

A Study on a Component RAW for a Supporting System Initiating Event

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1. Introduction

It is not easy to derive a Risk Achievement Worth (RAW)[1-2] for the basic events of a component used for the Supporting System Initiating Events (SSIEs) modeled by fault trees(FTs). Because when a component is used for a SSIE as well as for a mitigating system modeling, they have a frequency unit for which the RAW has not been defined. However, for an accurate calculation of a component's RAW, it should reflect the contribution from an SSIE modeling as well as from a mitigating system.

This paper presents how to acquire the RAW for components whose basic events are used in SSIEs as well as in mitigating systems.

2. Methods and Results

Even though a component, whose basic events are used in SSIEs as well as in mitigating systems, is out of service (OOS), a nuclear power plant(NPP) would be usually operating, and then we can find the increased core damage frequency(CDF), and which means that the RAW of the component could be calculated. Let's explain this situation in detail with the following example.

2.1 Example 1

A train of component cooling water(CCW) system consists of two pumps, 01PA and 02PA. Let's assume that the loss of CCW(LOCCW) initiating event(IE) of

the system can be modeled by the simplified FT as shown in Fig 1.

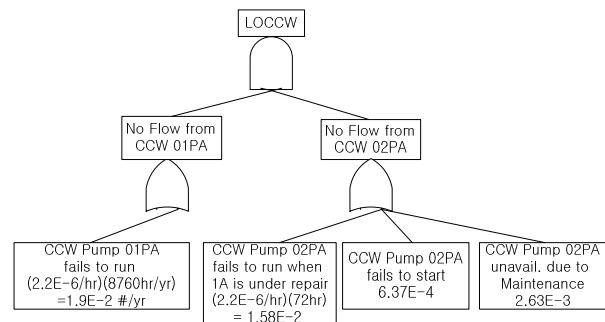


Fig. 1. A Simplified LOCCW Fault Tress

In Fig. 1, if CCW pump 01PA is OOS, then how can we model the LOCCW IE by a simplified FT? In that case, we can assume that CCW pump 02PA is alternately operating while 01PA is under repair. Thus, new LOCCW can be modeled as shown in Fig. 2.

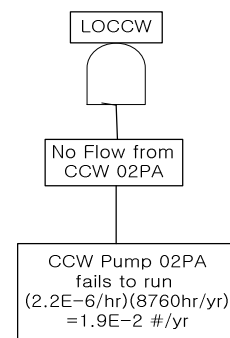


Fig. 2. A Simplified LOCCW Fault Tress When 01PA is OOS.

In this case, the FT change of Fig. 1 to Fig. 2 can be expressed as follows:

$$f_{01PA} * (P_{02PA_run}^{IE} + P_{02PA_start}^{IE} + P_{02PA_main}^{IE}) \rightarrow f_{02PA} \quad (1)$$

With the idea of Eq.(1), we could estimate the RAW of a basic event having the frequency unit. The following example 2 is to illustrate how to find the RAW of a basic event having a frequency unit which is used in a SSIE with the idea of Eq.(1).

2.2 Example 2

Let's consider a system whose risk R is expressed as below:

$$R = (C_1 + C_2)f_1 + Af_2 + Bf_3 + DEf_c \quad (2)$$

The definition of the events, their probabilities, or frequencies is given in Table 1.

Table 1. Assumed Events Prob. and Freq. in Example 2

	Event Description	Freq.	Prob
f_1	the frequency of the IE 1	0.4/yr	
f_2	the frequency of the IE 2	0.5/yr	
f_3	the frequency of the IE 3	0.2/yr	
f_c	frequency that CCW pump 01PA fails to run (= f_{01PA})	0.6/yr	
f_D	frequency that CCW pump 02PA fails to run (= f_{02PA})	0.6/yr	
C_1	component C (= CCW pump 01PA) failure due to failure mode 1		0.01
C_2	component C (= CCW pump 01PA) failure due to failure mode 2		0.01
A	Component A Failure		0.01
B	Component B Failure		0.01
D	Component D (= CCW pump 02PA) Failure = $P_{02PA_run}^{IE} + P_{02PA_start}^{IE} + P_{02PA_main}^{IE}$ = $f_D * (1/8760) * 72 + 0.0051$		0.01
E	Component E Failure		0.1

In Eq.(2), when the component C(=CCW pump 01PA) is OOS or unavailable, we could change the FT model to find the increase risk, R^+ . By using the idea of Eq.(1), when the component C is OOS, $f_c * D$ of Eq.(2)

can be changed as below;

$$f_c * D \rightarrow f_D \rightarrow f_c, \quad (\text{by assuming } f_D = f_c)$$

Thus,

$$R_C^+ = f_1 + Af_2 + Bf_3 + Ef_c.$$

$$RAW_C = \frac{R_C^+}{R} = 29.9 \quad (3)$$

Similarly, the following Eq.(4) could be derived.

$$RAW_{C1,C2}^{miti} = \frac{R_{C1,C2}^+}{R} = 26.1 \quad (4)$$

In Eq.(4), $RAW_{C1,C2}^{miti}$ means the RAW of component C considering only the mitigating system contribution without considering the SSIE contribution. However, in Eq.(3), RAW_C reflects both contributions.

3. Conclusions

Even though the proposed method does not directly calculate the RAW for the frequency unit, it could calculate the RAW for the component having a frequency unit. Also, although the method is suitable for only the SSIE models, since the problem of the RAW for the frequency unit mostly occurs in the SSIEs, the method is useful.

Acknowledgement

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