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A Design V&V Process of Hardwired PAMS for KJRR

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1. Introduction

A hardwired PAMS (Post Accident Monitoring System) of KJRR (KIJANG Research Reactor) provides the necessary information for operators to monitor and take actions after an accident condition. The hardwired PAMS consists of qualified digital bar-graph indicators and status lights. The hardwired PAMS are designed according to HSI (Human System Interface) guidelines. However the HSI guidelines are too high level requirements and do not reflect the detailed characteristics of commercial products. Thus, the system designers have a difficulty in the following how the system requirements are reflected in the actual and detailed requirements for purchase. Thus, a design V&V (Verification and Validation) of the hardwired PAMS should be specially managed and can be traceable through the entire development life cycle. Thus, this paper proposes a tracking matrix method for the design V&V of hardwired PAMS for KJRR.

2. Design Requirements of PAMS

2.1 Regulatory Requirements

Design requirements of PAMS for KJRR are as following Table I.

Table I. Design Requirements of PAMS

No.	Items	Design Requirements
1	Code & Std.	-R.G 1.97, Rev. 04[1] -IEEE Std. 497(2002) [2]
2	Safety Class	Safety Class 3
3	Seismic Class	I
4	Electric Class	1E
5	Single Failure	Two independent channels
6	Type of PAM	-Type B, C : PAMS (Type B,C,D,E : IPS*, OWS*)
7	Qualification	-IEEE Std 344-2004 -IEEE Std 323-2003

*: IPS(Information Processing System), OWS(Operator Workstation)

2.2 Common Cause Failures of Safety I&C System

The PAMS are as a position 4 display against common cause failures of digitalized safety I&C systems for KJRR. The position 4 display should be independent and diverse from the safety I&C systems. The diversity of the safety I&C equipment has led to an increase in the design and verification and validation cost.

The number of Type B and C variables for KJRR is less than that of a nuclear power plant. Thus, the PAMS is considered as a hardwired indication system of two independent channels. Each signal input into the PAMS is provided with dual measurement channels through hardwired instrumentation channels (i.e., channel A and B), where channel A is connected to train A, and channel B is connected to train B. The PAMS provides information in real-time for the operators in the control room.

2.3 Processing Configuration

The PAM variables of type B and C are processed and displayed as the safety system (ex. PAMS). The PAM variables of the other types are processed and displayed as the non-safety system (ex. IPS and OWS). The non-safety PAM processing system records all PAM variables. The PAMS and IPS are physically separated and electrically independent. The PAMS indicators take variables for safety directly from the local field sensors.

In particular, the variables are provided through signal splitters that are located in the reactor hall to the PAMS indicators in the MCR and SCR, respectively. Although a common cause failure (fire) in the MCR occurs, and the safety parameters in the PAMS are not available, operators can acquire the required information using the indicators in the SCR (See Fig.1).

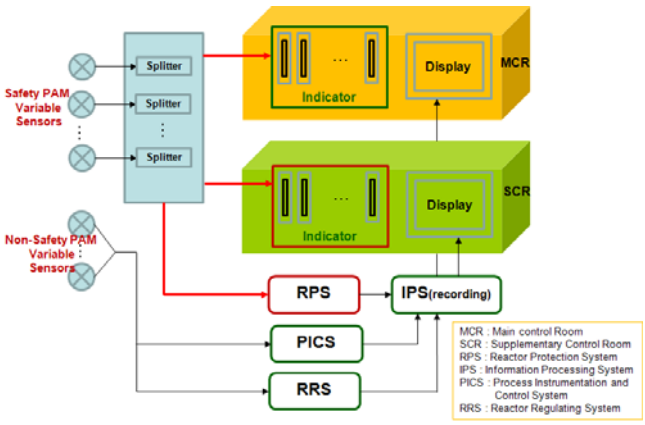

Fig. 1. Processing Configuration

3. Design V&V Process of a Hardwired PAMS

3.1 The problems of a Design V&V on a Hardwired PAMS

The HSI guideline items of hardwired indicators are as follows.

- Numbering of Scales, Axis Labels
- Numbering Grids, Scale Range and Labeling
- Linear/Nonlinear Scaling
- Location of Zero
- Tick Mark Separation
- Consistency of Orientation of Scale Marking
- Direction of Scale Increase
- Pointer Design
- Numerical Orientation on Scale
- Numeric Readouts, Label
- Coding, Indicator, Icon, Symbol

However the HSI guidelines are too high level requirements and do not reflect the detailed characteristics of commercial products. Thus, the system designers have a difficulty in the following how the system requirements are reflected in the actual and detailed requirements for purchase. Also, the process and bases for V&V are unclear.

Thus, there should be specific descriptions on the relationship of system requirements and detailed design requirements. Also, the descriptions should be complemented through each next development step and should be validation items. Thus, this paper proposes a design V&V process of hardwired PAMS for KJRR.

3.2 A Tracking Matrix for Design V&V of Hardwired PAMS

A tracking matrix for the design V&V of the hardwired PAMS is as follows in Fig.2. The tracking matrix consists of unique numbers, detailed means for the preceding step, and conformance evaluation results.

All development documents should have a consistent top-down numbering structure for traceability. The system requirements are more and more detailed by using inputted data throughout the development life cycle. In particular the procurement specifications are more detailed than the system specifications using commercial product data.

The items of each step in the development life cycle are to be structured V&V items and these are input into the tracking matrix. Also, the tracking matrix is continuously generated throughout the development life cycle. The V&V processes and results are simply recognized using this tracking matrix. Also, the items of each step can be easily followed to be reflected in the next step, and it is possible to reverse. Thus, the reliability of the PAMS can be improved by applying a structured V&V process.

Also, the activities and results for a validation of each step are based on the human factor engineering issue tracking system. The tracking matrix method can be equally applicable in the next steps of the integrated test.

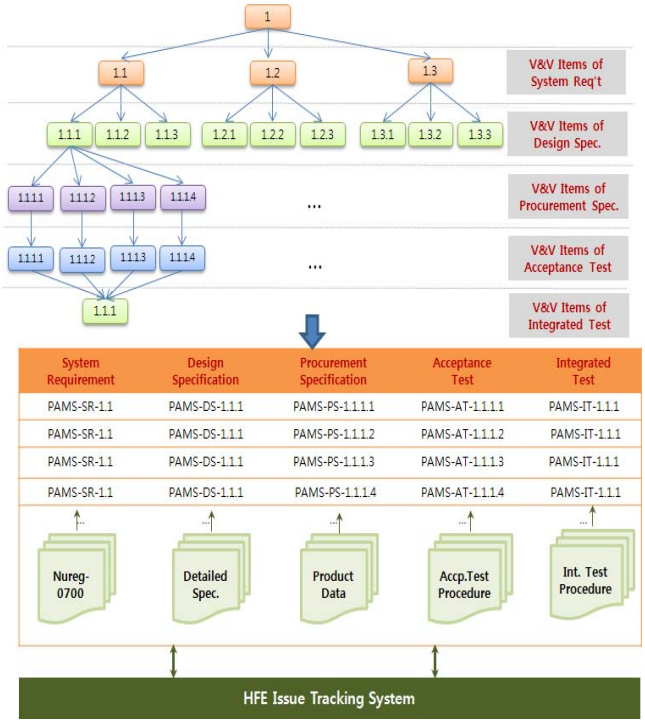

Fig.2. Tacking Matrix for Design V&V

4. Conclusions

The PAMS of KJRR consists of hardwired indicators. There are many differences between the system requirements and procurement speccifications for hardwired devices. The existing design V&V method for hardwired indicators is not clear. Thus, this paper proposed a tracking matrix for the design V&V of the hardwired PAMS. If the hardwired PAMS will be developed using this tracking matrix, the qualitative reliability of PAMS can be improved.

REFERENCES

[1] U.S. Nuclear Regulatory Commission, Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants, Regulatory Guide 1.97, Rev. 04, 2006.

[2] IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations, IEEE Std 497-2002.