Development of Safety Performance Indicators for HANARO

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Abstract

The effectiveness of a management system can be monitored and measured to confirm the ability of its processes to achieve the intended results with regards to safety by an assessment of its operational performance. Operational Safety Performance Indicators, also known as SPI, help an organization define and measure a progress with regards to its safety activity goals. The elements of SPI are quantifiable measurements that reflect the critical success factors of an organizational safety. The safety activities in HANARO have been continuously conducted to enhance its safe operation. HANARO has made an effort to select operational safety performance indicators which are specific to a research reactor operation and its utilization. The measurable elements of HANARO's operational safety performance evaluation consist of 4 safety attributes, 10 overall indicators, 22 strategic indicators and 42 specific indicators. These specific indicators can cover the most appropriate parameters to monitor the safety attributes of the operation and utilization in HANARO. Through reviewing these indicators, we can obtain information on the plant's safety status and the trends of the safety parameters. This paper describes the operational safety performance indicators for HANARO which implements the IAEA's approach for a safety performance monitoring.

1. Introduction

Nuclear facilities need an extensive basis for ensuring their safety. An operating organization should conduct its operation and utilization with regards to safety in accordance with approved procedures and regulations [1]. The general aims of a management system for nuclear facilities are to improve its safety performance through a planning, control and supervision of safety related activities and to foster a strong safety culture [2]. The effectiveness of a management system can be monitored and measured to confirm the ability of its processes to achieve the intended safety performance by an assessment of its operational performance. These operational safety performance indicators help an organization define and measure a progress with regards to its safety activity goals. The elements of the safety performance indicators are quantifiable measurements that reflect the critical success factors of an organizational safety. Since 1995, efforts have been directed towards the elaboration of a framework for the establishment of an operational safety performance indicator program in nuclear power plants (NPP). IAEA-TECDOC-1141, "Operational safety performance indicators for nuclear power plants" attempted to provide a frame work for an identification of performance indicators which have a relationship to the desired safety attributes, and therefore, to a safe plant operation. Three key attributes of a smooth operation, an operation with a low risk, and an operation with a positive safety attitude, were recommended, which are associated with a safe operation. Because these attributes cannot be directly measured, an indicator structure is expanded further until a level of easily quantifiable or directly measurable indicators is identified [3]. The intention of this approach is to use quantitative information provided by the specific indicators and to analyze performance trends relative to established goals.

HANARO has made an effort to select its own operational safety performance indicators which are specific to a research reactor operation and its utilization. The main frame is nearly the same structure recommended by IAEA-TECDOC-1141 except for the attribute of reactor utilization for a research activity and an application. The measurable elements of HANARO's operational safety performance evaluation consist of 4 safety attributes, 10 overall indicators, 22 strategic indicators and 42 specific indicators [4].

These indicators basically need the characteristics of a conformance to organizational goals, a team acceptance and a measurability of a performance. The indicators to monitor a plant's performance can include both safety and operational performance aspects. The general objective of this approach is to gather

plant data and to evaluate and feedback the plant status. These indicators can be used as one of the tools to measure the performance of an organization's safety management system.

2. Operational safety performance indicators for nuclear power plants [3]

The development of the IAEA framework began with the consideration of the concept of a NPP safety performance. To ensure a reasonable and complete set of operational safety indicators, a decision was made to work down a "structure" in which the top level would be an operational safety performance and the next level would be an operational safety performance indicator. For the definition of the key attributes, it was necessary to determine the key elements associated with plants that operate safely. Three important aspects were addressed like a normal operation, an emergency operation and an attribute of personnel towards safety. On this basis three key attributes were chosen that are associated with plants that operate safely:

- Plants operate smoothly.
- Plants operate with a low risk.
- Plants operate with a positive safety attitude.

The indicator structure with three key attributes was expanded further until a level of easily quantifiable or directly measurable indicators was identified. The overall or key indicators were envisioned to provide an overall evaluation of the relevant aspects of a safety performance. Strategic indicators were intended to provide a bridge from overall to specific indicators. Specific indicators represented a quantifiable measure of a performance. Specific indicators were chosen for their ability to identify declining performance trends or problem areas quickly so that after an investigation, the management could take corrective actions to prevent a further performance degradation. The quantitative information provided by the specific indicators can be used to analysis performance trends relative to established goals.
The main purpose of the IAEA program on NPP operational safety performance indicators is to establish a complete set of useful indicators so as to obtain a valuable tool, at all tiers of a plant management, for a decision making based upon indicator trends and a target accomplishment. The processes of defining indicators and goals have to be the most challenging and time consuming aspects of establishing a plant performance monitoring program by utilizing the model developed by the IAEA. IAEA approach describes three safety attributes, 8 overall and 21 strategic indicators, and 70 specific indicators which are considered as the most adequate parameters to assist in monitoring safety attitudes.
Figure 1 shows a hierarchical structure of an operational safety performance for nuclear power plants.
The overall indicators chosen to represent the degree of smoothness with which a plant operates are 'operating performance', 'state of the SSCs (structures, systems and components)', and 'events'. The safety attribute 'plant operates with a low risk' considers the overall risk of the plant and can be monitored by three overall indicators, the number of 'challenges to a safety system', the 'plant's ability to respond to such challenges', and 'a risk associated with a plant configuration'. The indicators, 'attitude towards safety' and 'striving for an improvement' are chosen to monitor the safety attitude of a plant's staff towards safety. The suggested NPP performance indicator framework is showed in Figure 2.

3. Development of operational safety performance indicators for HANARO

The safety activities in HANARO have been continuously conducted to enhance its safe operation. It was necessary that HANARO developed a program for a safety attitude monitoring that reflects its specific characteristics. HANARO made an effort to select operational safety performance indicators which were specific to a research reactor operation and its utilization. The main frame is nearly the same structure recommended by IAEA-TECDOC-1141 except for the attribute of a reactor utilization for a research activity and an application. It is the process of an indicator selection, definition and goal setting that helps to focus an organization on those elements that are critical for an operational safety monitoring. Once the indicators are selected and their definitions are agreed to, goals will be established for each indicator. Goal development was driven by a number of considerations, including an availability of data and an evaluation of previous operational performances.
A flow for the development of the HANARO operational safety performance indicators is shown in Figure 3.

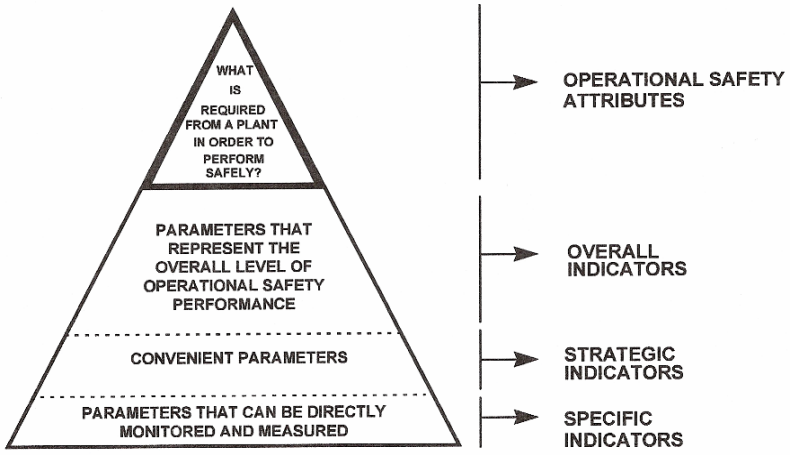


Figure1 An approach to monitoring NPP's operational safety performance

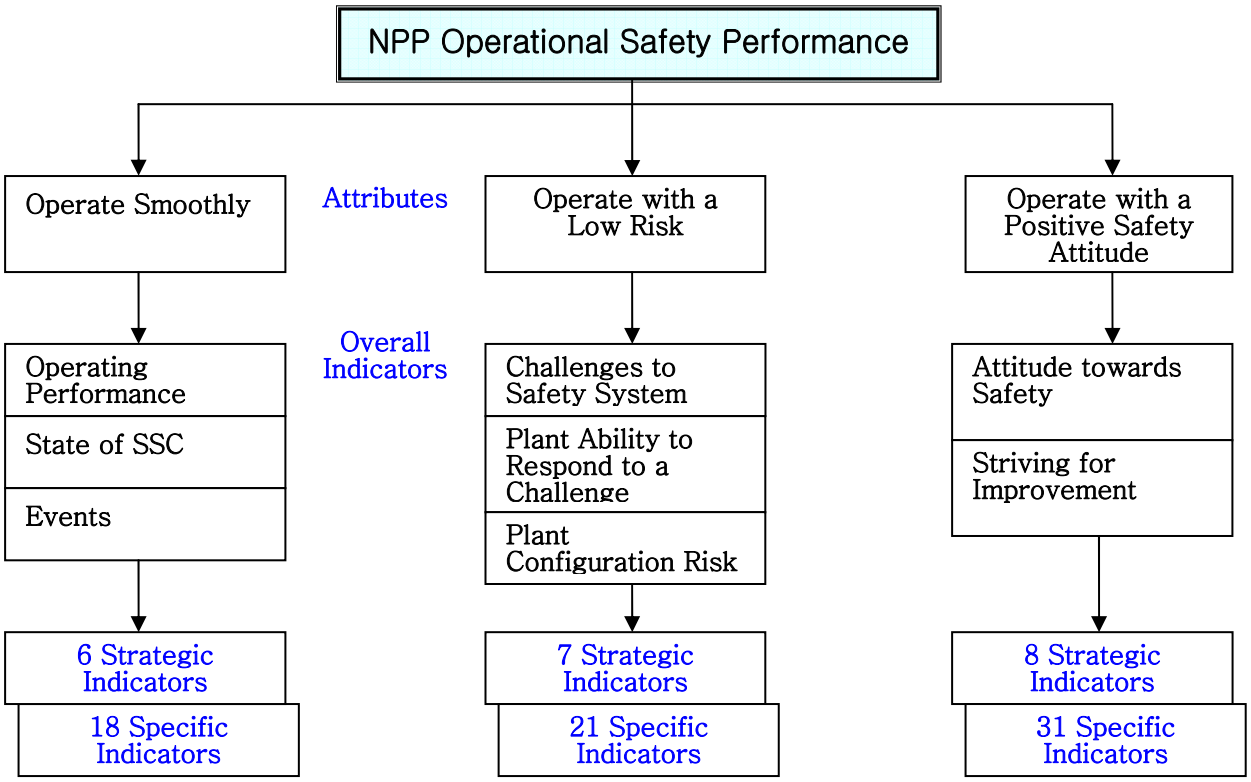


Figure 2 NPP safety performance indicator framework

The final objective of this process is to review and to evaluate a safety status. The establishment of the indicator definitions is a key step in the development of this process. The main process is to review the indicators for an appropriateness and ease of data collection and to establish the definitions to be used for each of the chosen indicators.

The operational safety performance of HANARO includes the following 4 attributes [4];

A. Plant operates smoothly
B. Plant operates with low risk
C. Plant operates with a positive safety attitude
D. Plant operates with a safe utilization

The measurable elements of HANARO's operational safety performance evaluation consist of 4 safety attributes, 10 overall indicators, 22 strategic indicators and 42 specific indicators. The framework of the HANARO operational safety performance indicators is shown in Figure 4.

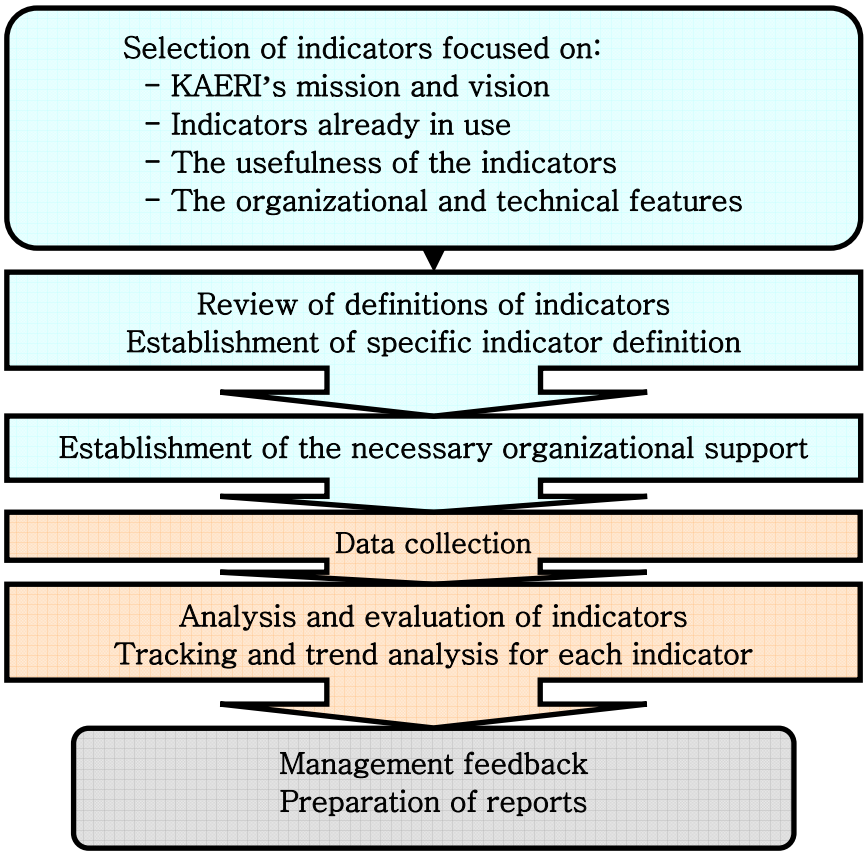


Figure 3 A flow for the development of the HANARO operational safety performance indicators

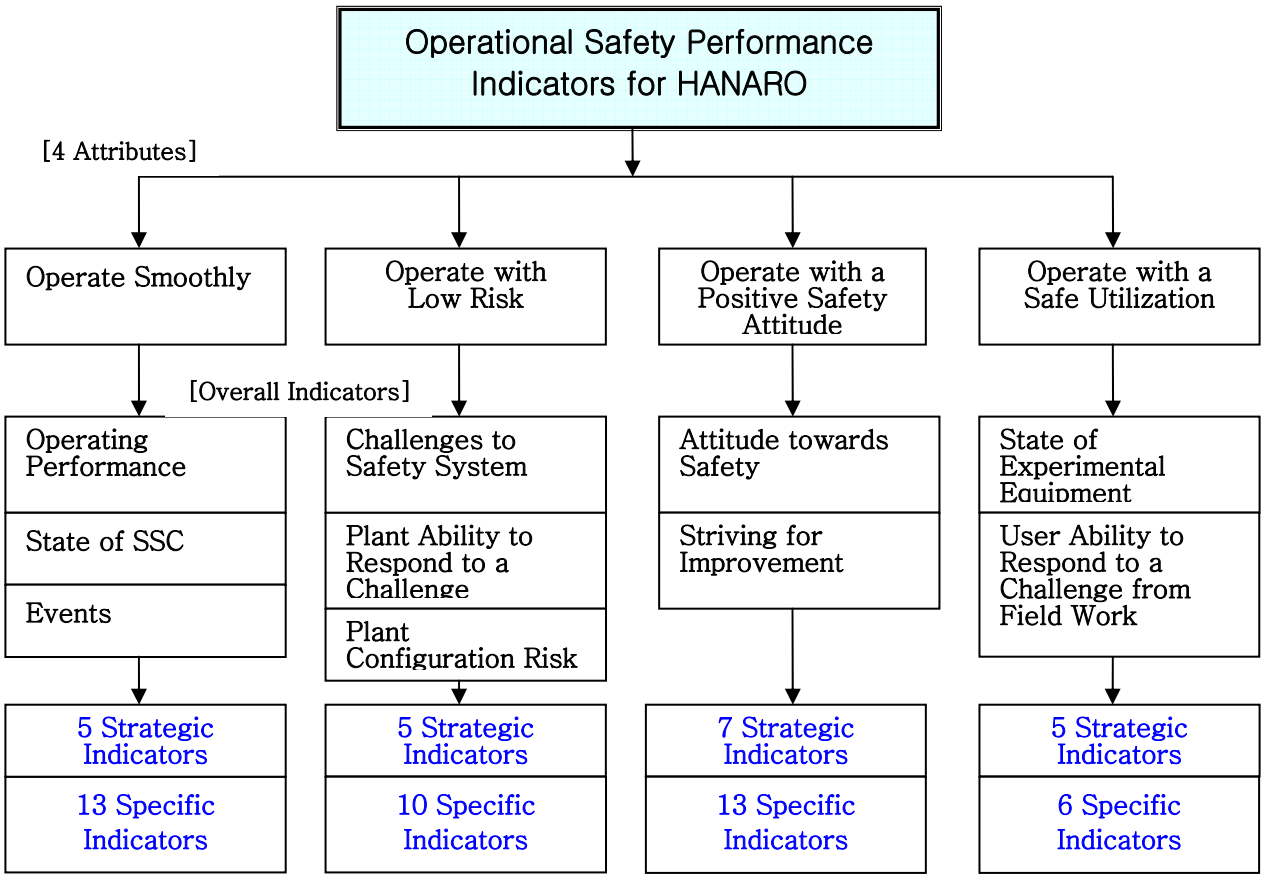


Figure 4 HANARO safety performance indicator framework

The HANARO does not have a final operational performance indicator program yet. Some indicators may need to be modified due to a lack of appropriate analysis tools and application experience.
The specific indicators chosen for each safety attribute are as shown in Tables 1, 2, 3 and 4.

Table 1. Specific Indicators of the attributes for a smooth operation

Operational Safety Performance Indicators for HANARO [Attribute : Plant operates smoothly]		
Overall Indicators	**Strategic Indicators**	**Specific Indicators**
Operating Performance	Forced power reductions and outages	No. of forced power reduction and outages due to internal causes
		No. of forced power reduction and outages due to external causes
		Power generation (MWD)
		Operation days
State of SSC (Structures, Systems, and Components)	Corrective NCR (Non Conformance Reports) and WO (work orders) issued	No. of NCR issued
		No. of WO issued
		Ratio of corrective NCR&WO executed to NCR&WO programmed
		No. of pending NCR&WO for more than 3 months
	Material condition	*Conductivity index of cooling water*
		Reflector tank ageing index
	State of the barriers	*Confinement leakage*
Events	*Reportable events and incidents*	*Significant events & incidents due to internal causes*
		Significant events & incidents due to external causes

Table 2. Specific Indicators of the attribute for an operation with a low risk

Operational Safety Performance Indicators for HANARO [Attribute : Operate with a Low Risk]		
Overall Indicators	**Strategic Indicators**	**Specific Indicators**
Challenges to Safety Systems	*Safety systems actuations*	*No. of automatic scrams*
		No. of demands on RPS, ECCS
Plant Ability to Respond to a Challenge	Safety systems performance	No. of failures in safety systems
	Operator preparedness	No. of hours devoted to training
	Emergency preparedness	Findings during emergency drills
		Findings during emergency plan audits
		No. of hrs devoted to training on the emergency plan
		No. of staff receiving training on the emergency plan
Plant Configuration Risk	Risk during operation	No. of technical specifications violations
		No. of LOC entries

Table 3. Specific Indicators of the attribute for an operation with a positive safety attitude

Operational Safety Performance Indicators for HANARO [Attribute : operates with a positive safety attitude]		
Overall Indicators	**Strategic Indicators**	**Specific Indicators**
Attitude towards safety	Compliance with procedures, rules and licensing requirements	*No. of violations of licensing requirements, SAR and technical specifications*
		No. of violations of operating procedures
	Attitude towards procedures, policies and rules	*No. of violations found through regulatory body's audits*
	Radiation protection program effectiveness	No. of workers receiving doses above limits
		Corrective radiation exposures
		Effluent activity vs. allowed limit
	Operator Performance	*No. of events due to operator errors*
	Safety Awareness	% of staff trained in safety management
		Safety culture
		No. of seminars on safety related matters
Striving for improvement	Self-assessment	No. of independent internal QA inspection and audits
		No. of findings from internal QA inspections audits
	Operating experience feedback	No. of events at other facilities that undergo review/analysis

Table 4. Specific Indicators of the attribute for an operation with a safe utilization

Operational Safety Performance Indicators for HANARO [Attribute : Plant operates with a safe utilization]		
Overall Indicators	**Strategic Indicators**	**Specific Indicators**
State of experimental equipment	*Corrective NCR (Non Conformance Reports)/WO (work orders) issued*	*No. of NCR/WO issued*
	State of safety barrier	*No. of high radiation alarms*
	Operating performance	*No. of reactor scram due to abnormal condition of experimental equipment*
User ability to respond to a challenge from field work	*User preparedness*	*No. of training*
	Emergency preparedness	*No. of hrs devoted to training on the emergency plan*
		No. of findings during internal and external inspections / audits

Some indicators are specific to HANARO, for example 'Reflector tank ageing index' and 'Confinement leakage' for the attribute of 'Operation smoothly' as shown in Table 1.

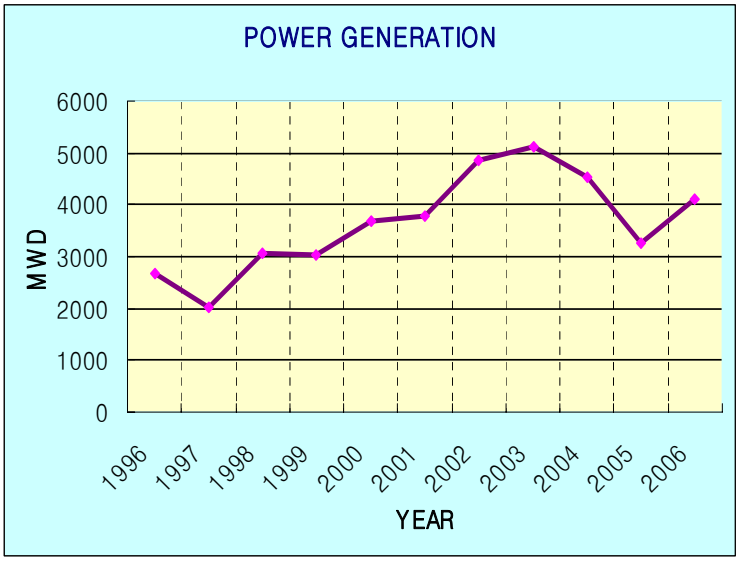
For a specific indicator, its status would be summarized in a sheet format and its performance result would be marked by an aggregate color. Performance relative to a goal would be assigned as one of four colors as follows:

- Red Unsatisfactory performance
- Yellow Needed improvement / Caution
- White Satisfactory performance
- Green Excellence

Figure 4 shows an example of a sheet format for an individual indicator, 'unit capability (max. power generation)'. It includes a graphic display of the trend, raw data, definition, expected goal, data sources, result analysis, etc. This sheet can be displayed in the control room CRT.
HANARO has operating data covering about a ten-year period. Some indicators can provide valuable information for a performance evaluation.

Plant operates smoothly	**Overall indicators**	**Operating performance**	**Performance Color: G/W/Y/R**
	Strategic indicators	**Forced power reduction and outages**	**G**
	Specific indicators	**0003 Unit capability (Max. power gen.)**	

Trend



Raw Data

Year	Anticipated Power Generation (MWD)	Actual Power Generation (MWD)
1996		2687
1997		2036
1998		3062
1999		3042
2000		3699
2001		3771
2002		4852
2003		5119
2004		4523
2005		3248
2006		4113

Definition	Unit capability is the maximum power generation that HANARO is capable of supplying for the neutron beams to the users. A high power generation indicates an effective reactor use.	
Goal	It depends on the requirement of the beam users and a program of an audit, inspection and maintenance.	
Data source/ Reference	Operation Records Annual Report of HANARO Operation	
Analysis/ Action		
Remarks	In 2005, 5 weeks of periodic inspection and audit were performed by regulatory body	
Responsible	HANARO management center	**Analysis by: - - -**

Figure 4 Example of the format for individual indicators

Most of the HANARO operational safety performance indicators will be reviewed on a yearly basis. Using the low data, the performance trend of each indicator can be displayed in a graph. Some examples of the trends are shown in Figures 5, 6 and 7.

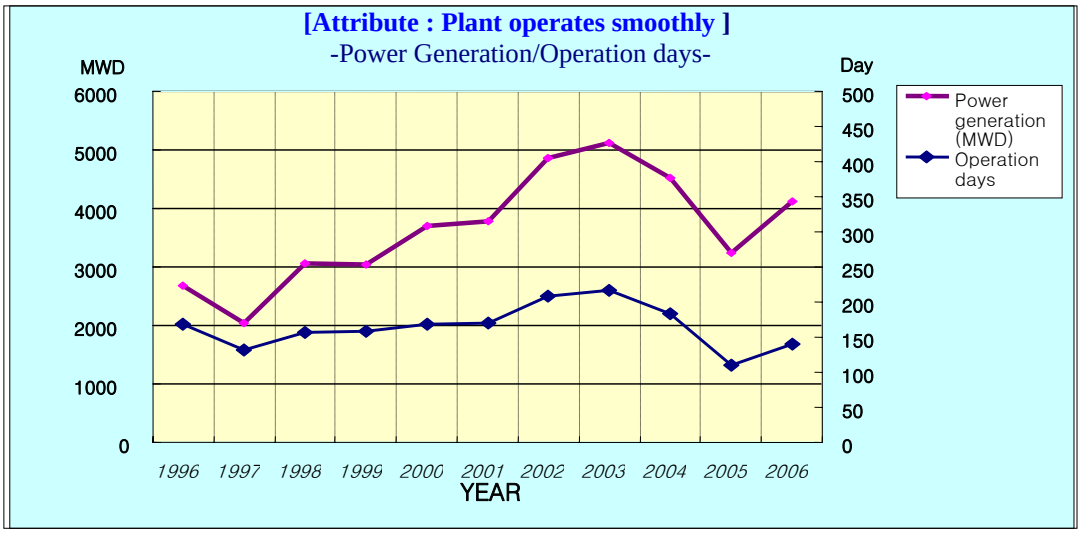


Figure 5 Power generation (MWD) and Operation days

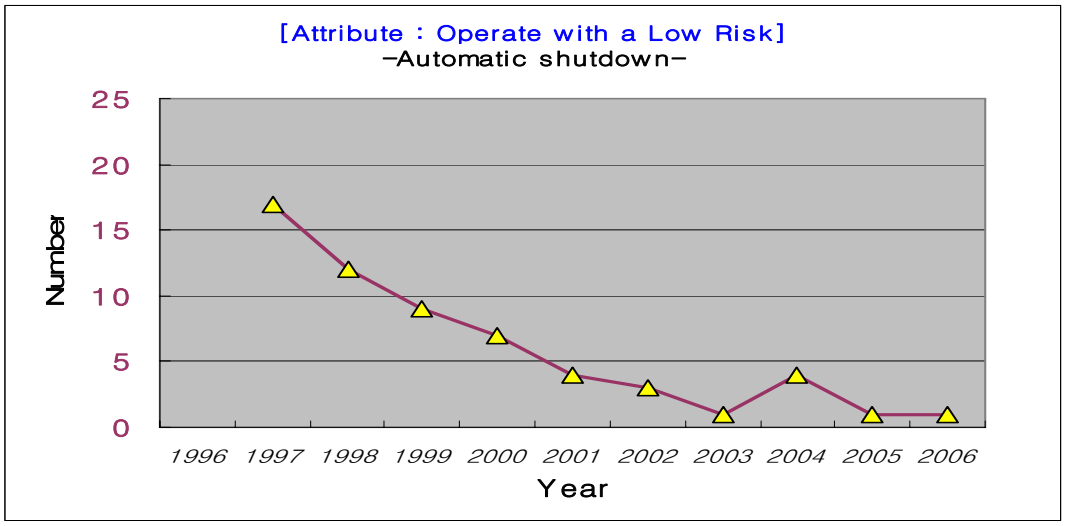


Figure 6 Number of automatic shutdowns

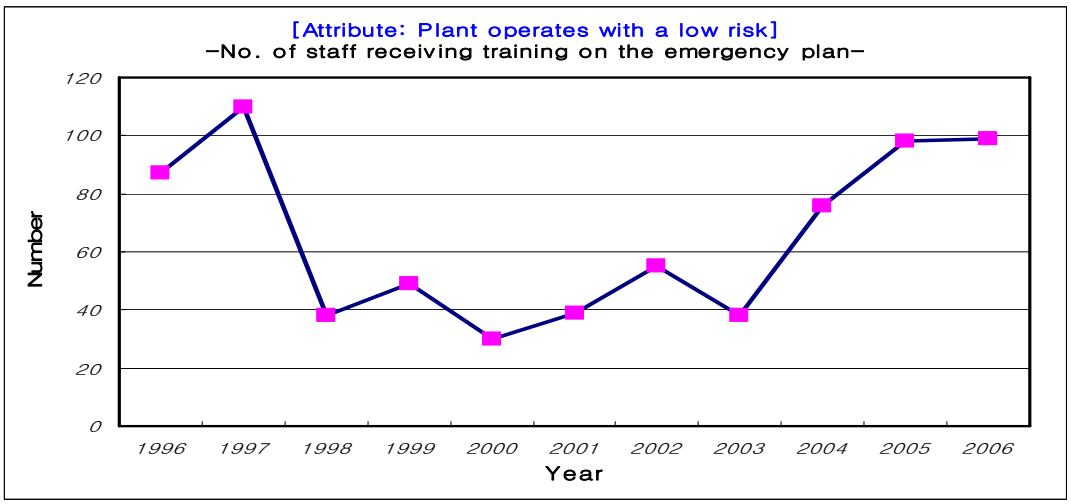


Figure 7 Plant operates with a low risk

4. Conclusion and future plan

The proposed IAEA concept and framework for a program to monitor an operational safety performance is considered as a good approach not only for a NPP but also for a research reactor. Even though the process of establishing its goals is a difficult task, the processes for a goal development and trend analysis are considered as important work. However, the significance of the data and the benefits derived are enhanced by establishing meaningful goals and targets against which a performance can be evaluated.
There are already lots of parameters and information on a reactor operation. It is necessary to gather and analyze their trends in order to effectively implement this approach to a safety performance monitoring process. Aggregating such performance monitoring data may assist management in focusing on unsatisfactory areas and provide a means to evaluate the overall health of an organization.
An evaluation of an overall plant performance may be enhanced by assessing the individual indicators relative to each other.

Referring to the IAEA document, 4 safety attributes, 10 overall indicators, 22 strategic indicators and 42 specific indicators were selected to cover the most appropriate parameters to monitor the safety attributes in HANARO. Through reviewing these indicators, it is expected to obtain the following information;

- Plant safety status
- Safety information, for example, reactor operation status and radiation safety
- Measures necessary to improve the safety

This year HANARO started to systematically gather the information on the operation/maintenance data and to study the evaluation method of the operational safety performances according to its own program. HANARO does not have a final performance indicator program as yet. Some indicators may need to be modified due to a lack of appropriate analysis tools and application experience. Next year HANARO will try to implement this performance indicator program case by case.

The established operational performance indicators will be very useful to review and evaluate the safety performance of a reactor operation and its utilization. The HANARO will continuously pursue the trends of the operational safety attributes of the plant performance for an effective safety management.

REFERRENCES

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