Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 28-30, 2015

Systematic Approach to Training for System Engineers in Nuclear Power Plants

Jeong-keun Kwak
Korea Hydro & Nuclear Power Co.
Human Resources Development Institute, 45014, Haemaji-Ro, Seosaeng-Myun, Ulju-Gun,Ulsan-si
**Corresponding author: bryan.kwak@khnp.co.kr*

1. Introduction

Intrinsically, the operation of Nuclear Power Plants (NPPs) includes very complicated and sensitive control of many components such as pumps, compressors, valves, and electrical devices. Therefore, a variety of accident preventive approaches have been adopted since the first commercial NPP operation in Calder Hall, United Kingdom.

Among diverse event preventive ways, training has played an important role for the improvement of NPPs reliability and safety. This is reason why nuclear industry in every country has established and maintained own training institutes and methods.

Since the Three Mile Island (TMI) accident, United States Nuclear Regulatory Commission (USNRC) recommended many betterment plans to US nuclear industry for the elevation of NPPs safety. In the suggested considerations, systematic approach to training, so called SAT appeared in the world.

Basically, SAT is composed of five stages, what is called ADDIE. Hence, through ADDIE process, holistic and trustworthy training could be realized in the actual NPPs operation and maintenance. For this reason, SAT is the representative training methodology in the US nuclear business.

In my paper, comprehensive preparations, tangible applications, and final establishments of training for system engineers are described using practical materials in KHNP.

2. Systematic Approach to Training

In this section, fundamental knowledge about Systematic Approach to Training (SAT) is explained. Especially, SAT is structured as ADDIE. In here, ADDIE stands for Analysis, Design, Develop, Implementation, and Evaluation.

2.1 Origin and Appearance

The year 1979, there was the worst commercial NPP accident happened in TMI Unit#2, the United States. And unlike many experts' expectation, it was proved that NPPs were not safe sufficiently and there were some possibility of NPPs calamity. Actually, after 7 years since TMI catastrophe, the most critical accident occurred in Chernobyl, the Union of Soviet Socialist Republics (USSR).

TMI accident was the significant momentum to elevate awareness about safety of NPPs. Hence, through deep investigations of TMI case, more than a hundred of alternatives were suggested by the USNRC and SAT was one measure among various proposals [1].

In KHNP, SAT methodology appeared after a NPPs export to United Arab Emirates (UAE) in 2009. In a contract, there was one sentence which described SAT based training. 'Operating services contractor shall ensure that approved (accredited) training programs are developed, established, implemented and maintained using a systematic approach to training (SAT).' This sentence was an initiation of SAT methodology application in the field of employee training in KHNP.

2.2. Fundamental outline of SAT

SAT is a systematic access that supplies a logical process from the analysis of competencies required to perform jobs for analysis, design, development and implementation to accomplish performance and subsequent evaluation of trainings [2]. Basically, SAT is composed of five stages: Analysis, Design, Development, Implementation and Evaluation [3]. Next paragraphs are succinct descriptions of each stage.

- Analysis
  Need Analysis, Job Analysis, and Task Analysis
- Design
  Job Performance Measure (JPM), Training Setting, Learning Objectives, Expected Trainee Entry Level Skills and Knowledge, Test Items, and Training Plans
- Development
  Specification of Learning Activities, Development of Training Materials, Selection of Training Methods, and Development of Lesson Plans
- Implementation
  Performance of Training Plan, Conduct of Training, Conduct of In-Training Evaluation, and Documentation of Training
- Evaluation
  Indicator Monitoring, Information Analysis, and Corrective Actions

  Next figure 1 exhibits the schematic diagram of SAT process in NPPs [4].

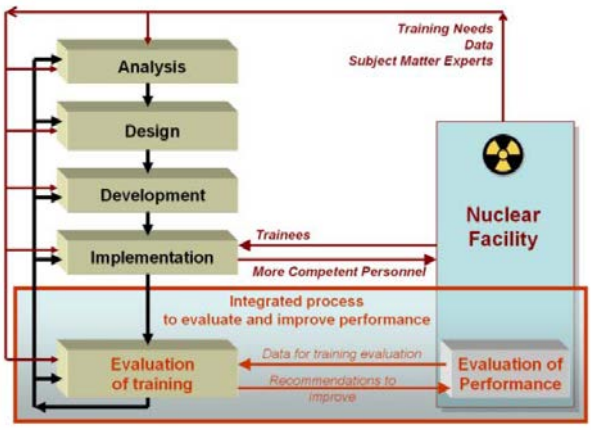

Fig. 1. Diagram of SAT process in NPPs.

3. Analysis for System Engineers

In this chapter, SAT for the training of system engineers in KHNP is displayed. In NPPs, system engineers are in charge of NPP systems whether systems meet plant safety and performance targets. This is accomplished, by tracking, trending, walking down, and monitoring system performance [5]. Hence, system engineers investigate root causes of events, propose the most recommendable alternatives, and improve NPPs accomplishments.

3.1. Roles and Responsibilities of System Engineers

According to EPRI document, roles and responsibilities of system engineers are displayed as below. [6]

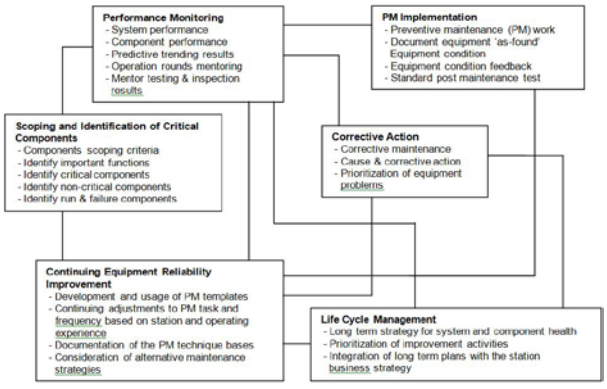

Fig. 2. Involvement of system engineers for NPPs reliability.

Major roles of system engineer are preventive maintenance (PM) monitoring, performance implementation, scoping and identification of critical components, corrective actions, continuing equipment reliability improvement, and life cycle management. Through these activities, system engineers improve the safety of NPPs and performance index such as frequency decrease of unplanned Limiting Conditions for Operation (LCO), untimely completion of PM, and the number of severe events due to human errors [7]. Therefore, system engineers are key personnel to guarantee the reliability of NPPs.

3.2. Task Analysis

On the basis of Analysis phase, the acquired task analysis results for system engineers are described in Table I.

Table I: Task analysis for system engineers in KHNP

Task code	Task Name
SE-T001	Establish and update a System performance Monitoring Plan (SMP).
SE-T002	Perform system performance monitoring.
SE-T003	Develop and utilize a System Health Report (SHR).
SE-T004	Identify, analyze and improve mid- and long-term performance issues related to Systems/ Structures/ Components (SSCs).
SE-T005	Keep track of system failures and current issues.
SE-T006	Perform a System Walk-Down (SWD) and prepare a report.
SE-T007	Develop and update a System NoteBook (SNB).
SE-T008	Perform a cause analysis.
SE-T009	Perform a Common Cause Analysis (CCA) for events.
SE-T010	Determine functions in the scope of the Maintenance Rule (MR).
SE-T011	Confirm the safety significance values of the functions in the scope of the Maintenance Rule (MR).
SE-T012	Verify performance criteria for the functions in the scope of the Maintenance Rule (MR).
SE-T013	Perform performance monitoring for the functions in the scope of the Maintenance Rule (MR).
SE-T014	Perform focused monitoring and management of the functions in the scope of the Maintenance Rule (MR).
SE-T015	Perform a periodic assessment of the functions in the scope of the Maintenance Rule (MR).
SE-T016	Analyze the Maintenance Rule (MR) functional failures and supervise the follow-up actions.
SE-T017	Prepare and process a design change proposal.
SE-T018	Prepare and process a design change package.
SE-T019	Prepare and process tentative drawings, engineering Documents Change Request (DCR) and Field Change Report (FCR).

SE-T020	Review Preventive Maintenance (PM) items and frequency based on Functional Importance Determination (FID).
SE-T021	Perform FID on the components of the system.
SE-T022	Review Preventive Maintenance (PM) task lists.
SE-T023	Review Single Point Vulnerability (SPV) and update the list of SPV.
SE-T024	Review for major maintenances test results and engineering documents for engineering technology support.
SE-T025	Perform technical review of the major work orders and work plan.
SE-T026	Review issues of system failure.
SE-T027	Review maintenance results.
SE-T028	Provide ENgineering TEchnical Report (ENTER) to system operation and maintenance teams.
SE-T029	Review and implement domestic and overseas Operation Experience (OE).
SE-T030	Organize and operate a system team.

At the end of Analysis stage, 30 tasks for system engineer are determined.

3.3. Completion of Job and Task Analysis Document

After the task determination for system engineers, the establishment of Job and Task Analysis (JTA) document is showed in Table Ⅱ.

Table Ⅱ: List for JTA document for system engineers

No	Items	Description
1	Code	Task number
2	Name	Task name
3	Element	Segmentation of tasks
4	Condition	Recommendations and circumstance
5	Standard	Reference procedures and document
6	Prerequisite	Predominated concept before the implementation
7	Knowledge and skill	Practical information and experiences
8	Learning objective	Final goals of training
9	Training setting	Type and location of training

The completion of JTA document settlement means the end of Design step.

3.4 Training preparations for system engineers

After completing JTA document, the next step is to secure the effectiveness of training through specified ways for learning activities, application of audiovisual media, useful methods for training progression, and development of learning plans. Next table Ⅲ shows considered factors for an efficient training for system engineers in Development stage.

Table Ⅲ: Considerations for the efficient training

No	Item	Description
1	Specification of learning activities	- Classroom expectations - Evaluation methods and safety moment
2	Development of training materials	- Big picture for overall topic - Introductory video clip - Summarization of learning objectives
3	Selection of training methods	- Classroom lecture - Case study and related discussion
4	Development of lesson plans	- Establishment of 19 lesson plans

3.5 Training fulfillment and feedback

In the previous Development step, preparations for all training are finalized. Therefore, the next stages are Implementation and Evaluation. Especially, through Implementation phase, training programs are put into real trainings in the classroom, laboratory, OJT even computer based training (CBT).

Unlike other stages, Evaluation is interactive with other steps directly to guarantee of training effectiveness. Next figure Ⅳ is the evaluation feedbacks for system engineer training in KHNP.

Table Ⅳ: Feedbacks to each stage from Evaluation

No	Items	Feedbacks
1	Analysis	- Deeper segmentation of each task - Perspicuity of quantitative elements - Resetting of Initial Training (IT) and Continuous Training (CT) based on training significance
2	Design	- Transition of training between classroom and OJT - Consistency between learning objectives and referred plant procedures - Establishment of reasonable test items

3	Development	- Efficient safety moment policy - Change of training methods - Modification of lesson plans
4	Implementation	- Additional analysis for training performance - Summarization of documents storage

4. CONCLUSION

The purpose of this paper is to formulate SAT based training in KHNP, especially for system engineers. Hence, to achieve this goal, over one year study was performed considering voluminous materials and working experiences. Through the process, SAT based training package for system engineers was finished, in the end.

In terms of training in NPPs, SAT methodology is the unwavering trend in South Korea since NPPs export to UAE. Therefore, materialization of SAT based training for system engineers from the origin of SAT to the finalization of SAT should not be overlooked.

REFERENCES

[1] USNRC, NUREG-0737, Clarification of TMI Accident Plan Requirements, Washington D.C, 1980.
[2] IAEA, IAEA-TECDOC-1057, Experience in the Use of Systematic Approach to Training (SAT) for Nuclear Power Plant Personnel, Vienna, 1998.
[3] INPO, ACAD 85-006, Principles of Training System Development, Atlanta, 1993.
[4] IAEA, Overview of IAEA Guidance the Systematic Approach to Training (SAT), Tom Mazour, 2009.
[5] EPRI, TR-107668, Plant Support Engineering: Guideline for System Monitoring by System Engineers, California, 2010.
[6] EPRI, TR-1003479, Equipment Reliability Case Studies: INPO AP-913 Equipment Reliability Process Implementation Summaries, California, 2002.
[7] INPO, ACAD, 98-004, Guidelines for Training and Qualification of Engineering Personnel, Atlanta, 2003.