5.00E-03 | 5.10E-07 | 7.43E-6 : 8.04E-6 | 8.1 % |
| 1.00E-02 | 1.02E-06 | 7.43E-6 : 8.55E-6 | 15.0 % |

### 4. Conclusion

In this paper, we introduced a method for analysing and quantifying the potential for diagnosis failure of the events that might be taking place in emergency situations of NPPs. The application to the SLOCA event has shown that the risk impact of its misdiagnosis cannot be overlooked in risk assessment.

### REFERENCES

[1] USNRC, Technical Basis and Implementation Guidelines for A Technique for Human Event Analysis (ATHEANA), NUREG-1624, Rev. 1, 2000.
[2] J. Kim, W. Jung, A Systematic Approach to Analysing Errors of Commission from Diagnosis Failure in Accident Progression, *Accepted for Publication*, RESS, 2004.
[3] J. Grobbelaar, J. Julius, Guidelines for Performing Human Reliability Analyses, Draft Report, June 2003.
[4] K. Min, et al., Reliability Study: KSNPP Engineered Safety Feature Actuation System, KAERI/TR-2165, 2002.