Failure characteristic analysis of a component on standby state

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1. Introduction

Considerable number of components in nuclear power plant stays in standby state to mitigate accident consequence. Generally, to ensure the integrity, these components are operated periodically. Periodic operations for a specific type of component, however, can accelerate aging effects which increase component unavailability. For the other type of components, the aging effect caused by operation can be ignored. Therefore frequent operations can decrease component unavailability. Thus, to get optimum unavailability proper operation period and method should be studied considering the failure characteristics of each component.

2. Methods and Results

In this section, failure characteristics of general component are studied and the proper inspection method and period are suggested.

2.1 failure characteristics of general component

Some information about component failure can be given in two forms which are failure probability and failure rate. Information of failure probability is applied to the component that number of operations rather than time flow increases the risk of failure; a valve which is on standby state belongs to this component. Then the information of failure rate is applied to the component that the risk of failure increases with time flow; an electronic component belongs to this sort. In other words, the information form of component failure is determined according to the time dependence of its main cause.

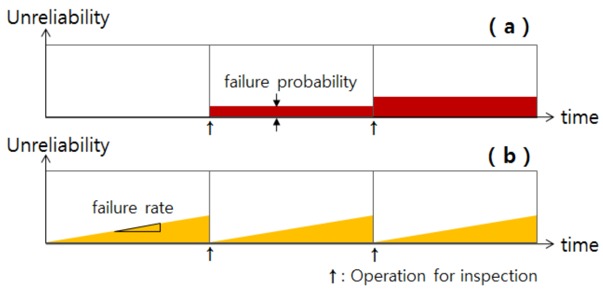

Figure 1 Schematic unavailability change according to the failure information

Probability that a component is in the failed state at a specific time can be expressed by unavailability. If the effect of inspection and repair to the unavailability is ignored, schematic unreliability can be expressed as shown in Figure 1 (according to the time dependence of component failure.) In case of a MOV whose failure information is given as failure probability form, it will follow characteristic (a) in Figure 1. Intuitively, there is a need to operate a component to ensure its soundness. However, once a component is operated, component unavailability is increased even if the operation is performed for inspection. According to this logic, MOV should not be operated for inspection to obtain optimal unavailability. Whereas electronic component whose failure information is given as failure rate form will follow characteristic (b) in Figure 1. After inspection, component unavailability becomes zero by adopting reliability renewal concept. Consequently, the more frequent operations for inspection are connected to the more reliable component. Unrealistic conclusions are obtained when extreme cases are considered in both conditions.

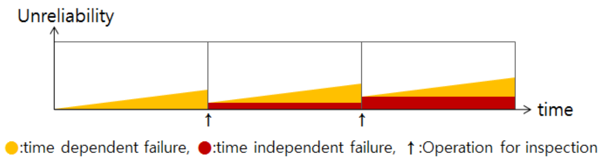

Figure 2 Realistic unavailability change according to the operation for inspection

Actually, component availability change will be the same in Figure 2. In the failure of all components, time-dependent and independent causes are mixed. According to the failure characteristics of main causes, specific form of information is represented.

2.2 Component testing period and method considering the failure characteristics.

To get optimal component unavailability, interval of operations for inspection should be determined. Firstly, when the unreliability accumulated with time flow is smaller than the one added with operations, operation for inspection is not recommended. The other cases are explained in Figure 3. In this figure, increasing unreliability after one operation and failure rate with time flow was assumed identical.

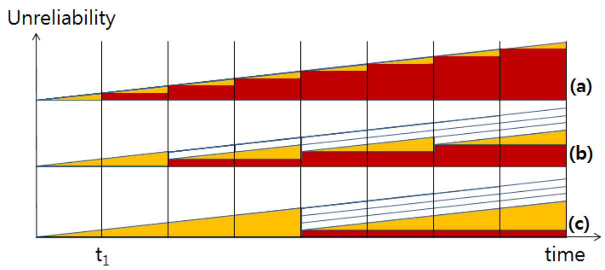

Figure 3 Unavailability change according to the test interval

In Figure 3, t_1 represents the time when the unreliability accumulated by time dependent causes becomes equal to the one of caused by operation for inspection. (a) explains the case when the component is operated to inspect its integrity with t_1 interval and has equal unavailability change to that not operated for inspection. (b) and (c) explain the cases that operate with 2t1 and 4t1 interval respectively. In sight of long term standby with periodic inspection, both cases have same effect. However, in actual situation, the magnitude increased after operation may be different for each case: a case after first operation and a case after a thousand of operations. Therefore, the number of operation and the magnitude of unreliability growth may have exponential relation. In addition, this relation is different to the type of component. Moreover, expected waiting time and allowed number of operation for inspection are also different. In this study, mathematical way to obtain optimal component unavailability is suggested considering the factors mentioned above.

3. Conclusions

The information of component failure is given according to the main causes of failure depending on time flow. However, to get the optimal unavailability, proper interval of operation for inspection should be decided considering the time dependent and independent causes together. According to this study, gradually shorter operation interval for inspection is better to get the optimal component unavailability than that of specific period.

ACKNOWLEDGMENT

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