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Monitoring method development for safety component on standby state

Sung Min Shin, Bo Gyung Kim, Hyun Gook Kang *
Department of Nuclear and Quantum Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701
**Corresponding author: hyungook@kaist.ac.kr*

1. Introduction

In the nuclear power plant, there are several safety components which are not in operation during normal plant condition but are expected to be operated in case of an emergency situation. Soundness of these components can be checked only by periodic testing which is usually performed with fixed interval since they are not in operation status during normal operation. In some extreme cases, it can be done only at the overhaul period. In addition, it is difficult to check internal elements without invasive decomposition inspection. When a demand for operation occurs to a certain component, the corresponding function is expected to be carried out with very high reliability. If the testing period is large, however, this periodic testing hardly guarantees the successful operation of safety components. In this study, a monitoring method checking the soundness of the components under the standby state was proposed to guarantee the successful functioning of the safety components. For this purpose, the concept of monitoring methods was described and applied to a motor operated valve (MOV). In addition, the effectiveness of the proposed monitoring method was shown by estimating the risk-reducing effect.

2. Methods and Results

In this section, the concept of the monitoring method, the concrete example of the concept, and the way of quantitative measurement are described.

2.1 Concept of the monitoring method

Proposed monitoring method has the following three main functions and two preconditions. Three main functions are: (1) Surveillance of the main causes of failure through non-operated test, (2) surveillance of normal performance and potential causes of failure through operated test and (3) surveillance of the flow phenomena. Two preconditions are: (1) It is possible to operate the component as an operated test owing to the isolation from the operating system and (2) it is possible to take a signal containing the overall condition of the component. The concept of proposed monitoring method is described in figure 1. Except the operation for the operated test or emergency situation, the component stays in loop A (non-operated test) and surveils the main causes of failure. Then, periodic operated test is conducted through the loop B. Before operating the component, it has to be isolated from the operating system. Next, through B-1, the signal obtained from the operation can be compared with one of the normal condition to identify the potential causes of failure. And through B-2, flow phenomena can be obtained and applied to check whether a target function (flow rate) was satisfied or not. This module B-2, moreover, can also be used in an emergency situation. Obviously, the main advantage of this operated test is that the performance of component can be checked directly.

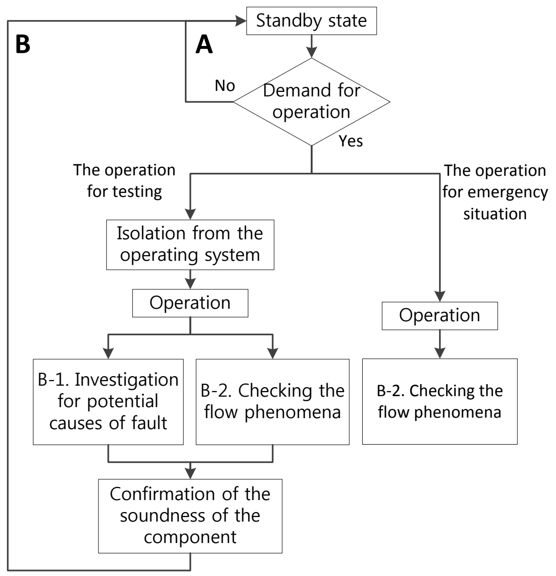

Figure 1. concept of the safety component monitoring method.

2.2 Application of the monitoring method

2.2.1 Safety component in Passive Auxiliary Feedwater System (PAFS)

Proposed monitoring method was applied to the Passive Auxiliary Feedwater System (PAFS) which is one of the passive cooling system using secondary loop. PAFS is operated by gravity and density difference of flow and is mainly composed of MOV, check valve and pipe [1]. For this system to function properly, sufficient flow should be ensured. To do this, the MOV and the check valve that were normally closed must be opened. Such situation can be a good example to apply this monitoring method. Therefore, in this paper, we specially choose MOV of PAFS to explain the monitoring method in more detail.

2.2.2 Application of the monitoring method to MOV in PAFS

The purpose of the non-operated test is to figure out the main causes of failure and to monitor these causes at ordinary time. For this purpose existing technology can be applied to this component through the inspection of its economic advantage and reliability. If there is no existing technology to adopt in reasonable way, new technologies have to be explored. For this, as a first step, the failure history of MOV is analyzed and is shown in table 1.

Table 1. Failure of MOV and its fraction

Cause of failure	Number of failure	Fraction (%)
Breakage	13	27.1
Poor Lubricant	7	14.6
Breakaway	7	14.6
Poor insulation	6	12.5
Leakage	6	12.5
Wear out	3	6.3
Fixation	2	4.2
Fall out	2	4.2
Bent	1	2.1
Corrosion	1	2.1

27.1% of the failures were caused by the breakage of keys, bearings, clutches and gears. To surveil these breakages, impedance analysis and acoustic sensor can be adopted. Proper technologies for poor lubricant, breakaway, poor insulation and leakage are also needed.

The purpose of the operated test is to identify the potential causes of failure by comparing the signal obtained from the operation with one of the normal condition. However, first, in order to take an operated test, MOV has to be isolated from the operation system. Although there isn't a specific way to isolate the component from the operation system, bypass loop, operation sequence, additional component and arrangement of the components can be adjusted. A simple example for this isolation is shown in figure 2.

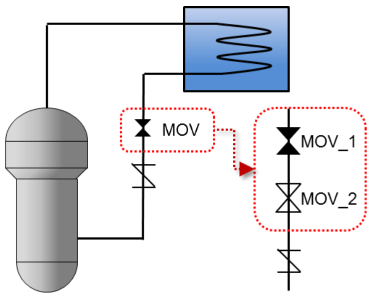

Figure 2 Modification of system configuration for MOV isolation

As shown in figure 2, extra valve is added. The operation sequence is that one valve never opens until another is closed. The operation system doesn't be disturbed by these configuration and sequence.

To obtain the signal that contains the overall conditions from the operation, Motor Current Signature Analysis (MCSA) method can be adopted. Originally, MCSA was the technology which checks the condition of a motor by taking the electrical signals (voltage, current). However, in recent years, these signals have been used to check the internal component of MOV by frequency analysis and by converting it to a specific value through some algorithm [2]. By this technique, potential causes of failure can be detected if the relation between some specific modified signal and the internal element is investigated.

In addition, satisfaction of the target function can be confirmed by simple measurement of the flow rate.

2.3 Evaluation of the feasibility of the monitoring method

The effectiveness of such monitoring method can be confirmed by comparing the risk-reducing effect and economic feasibility. The risk-reducing effect can be calculated with the data of adopted technologies: reliability, coverage, inspection period and integration method of data. In this study we calculated the risk of existing configuration of PAFS and that of the configuration which adopts the proposed monitoring method, respectively. As a result, when the proposed monitoring method is applied, the risk of entire system was reduced.

3. Conclusions

In this paper, we investigated the monitoring method for the component on the standby state. An example application of the proposed method to the MOV in PAFS was illustrated. It is possible to be applied to any usual standby component if the preconditions are guaranteed. Currently, the approach to increase the system reliability by improving the quality of component is not feasible due to practical limitations. Under these circumstances, the proposed monitoring method is considered as a promising approach to improve the reliability of nuclear power plants.

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