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Application of Requirements Engineering to NSSS Design

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1. Introduction

Nuclear power plant (NPP) design starts with the identification of top level requirements of stakeholders and licensing body followed by development of comprised system design requirements. A detailed design of systems and components is performed on the basis of the system design requirements and the requirements are verified in the upward direction [Figure 1].

Requirements engineering [1] enables this whole design and verification process by streamlining the requirements flow. It helps to identify the top level functional and performance requirements and to decompose them into detailed requirements for design, manufacturing, operation, etc. The requirements engineering also links all the requirements by providing them with traceability which is expected to remove latent design errors arising especially from the insufficient interface management among specific design activities.

In this study, KOPEC's efforts are reported for the application of requirements engineering to NSSS system design.

2. Application of Requirements Engineering

The design requirements for the major NSSS – the chemical and volume control system, the plant protection system, etc - were identified and traced by reviewing the design documents such as system design requirements, interface requirements and design specifications documents. The license documents including codes and standards were also reviewed.

NSSS design has to comply with roughly 6,000 system and design requirements. In the course of NSSS design process, about 30,000 detailed requirements are decomposed or derived, which are contained in the design specifications, interface requirements, and various guidelines and procedures. The number of requirement was estimated by the number of auxiliary verb "shall" indicating a mandatory requirement.

As a pilot program for detailed requirement analysis, an Ex-core Neutron Flux Monitoring System (ENFMS) which provides the neutron flux power to the reactor protection system was selected. Related design documents (Table 1) were reviewed to identify and extract requirements and to establish the traceability successively.

Table 1 shows the design documents and the number of related mandatory requirements. ENFMS design starts with about 140 requirements contained in system and design requirement documents which originate from the contract and license requirements. Some requirements – such as thermal neutron flux monitoring range requirement – are transformed or specified to adequate forms for the successive design process through design calculations.

The requirements were traced from top level contract or license documents to the design specifications or operation procedures [Figure 2]. The derived design requirements for each system were interlinked according to the design flow to give traceability. The requirements were also connected to the test or operation procedures to confirm the verification process. The ENFMS requirements deliver to the Architecture Engineer (A/E) and Component Designer (C/D) by the interface requirement and design specification, respectively, as shown in Figure 2.

Full traceability model will be established using the commercial software such program as DOORS [3].

3. Conclusion

Establishing a requirement management system with traceability takes lots of efforts. The system can, however, afford an efficient and effective way of enhancing the understanding and fulfillment of design process.

Currently, the nuclear industry and governmental organizations show an increased interest in the implementation of the configuration management process as an effective way of minimizing configuration errors and related risks. The completed requirements management system satisfying full requirements traceability will be a cornerstone for the configuration management.

REFERENCES

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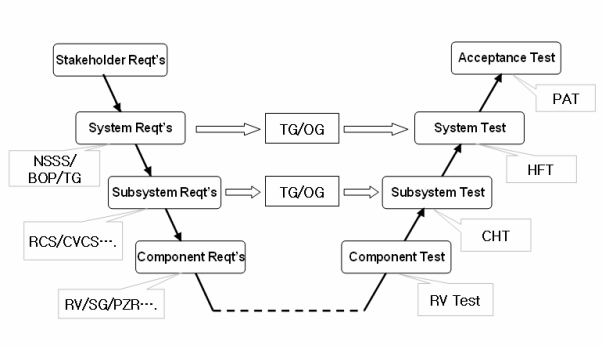
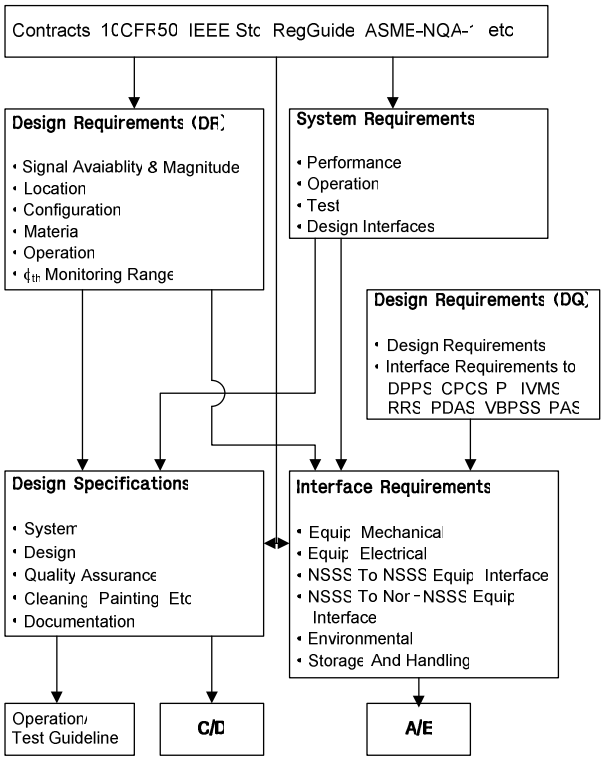


TG/OG : Test/Operation Guideline
PAT : Power Ascension Test
HFT : Hot Functional Test
CHT : Cold Hydrostatic Test
RV : Reactor Vessel

Figure 1. NPP System Design Diagram

Table 1. ENFMS Design Documents and Requirement Number

Documents	shall #
Design Requirement (DQ)	31
Design Requirement (DR)	40
System Design Requirement	66
System Description	5
Design Specification	421
Interface Requirement	142
Operations Guideline	6
Test Guideline	15
Test Procedure	38
Total	**764**



DPPS : Digital Plant Protection System
CPCS : Core Protection Calculation System
PI : Process Instrumentation
IVMS : Internals Vibration Monitoring System
RRS : Reactor Regulating System
PDAS : Plant Data Acquisition System
VBPSS : Vital Bus Power Supply System
PAS : Plant Annunciator System

Figure 2. ENFMS Requirements Flow