Operator Response Time Analysis Method for Important Human Actions

Yun Goo Kim*, Eung-se Oh

Korea Hydro and Nuclear Power Co., ltd, Central Research Institute, Daejeon, Korea
**Corresponding author: ygkim.stpn@khnp.co.kr*

1. Introduction

The important human action is categorized by risk informed important human action and deterministically important human action[1]. deterministically important human action is identified from operator actions credited in the transient and accident analysis(TAA, FSAR Ch15) and operator actions identified in the diversity and defense in depth coping analysis(D3CA, FSAR Ch7). The human factors engineering analysis is required to ensure that those human actions are both feasible and reliable. NUREG-0800, Appendix-18A, requires the analysis of time margin between time required and time available[2]. ANSI/ANS 58.8 provide an acceptable task decomposition methodology but it is not applied to the TTA and D3CA. For the application of task decomposition methodology to the analysis, time line modeling should be defined.

In this paper, the detail time line modeling and analysis method is provided for the evaluation of operator response time in TTA and D3CA.

2. Operator response time line model

Task decomposition methodology is based on time line model. The Table 1 and Figure 1 show the time line model[3]. The application of the time line to deterministic analysis is reviewed and detail modeling and analysis method is provided.

Table 1 Description of time line model

Time	Description
Start time of event (t_{st})	The time at which the DBE begins.
Indication time of event (t_{ind})	The time at which information is readily available.
Earliest credited action time (t_{eca})	The time at which credit for the initiation of a safety-related operator action can be taken.
Manual action initiated time (t_{mai})	The time at which the analysis credits the initiation of operator action.
Safety-related action completed time (t_{sac})	The time at which the safety-related operator action is evaluated to be completed.
Safety-related function completed time (t_{sfc})	The time at which an indication is received that a safety-related system has performed its required safety-related function.
Event limit time (t_{lim})	The time at which the limiting design requirement would be exceeded if a safety-related function has not been completed

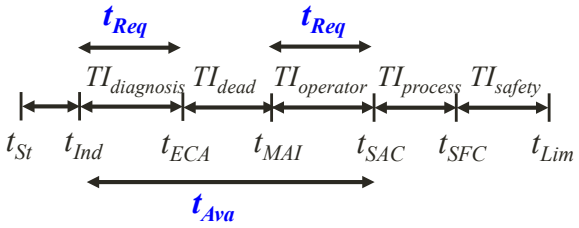

Fig. 1. The time line model for deterministic analysis

3. Development of detail time line model

3.1 Definition of time available at deterministic analysis

Time available is generally the available time to operator for the required manual action. In human reliability analysis(HRA), time available has been defined to calculate the failure rate of the operator action. NUREG-1852, "Demonstrating the feasibility and reliability of operator manual actions in response to fire" defined the time available as the time period from a presentation of a cue for an action to the time of adverse consequences if the action is not taken[4]. HRA scenario assumes that the human actions are failed and analysis the consequences of the failure. Therefore, in HRA the t_{Lim} in ANSI/ANS 58.8 can be calculated.

Time available for deterministically important human actions may need a different definition compare to HRA. In the past, deterministic analysis does not calculate t_{Lim}. Deterministic analysis evaluates the event until 30 minute after the event initiation because it assumes that the operator may start manual actions at 30 minute. Also, deterministic analysis assumes that the t_{MAI}, t_{SAC}, and t_{FAC} are all 30 minute. The it assumes that the difference between these time are negligible because it already assume 30 minute which is conservative compare to time required for operator manual actions.

However, NUREG-0800, Appendix-18A requires the time margin between time required and time available. Time required is the summation of $TI_{diagnosis}$ and $TI_{operator}$. For the time margin evaluation the time available should be defined time from t_{Ind} to t_{SAC}. The time margin should be summation of TI_{dead} and TI_{safety} because $TI_{process}$ is also not available time to operator. Therefore, when the deterministic analysis does not evaluate t_{Lim} and just assumes that the operator action at

t_{MAI} then the time margin will be TI_{dead} only then the time available should be time from t_{Ind} to t_{SAC} as Figure 1.

3.2 Indication time of event (t_{Ind})

Time available starting point is indication time of the event. It is assumed that the event may change the status of plant and a certain variable may change to indicate the starting of the event. There are many variables that operator need to monitor. Therefore, the change of the variable should be big enough to be noticed. In TTA and D3CA, it has been analyzed the identification of event. For example, in steam generator tube rupture, operator may identify the event with the radiation level in secondary system or with the RCS changes such as pressure and level of affected steam generator. However the analysis does not provide the indication time and amount of changes. The analysis just assumes that the operator action is credited 30 minute after the time of start event because of that indication. The indication time is needed for the evaluation of operator action. The operator has available time after the indication of the event. When indication is too late, there is no available time to operator mitigate the event. Therefore, the TAA and D3CA should provide the indication time, amount, and basis for the time selection. Figure 2 show the typical time line model with plant representative status.

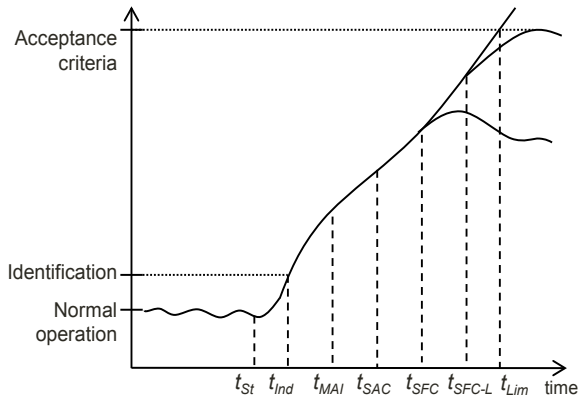

Fig. 2. The time line model with plant status

Besides, in the conservative analysis such as TAA, the indication time can be shorter than realistic analysis. For example, in SGTR, TAA assumes that SG level is just under the trip setpoint when the event is started. But in realistic analysis, SG level does not increase enough to reach the trip setpoint. Therefore, in conservative analysis the indication can be earlier than realistic analysis for some event. Figure 3 shows the possible relation between conservative analysis and realistic analysis. In the realistic analysis the indication time is $t_{Ind}2$ in the Figure. In this case, the indication is too late and the time for manual action($t_{MAI}1$) is very closed. So it may not reasonable that operator can control the manual action at $t_{MAI}1$. So, in the realistic analysis, the new manual action time($t_{MAI}2$) should be considered. And the time available to $t_{MAI}2$ also need to be evaluate. However, if the manual action is too late, then the other plant status can be jeopardized. For example, the radiation release will be increased when the operator manual is taken too late.
Therefore, for the TTA, indication time and time available should be evaluate in consider of realistic analysis time line model.

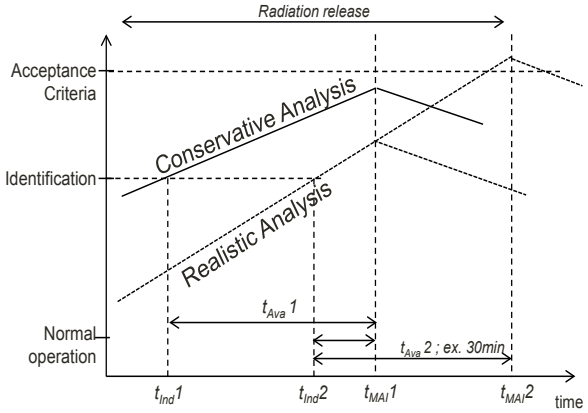

Fig. 3. Indication time in conservative analysis and realistic analysis.

3.3 Event limit time (t_{Lim})

HRA define a time of undesired condition as a time of adverse consequences if the action is not taken for time available. ANSI/AN 58.8 also defines event limit time(t_{Lim}) as the earliest time at which a limiting design requirement would be exceeded if a safety-related function has not been completed. Figure 2 show the t_{Lim} and related plant status. However, the safety function from the operator action should be completed at t_{SFC-L}(Safety function completion time limit) because of process time. Figure 2 shows the t_{SFC-L} and plant status reaches to the acceptance criteria. Therefore, when the process time between t_{Lim} and t_{SFC-L} is long, then the these time is not available to operator.
In deterministic analysis, when time available include the TI_{safety}, then the t_{SFC-L} should be time at which the limiting design requirement would not be exceeded.

4. Discussion

Timing decomposition modeling is been provided for the evaluation of operator manual action response time. Followings are suggestion of the time line modeling.

- The TAA and D3CA should provide the indication time and basis for the time selection.
- For the TTA, indication time and time available should be evaluate in consider of realistic analysis time line model.
- t_{SFC-L} should be time at which the limiting design requirement would not be exceeded.

The proposed time line modeling will be applied to important human action evaluation.

REFERENCES

[1] NUREG-0711, Revision 3, "Human Factors Engineering Program Review Model," US NRC, November 2012.
[2] NUREG-0800, 18-A "Crediting Manual Operator Actions in Diversity and Defense-in-depth analyses", Rev.0, 2014.
[3] ANSI/ANS 58.8, American Nuclear Society Time Response Design Criteria for Safety Related Operator Actions, 1994.
[4] NUREG-1852, "Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire", 2007.