Safety Performance Indicators Program

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ABSTRACT

In 1997 the Nuclear Regulatory Authority (ARN) initiated a program in order to define and implement a Safety Performance Indicators System for the two operating nuclear power plants, Atucha I and Embalse.

The objective of the program was to incorporate a set of safety performance indicators to be used as a new regulatory tool providing an additional view of the operational performance of the nuclear power plants, improving the ability to detect degradation on safety related areas.

A set of twenty-four safety performance indicators was developed and improved throughout pilot implementation initiated in July 1998.

This paper summarises the program development, the main criteria applied in each stage and the obtained results.

1.- INTRODUCTION

The use of performance indicators systems is a widely spread practice in the nuclear industry, both on the operating companies and the regulatory bodies. For that reason they have undertaken programs in order to develop or improve these systems.

A safety performance indicators system provides a global view of safety plant status. It can be use in conjunction with inspection and evaluation activities carried out for the regulatory control of nuclear installations. There is a feedback of information among those activities. Safety indicators evaluation results can be use as an input for inspections or audits planning. On the other hand, findings from others regulatory activities give information for safety indicators interpretation. Also, safety indicators system is useful to evaluate efficiency of regulatory strategies.

Measurement is a necessary condition to carry out the control of the performance. In some cases, there is a direct measure to evaluate efficiency of a plant process, but when efficiency of organisational aspects have to be evaluated, indirect measures have to be defined. A set of safety performance indicators is an assembly of direct and indirect measures of the plant safety.

2.- DEVELOPMENT OF SAFETY PERFORMANCE INDICATORS

In order to get a general view of the use of performance indicators, during the first part of the program an investigation of the use of performance indicators by several organisations around the world was made, giving special attention to those used by regulatory bodies. Not only antecedents of performance indicators systems were considered, but also single indicators that utilities and regulators use to evaluate specific aspects of the plant operation. These indicators were considered in order to analyse their adequacy to be incorporated within a system.
In relation to the development of performance indicators systems, useful contributions were obtained from documentation issued by organisations like INPO, WANO, NRC, AECB and Canadian and American operating companies. The IAEA-TECDOC-600 “Numerical indicators of nuclear power plant safety performance” was the main reference document at the beginning of the program, as well as further publications issued by IAEA.

During the second stage, characteristics and scope of the system were defined, considering desirable characteristics recommended by IAEA-TECDOC-600 “Numerical indicators of nuclear power plant safety performance”.

The scope of the performance indicators system was defined according to the objectives of the program and the desirable characteristics mentioned. The main goal was to look for a possible and applicable system according with the available resources (a useful system instead a theoretic model without a practical applicability).

The size of the set was limited in order to get the required information using the smaller possible number of indicators.

The system was implemented in operating plants and was constrained to safety related areas. Also, it was avoided to require additional efforts to the plants as much as it was possible.

In order to be useful, indicators have to be predictive and sensitive. Considering the consequences produced by degradation at organisational and programmatic level, indirect indicators have been included in order to evaluate those aspects.

Before defining the set of performance indicators, it was necessary to establish a framework to define the parameters and the associated indicators in order to assure that all the areas having influence on the plant safety were included.

After that, preliminary indicators were proposed in each area. In this stage all adequate indicators should be included. A screening process of the resulting set was done later.

Screening process was carried out analyzing several aspects of each proposed indicator. The main aspect to be considered was the relevancy of the information given by the indicator and its significance into the set. The most important limitation to define and include an indicator was how to quantify it. Also the feasibility of getting information was considered. Data have to be always available in the same form to validate the indicator. Variation of an indicator because of lack or change of the data must be avoided. For this reason, the first set of indicators was discussed with the plants personnel before pilot implementation.

4.- SET OF SAFETY PERFORMANCE INDICATORS

Plant Stability
1) Forced outages: Number of unplanned shutdowns \( \times 100 \) 
   \[ \text{Load Factor} \]
2) Forced power reductions: Number of unplanned power reductions below 95% full power \( \times 100 \) 
   \[ \text{Load Factor} \]
3) Load Factor: \[ \frac{\text{Energy generated}}{\text{Maximum possible generation}} \times 100 \]

Radiological Protection
4) Individual maximum dose: Maximum monthly dose in the period (mSv)
5) Total equivalent dose: Total equivalent dose in the period (Sv – M)
6) Liquid effluent discharges: Percentage of the quarterly discharge limit

7) Gaseous effluent discharges: Percentage of the quarterly discharge limit

8) Radioactive wastes: Volume [m³] of low activity solid wastes generated in the period.

**Surveillance:**

Maintenance

9) Corrective work orders issued: Number of reports on safety or safety-related system deficiencies of a corrective nature submitted during the period

10) Pending corrective tasks: Number of reports on safety or safety-related system deficiencies of a corrective nature which are still pending, excluding those requiring the cool shutdown of the nuclear power plant

11) Pending corrective tasks because of lacks of supply: Number of reports on safety or safety-related system deficiencies of a corrective nature, which are still pending due to lack of supplies

12) Reworking: Number of reports on corrective-type deficiencies in the safety or safety-related system components subject to corrective or preventive maintenance in the previous six months

13) Overdue preventive maintenance tasks: Number of overdue preventive or predictive routine inspections and maintenance tasks involving safety or safety-related system components, excluding those requiring the cool shutdown of the power plant.

**Repetitive Tests**

14) Overdue repetitive tests: Number of overdue repetitive tests of safety or safety-related systems

15) Failure discovered by repetitive tests: Number of deficiency reports submitted on the basis of the repetitive tests performed on safety or safety-related systems

16) Test procedures under revision: Number of test procedures whose revision or issuance is overdue

**Organisation**

Training

17) Training: Number of hours devoted to training on safety-related issues

Operating Experience

18) Operating experience: Number of documented event analyses, findings or design modifications in similar power plants

Internal control

19) Internal control: Number of internal technical audits

Compliance

20) Pending Regulatory Requirements: Number of pending Regulatory Requirements
Abnormal Operation

21) Significant events: *Number of significant events*

22) Safety Systems actuations: *Number of automatics actuations of Safety Systems*

Risk

23) Safety Systems unavailability

24) Impact of reported events on core damage frequency

3.- PILOT IMPLEMENTATION

In order to test the first set of performance indicators a pilot implementation was carried out during about eighteen months. It began en July 1998, when the ARN required to the plants the quarterly report of the indicators as well as the necessary information for indicators that are calculated by the ARN.

Considering the objectives of this pilot implementation, continuous contact has been maintained with N.P.F’s personnel assigned to elaborate indicators. During pilot implementation, meetings were carried out in order to discuss several problems that had not been detected before.

Modification and clarification of some definitions were the outcomes from this interrelationship. As a result, some indicators were reviewed and modified.

According to the data availability, three ways for indicators elaboration were established:

- Indicators that are calculated and reported by plants
- Indicators that are elaborated by ARN using information routinely reported by plants
- Indicators that are elaborated by ARN using information specially required to the plants

4.-INFORMATION MANAGEMENT

The indicators are analysed, verified and stored in a database to evaluate their temporal variation. Since all the indicators do not have the same sensitivity, it is necessary to make an evaluation of the statistical relevance of the observed changes in an indicator. Therefore the data must be collected and stored on an adequate way to facilitate this analysis.

Additionally, any information that could be useful to improve indicators interpretation is stored. An indicator is a number obtained as a result of the information processing. It is necessary to assure that no information was lost during that process.

Quarterly reports are issued to show the program results. At the moment these reports are not of public domain.

5.- PILOT IMPLEMENTATION RESULTS. Improvements and modifications

The process of selection and definition of the performance indicators was made according to several desirable characteristics that they should comply. The fulfilment of this requirement was improved during the period of pilot implementation of the first set of indicators. This was achieved by means of the continuous interaction with the plants personnel and the indicators analysis. The following are some of the most important aspects that can be mentioned:
• Data collection became methodical and the reports of the required information were integrated to the documentation that the plants routinely report to ARN.

• The definitions of the indicators were clarified and corrected, in order to avoid misunderstandings and ambiguities. That was especially necessary for some indicators whose elaboration requires the use of databases.

• Some of the reported indicators were randomly audited to verify that these were not manipulated to show non-real tendencies. Also, nuclear power plants send the records from which some indicators are calculated.

• Since the nuclear power plants already used their own systems of performance indicators (for internal use or to be reported to WANO), their understanding of the importance of the use of this type of tools was easier. Nuclear power plants have also incorporated to their own use some ARN’s indicators.

• Indicators that did not offer the information for which they were incorporated to the set were revised or eliminated.

• Indicators behaviour was observed and their changes were investigated to correlate them with operational factors. This analysis is part of indicators validation process.

• Conclusions of pilot implementation were less useful for one of the plants because it had long outage periods, affecting most of the indicators.

5.- EVALUATION. Thresholds definition

When the indicators system is evaluated it must be considered like a helpful tool to identify areas that affect performance, but the results must be carefully evaluated and understood considering the rest of the available information.

Regulatory actions based only on a single indicator value are not taken and plants are not ranked. Performance indicators system is a regulatory tool to evaluate trends of the overall performance of one given plant. The system must be considered as an assembly of measures of the plant performance. The same set of indicators is being implemented in both plants (Embalse and Atucha I). However, plants performance is not compared. This is one of the main criteria of the program. Though some indicators would be compare, others vary from plant to plant without any implications on safety performance.

In order to systematise the performance evaluation through numerical indicators, thresholds or acceptability values must be defined. Thresholds for indicators of each plant should be calculated separately because of the already explained reason.

In order to establish values is necessary to analyse historical data and validate a relation between the value of the indicator and its influence on the safety performance. To get historical data was not possible for most of the indicators at the beginning of the program. Statistics was made for those indicators that have been reported in the past (outages, power reductions, dose, training, wastes and effluents), but such method was not applicable for indicators in areas like maintenance or repetitive tests. Requiring historical information about the last two areas should involve an important additional effort for N.P.P’s personnel. For that reason, until 2002, the indicators evaluation was made throughout the analysis of changes on their behaviour, but there were not acceptability criteria.

In 2002 frequency distributions of each indicator were made using the data collected since 1998. From these distributions an acceptability criteria were defined and a pilot implementation was initiated for validation. Limits of three zones were established: Satisfactory, Attention and Unsatisfactory. Also, an Unacceptable zone was defined for indicators for which a regulatory limit was applicable.

As a result of the pilot implementation experience, evaluation criteria were changed. It was decided to define only one satisfactory zone which is considered as a range of normal behaviour
of the indicator. The main reason to define a zone instead three was that indicators frequency distribution does not allow to establish representative limits for more than a zone.

The criteria to defined satisfactory zone limits are the following:

- The limit of satisfactory zone is the most probable range of the frequency distribution, if this value is considered acceptable from regulatory point of view.
- If an indicator has had periods with different frequency distributions, the most conservative distribution is considered.
- If an indicator is strongly dependent on operational conditions, the actual condition is considered.
- If indicator statistics are not satisfactory from regulatory point of view, limits are defined according to regulatory expectations.
- Limits could be modified according to indicators behaviour.

Three aspects are considered to evaluate the indicators:

1. Comparison of the indicator value with respect to the satisfactory zone
2. Trend of the indicator over the last three-quarters.
3. Additional information related to the indicator.

Validation or modification of the defined limits is a continuous task. Some indicators have an almost constant value along the time and good operational conditions are observed so this value could be considered as an acceptable reference value. However, it is difficult to define an optimum, acceptable or unacceptable value. Even for indicators for which regulatory limits are applicable, they can not be used as a threshold because the historical values of the indicators are below those limits.

6.- CONCLUSIONS

- A methodical system for collection and analysis of data has been established. Some definitions have been clarified or corrected of way to facilitate the processing of the indicators. Also, the usefulness of some indicators has been reviewed.
- Amount of collected data has allowed to establish trends, make statistics and relate indicators with operational conditions and plants safety
- The performance indicators system has included different aspects already covered by regulatory control into a global vision of the plants and systematised their evaluation.
- Safety performance indicators results have been incorporated as an input for regulatory activities planning.
- As a result of the Safety Performance Indicators Program implementation, plants have taken actions to improve the values of some indicators.
- Additional indicators to evaluate organisational aspects could be incorporated to the set, especially by the inclusion of Safety Culture indicators. Also, the evaluation criteria are under continuous improvement process.