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Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2001)11
Unclassified

Summary Report on the Use of Plant Safety Performance Indicators

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), Korea (12th December 1996) and the Slovak Republic (14th December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency (NEA) is an international committee made up of senior scientists and engineers. It was set up in 1973 to develop, and co-ordinate the activities of the Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. The Committee's purpose is to foster international co-operation in nuclear safety among the OECD Member countries.

The CSNI constitutes a forum for the exchange of technical information and for collaboration between organisations, which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of the programme of work. It also reviews the state of knowledge on selected topics on nuclear safety technology and safety assessment, including operating experience. It initiates and conducts programmes identified by these reviews and assessments in order to overcome discrepancies, develop improvements and reach international consensus on technical issues of common interest. It promotes the co-ordination of work in different Member countries including the establishment of co-operative research projects and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of co-operation, such as information exchanges, establishment of working groups, and organisation of conferences and specialist meetings.

The greater part of the CSNI's current programme is concerned with the technology of water reactors. The principal areas covered are operating experience and the human factor, reactor coolant system behaviour, various aspects of reactor component integrity, the phenomenology of radioactive releases in reactor accidents and their confinement, containment performance, risk assessment, and severe accidents. The Committee also studies the safety of the nuclear fuel cycle, conducts periodic surveys of the reactor safety research programmes and operates an international mechanism for exchanging reports on safety related nuclear power plant accidents.

In implementing its programme, the CSNI establishes co-operative mechanisms with NEA's Committee on Nuclear Regulatory Activities (CNRA), responsible for the activities of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with NEA's Committee on Radiation Protection and Public Health and NEA's Radioactive Waste Management Committee on matters of common interest.

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**SUMMARY REPORT ON THE
USE OF PLANT SAFETY PERFORMANCE INDICATORS**

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SUMMARY REPORT ON THE USE OF PLANT SAFETY PERFORMANCE INDICATORS

1. Introduction on the use of performance indicators in a regulatory perspective

In the NEA/CNRA/R(2001)3 report [1] on Improving Regulatory Effectiveness the role of indicators in a regulatory process is defined. In order to identify meaningful and measurable performance indicators (PIs) it is necessary for a Regulatory Authority to identify all of its stakeholders and the expectations that each stakeholder has about the interactions between them. Once a regulator has established such a suite of PIs it can use them to attempt to determine the added value that it contributes to the overall safety system.

A performance-based management approach applied to decision-making processes which also permeates its organisational culture and performance history enables the regulatory body:

- To have a clear, well-defined and predictable regulatory regime.
- To focus attention on the most important risk-significant safety related activities of utility organisations.
- To establish objective criteria for evaluating the performance of utility organisations.
- To provide a feedback mechanism for evaluation of direct and indirect influences of regulatory actions on maintaining and improving the safety of nuclear power plants.
- To identify utility organisational and cultural problems affecting safety.
- To identify factors that affect safety which may include utility organisational and cultural problems.

Therefore, it is desirable to attempt to develop a comprehensive indicator system that will contribute to fulfilling these objectives. A performance-based approach to management should ideally focus on the regulatory body's actual performance results (i.e. desired outcomes) and not just its products (i.e. outputs).

1.1 Categorisation of performance indicators

Performance indicators can be categorised in several ways. For regulatory bodies the most useful approach is to consider them under two headings: *direct* and *indirect* indicators.

- Direct performance indicators attempt to measure the regulator's own activities and tend to use data generated within the regulatory body itself, while
- Indirect performance indicators rely on the PIs of other stakeholders, principally the licensees, to deduce the performance of the regulatory body.

The advantage of direct PIs is that they can provide a relatively unambiguous measure of relevant aspects of the regulator's performance. The problem with most of them is that they do not provide insights into the regulatory body's fundamental mission and desired outcomes in terms of risk reduction or safety achievement amongst its licensees. On the other hand, while indirect PIs can shed light on such desired regulatory outcomes, they must be treated with great caution in order to isolate the contribution of the regulatory body to the achievement of the eventual outcome.

1.2 Criteria for good performance indicators

The overriding criterion for any good PI is that it should be suitable for the purpose for which it is intended (fit for purpose) and measurable. Other important criteria are that PIs should be:

- Used as part of a structured, formal process for communicating within the regulatory body and with its stakeholders.
- Capable of identifying undesirable trends to trigger actions by the regulatory body.
- Of value in helping to focus and prioritise the regulator's activities.
- A stimulus to the regulatory authority to improve its performance.

However, it is clearly difficult to achieve a fully representative and comprehensive set of PIs for regulatory bodies and so care must be taken in measuring them and using them to initiate action. Some PIs are capable of being "controlled" by the regulatory body *(direct* PIs) while others can only be "influenced" by it (*indirect* PIs). Clearly, since the responsibility for achieving and maintaining NPP safety lies with the licensee, any PIs that relate to engineering safety or management of safety fall within the latter category. Though these are undoubtedly of the greatest value in attempting to assess the extent to which a regulatory authority is fulfilling its fundamental *mission* they are the most difficult to interpret in terms of the "safety value" added by the regulator. Regulators also need to be careful not to allow PIs to constrain their activities too much; they have to be able to assess them carefully and use the results of inspections and reviews to help them to decide on taking action towards a licensee.

Nevertheless, a well thought-out and properly constructed set of indirect PIs, that describe the safety performance of utility organisations and their individual NPPs, is a valuable tool for the regulatory body, both in measuring its effectiveness and in directing its inspections and safety review activities. Properly chosen and defined indicators can provide an objective way for the regulator to assess nuclear safety and to evaluate its own priorities. Trends in safety performance or safety culture indicators can make possible an early detection of deteriorating safety.

2. Objective

In 1998, the OECD/NEA committee on Nuclear Regulatory Activities (CNRA) initiated an activity with the objective of advancing the discussion on how to enhance and measure regulatory effectiveness in relation to nuclear installations. One of the outcome of this activity was to establish a Task group to develop internal (direct) performance indicators which would be used to monitor regulatory efficiency ("do the work right").

In parallel, a joint CNRA/CSNI group was launched in December 2000 to exchange information and develop *external (indirect) indicators* to measure regulatory effectiveness, i.e. impact on licensee's safety performance ("do the right work"). These external indicators are, in other words, the traditional plant performance indicators and these are the ones that this report deals with.

According with CNRA and CSNI mandate [2,3], the objective of this joint activity is:

- To compile a summary report on plant performance indicators currently being used or being tested by regulatory bodies;
- To prepare sets of common performance indicators that could be used by each regulatory body;
- To prepare a summary paper to be presented as input to the IAEA topical meeting in September 2001 on this subject.

3. Background

On the initiative of the NEA/CSNI Working Group on Operating Experience the Spanish CSN hosted a workshop (Madrid, 2000) to review the state of the art on Safety Performance Indicators. This workshop, which was cosponsored by the IAEA and WANO was attended by 73 participants from 19 countries, representing the industry, regulators, service companies as well as international organisations. [4]

The conclusions were:

1. There is considerable development effort on performance indicators in many countries.
2. Utilities continue to rely on the WANO Performance indicators system which consists of indicators in 8 key areas and receives data from virtually all commercial NPP's in the world.
3. Regulators do not have a common set off performance indicators.

This report presents the work performed by the joint CNRA/CSNI task group mentioned above. It provides a summary of the sets of PI's being used by different regulatory bodies and WANO, it describes the national practices on the use of PI's and proposes a set of PI's that could be used nationally describing regulatory effectiveness and also as a basis for an international system.

4. Task Force Method

According to CNRA/CSNI directive, the task force consisted of regulators, organisations which have a performance indicators system in operation or under testing. Members of the group are listed in Appendix 2.

The task force met in Paris on February 19-20, 2001. Each participant provided a brief description of the PI System at his organisation and its usage.

The group identified a list of PI's that are recommended to be used nationally by regulators.

This paper has been elaborated based on the information exchanged and discussions held in the February meeting. A first draft was prepared and group members comments and concurrence have been managed through e-mail communications.

5. Experience by the Users of Performance Indicators

The participating countries and WANO were asked to provide an overview of systems in use. The systems for Spain, Finland, US, Sweden (proposal) and WANO are attached in Appendix 3. Notice that, except for WANO system, this part deals with performance indicators used by regulators to monitor plant performance.

Finland

Indicators used at STUK are measures related to the safety of nuclear installations and regulatory activities. Indicators are numbers, ratios, percentages and amounts of matters that are found suitable for regulatory purposes that is assessment and trending of the safety of nuclear installations and regulatory activities. STUK's indicator system is divided into two main areas; safety of nuclear facilities and regulatory activities. Safety of nuclear facilities is divided into 3 areas based on the concept of defence in depth; safety and quality culture, operational events and physical barriers. Regulatory activities are also divided into 3 areas, working processes, resource management and regeneration and ability to work.

Data needed for the calculation of indicators related to the safety of nuclear installations is gathered mainly from the reports sent regularly and according to the reporting requirements to the regulator. However, there are some indicators which calculation requires data that is not regularly reported to the regulator. These are mostly related to the failure data. Every nuclear safety indicator has a responsible person who is responsible for the data collection, calculation, assessment and reporting of his or her indicator on annual basis.

Some of the indicators (bolded in the table in Appendix 3) are included in the management system of the department of Nuclear Reactor Regulation. This means in practise that these indicators have internal goal values and these are systematically (annually) calculated, assessed and reported within the regulator. Some of these indicators are also included in annual report of STUK, but no formal decision has been made so far to include all indicators to the annual report systematically. All indicators are available for the personnel of STUK in the Intranet. So far, there is no formal decision to open these indicators to the public at the STUK Internet site.

Indicators describing the safety of nuclear installations are used as a background material for the discussions between regulatory and licensee management, safety assessment and inspections and also focussing of regulatory investigations. How indicators are used to assess performance safety is mainly to identify changes in the trends of safety and then to find out the causes for the changes.

France

In France a committee has started the development of indicators for the confidence in the transparency of information about French nuclear facilities. The committee works are devoted to Government and Public.

The RECUPERARE method, a model developed by IPSN for operating experience feedback analysis presented at the October 2000 PI meeting in Madrid, is used to analyse incident reports. For the time being, IPSN emphasises the difficulty in connecting performance indicators to safety.

Spain

CSN has operated a PI system since the mid 1990's. The system is based on the one used by the USNRC and therefore can be used to compare the performance of Spanish and US plants of similar technology and vintage. When USNRC changed its system in 2000, CSN designed a new system that build on the experience of the existing one and gathers data on the following parameters: performance stability, reliability of mitigating systems, barrier integrity, and radiological impact.

The average values for the Spanish NPPs are currently made available to the public, in the future the values for each individual plant will also be released to the public.

Spain has found it useful to compare the performance indicators for its plants with those of US plants. As an example, differences have been identified in the reliability of external power supply due to the lower stability of the Spanish electrical grid, and in operating practices such as faster start ups after non scheduled shutdowns in Spanish NPPs. The root causes and impact of these differences on safety have been evaluated by the CSN.

Based on this experience the CSN supports international efforts to develop a common set of PIs that allow exchange of data among interested parties.

In Appendix 3 are included the list of the running Spanish PI System and the draft list of the new ones under development.

Sweden

SKI is developing a PI System. The indicators to be collected are given in Appendix 3. The set has been developed based on a research project presented at the Madrid meeting. In order to get a quick start and not so time consuming work SKI decided to test an indicator system without the part dealing with the probabilistic approach as shown in the Madrid meeting. The probabilistic part is planned to be used at a later stage. So far SKI has for the last half year used indicators for safety evaluation during the plant safety review meetings. It should be noted that this set represents SKI, Swedish Nuclear Power Inspectorates area of responsibility. In Sweden the Radiation Protection Institute provides information on radiological doses and releases.

United Kingdom

The NII is examining the requirements for safety performance indicators for the regulator and the industry in the UK. External and internal indicators are being considered, together with direct and indirect measures in order to develop the two sets.

The industry in the UK has seven major types of installation e.g. Large power reactors, waste treatment plants, submarine refuelling facilities. Therefore, longer term intention is to develop a set of indicators for the industry which can be applied to all types. This is likely to involve a common set of indicators plus surrogates for the different types. Earlier internal methods of NII for measuring the trends in the safety performance at large power plants and at reprocessing plants are being re-examined.

The seven or eight indicators *from this meeting* will be tried during 2001 in a pilot study of their practicality.

United States of America

No NRC representative attended the February meeting of the task force. However, NRC provided input for this activity. The input consisted of and excerpt of the US NRC document SECY 99-007 “Recommendations for Reactor Oversight Process Improvement”.

The NRC has revamped its PI System and the new one running since 2000 consists of 3 safety strategic areas: reactor safety, radiation safety and safeguards. Each area is split into one to four cornerstones: initiating events, mitigating systems, barrier integrity and emergency preparedness, for the area of reactor safety; public radiation safety and occupational radiation safety, for the area of radiation safety, and physical protection for safeguards.

For monitoring each cornerstone specific indicators have been developed. For each indicator there are numerical thresholds of acceptable performance and those thresholds are established making use of performance experience, PSA insights.

The NRC Performance Indicators System, as part of its Reactor Oversight Process is described at the internet address www.nrc.gov/NRR/OVERSIGHT/ROP/ documents.html.

WANO

An overview of WANO indicators is given in Appendix 3.

WANO emphasises that the definitions of their indicators are very specific, and closely connected to WANO's mission. The system is continuously under a review process.

WANO is developing a tool to enable their members to evaluate routinely the collected set of indicators according to their desires. Presently, about 200 000 data points are available. Some statistical indicator values are presented in a yearly trifold annual report publicly available.

6. Commonalities and Differences in Used Performance Indicators

The presently used Performance Indicators were reviewed in a three steps process.

1. First indicators used in at least two agencies were identified.
2. The second step was to identify the most used indicators.
3. The third step was to assess if the indicators were universally understood, objective and obtainable from available data.

6.1 PIs used in more than one agency

The task force participants reviewed the list of PIs in use at their agencies and withdrew the list of indicators used at least at two of them. The list obtained is presented in table 1.

Table 1. List of performance indicators used at more than one agency

	Running Programs				Programs in development			
	STUK	CSN	NRC	WANO	SKI	NII	IPSN	CSN
Unit Capability Factor				X			X	X
Unplanned capability loss factor				X	X			
Power reductions	X	X	X			X		X
Scrams	X	X	X	X	X	X	X	X
Availability of safety systems	X		X	X	X		X	X
Unplanned safety system actuations		X			X		X	X
Safety system failures in actual events		X	X		X			X
Fuel integrity	X		X	X	X			X
Chemistry PI	X			X				
Integrity of reactor coolant system	X		X		X		X	X
Integrity of containment	X				X		X	
Radioactive releases	X						X	
Radioactive dose to public	X		X					X
Collective radiation exposure	X	X		X		X	X	X
Significance of events	X	X		X	X		X	
Violations of technical specifications	X				X		X	
Delays in documentation of plant modifications	X					X		
Maintenance poor interventions	X				X		X	
Industrial safety				X		X	X	
Causes of events	X	X					X	

Table notes:

Running programs – Performance Indicators programs that are presently run.

Programs in development – Performance Indicators programs that are in a development phase. Indicators contained in these programs need still to be formally approved.

Significance of events – this indicator has several meanings. It is, for instance, the conditional core damage frequency estimated for a given event after making use of Probabilistic Safety Analysis Technics (STUK, IPSN). In the case of CSN, it is referred to significant operating events based on national reporting requirements and in a case of WANO, it is referred to the events by separately issued confidential documents dealing with operating experiences that are considered specially relevant for their root causes, lessons learnt and/or risk to the plant.

Number of events – some agencies take this figure as an indicator including safety significant events based on national reporting requirements. However, taking into account that national reporting requirements vary very much from country to country and that more explicit indicators related to number of events such as number of scrams and power reductions are already included in the list, the number of events was not included in the list.

6.2 PIs used in at least four agencies

There are seven indicators that are present at most agencies (at least at four out of the seven represented at the Task Force February 2001 meeting). These indicators are:

- Power reductions
- Scrams

- Availability of safety systems
- Fuel Integrity
- Reactor coolant system integrity
- Collective radiation exposure
- Significance of events

6.3 Characteristics of the seven most used indicators

The *seven most used indicators* were assessed as to whether they meet the following characteristics considered recommendable for any use:

- *Universally understood*

  In spite of differences in definitions, it was found out that there is a rather broad consensus on the meaning of each of these indicators. Probably the main difference is for scrams, as WANO and NII are counting only automatic scrams, while all others are counting both automatic and manual scrams.

- *Objective*

  It was agreed that these indicators are not susceptible to manipulation, subjective approaches.

- *Easily obtainable from available data*

  It was verified that the data needed to obtain these indicators are already available at all participant regulators, the exception being "Safety System availability", which is not directly available at some regulators, but is obtainable by computing some data. Many NPPs have such data, anyway, as they are reporting this indicator to WANO .

- *Applicable to international exchange among interested regulators*

  As long as the definitions are the same, or close, they allow exchange among interested parties.

All of the above seven indicators meet these characteristics Significance of events excluded. The reason is that the definition of "significance" varies very much; even when PSA is used as the main "significance" measure. PSA models vary very much from place to place in terms of scope, depth of the model, etc., plus Accident Sequence Precursor techniques are also different. Therefore, the task group decided that this is not an appropriate indicator to be used at an international level for the time being.

The task group also checked out availability and publicity of these indicators, in terms of:

Availability – Data needed to calculate the indicator is easily available for the regulator (regularly reported by licensees through licensee event reports, periodical reports (monthly, quarterly, annual).

Publicity – the regulator is presently publishing these indicators on the annual report to the parliament, website etc.

The results of this survey are presented in Tables 2 and 3.

Table 2. Information needed to obtain the indicator is easily available for the regulators for the indicators marked with X on the table

	STUK	CSN	NRC	SKI	NII	IPSN
Power reductions	X	X	X	X	X	X
Scrams	X	X	X	X	X	X
Availability of safety systems	X	X	X	X		X
Safety system failures in actual events	X*	X	X	X	X	X
Fuel integrity	X	X	X	X	X	X
Integrity of reactor coolant system	X	X	X	X	X	X
Collective radiation exposure	X	X		X	X	

* Data is available and reported to the regulator but the indicator is not calculated as a separate indicator in STUK because of the rarity of this kind of events.

Table 3. Regulators are presently publishing following indicators marked with X on the table

	STUK	CSN	NRC	IPSN	SKI	NII
Power reductions	X	X	X	X	X	X
Scrams	X	X	X	X	X	X
Availability of safety systems			X			
Safety system failures in actual events			X			
Fuel integrity			X			
Integrity of reactor coolant system			X			
Collective radiation exposure	X	X	X	X	X	

Note to Table 3: WANO data are not generally available to public. Only the annual global results are available.

Performance Indicators definitions

The task group has noticed that even counting a specific indicator, there are some slight differences in definitions:

- *Power reductions*: some agencies are counting any power reduction of rated power (STUK), over 20% power reductions (NRC), or turbine generator disconnection from external electrical grid (CSN, IPSN).
- *Scrams:* Some agencies are counting only automatic scrams (WANO and NII), while all others are counting both automatic and manual scrams. Some are defining a scram as a "an actuation of the reactor protection system that takes the reactor from critical to subcritical", while others are counting scrams only if the reactor power is above a given value, e.g. 5% of reactor power.
- *Fuel integrity*: some are assessing it as a % of the Technical Specification limit of reactor coolant concentration of equivalent I-131 equivalent (CSN, NRC), while others are considering the absolute reactor coolant activity.
- *Availability of safety systems*: most agencies are taking into account availability of the Emergency Core Cooling Systems (either high or low pressure), emergency feedwater and emergency AC power sources.

It was concluded that some harmonisation in definitions is needed to make sure that each one is counting precisely the same matter if these indicators are going to be used and presented at international level.

7. Conclusions and Recommendations

Experience

1. Many regulatory bodies of the OECD countries have considerable experience in developing and using performance indicators. In several cases, performance indicators data have been collected for a significant period of time and the use of indicators has been gradually improved based on experience.
2. Basic criteria for selecting and using a performance indicator system should be established. The Task Group recommends that the following criteria be used:
   a) the indicators should provide an objective indication of safety performance;
   b) the indicators should be easily understandable; and
   c) the data needed should be easily obtainable from existing data collection systems
3. The review of the Task Group indicates that there is a set of indicators which fit the above criteria and is already commonly used by a number of Regulatory Bodies.

These indicators are:

- power reductions
- number of scrams
- availability of safety systems
- fuel integrity
- reactor coolant system integrity
- collective radiation exposure

Limitations

1. Performance indicators by themselves provide an indication but not a complete measure of the safety of a nuclear power plant. Furthermore, some indicators are an aggregation of several parameters. This must be carefully considered when trends in indicators are evaluated.
2. Although the indicators shown above are common to several Regulatory Bodies, there are slight differences in the definitions used by various organisations. Caution must therefore be used when exchanging information even on indicators that have identical names.
3. Performance indicators should be used preferentially to compare performance over time; caution must be used in comparing different plants and/or plants in different countries.

Task Force proposals and recommendations

1. The minimum set of performance indicators listed above may be used by all CNRA/CSNI member countries. Experience with the use of these indicators should be reported to the CNRA/CSNI.

2. Further work to harmonise the definitions of the various indicators is needed; this can be carried out in a follow-up meeting of the Task Force.
3. There is development work being performed by various organisations, CSNI/CNRA should authorise the Task Group to meet periodically to assess these new developments and provide recommendation for a common set of performance indicators.
4. CNRA/CSNI should also promote exchange of other nationally collected PIs among interested regulators. However, new indicators need to be evaluated before added to list. For this task CNRA/CSNI should assign a group to harmonise definitions and evaluate experience with new indicators.
5. Development of standard tools to display, interpret and analyse trends would be useful; this work could be carried out by the current Task Force supported by the NEA Secretariat.
6. Given the vast experience acquired by WANO in operating a universal system of performance indicators, the Task Force recommends that co-operation with WANO be intensified.
7. Co-operation with the IAEA should also be intensified to support them in their effort to promote the use of performance indicators worldwide.

References

1. Improving Regulatory Effectiveness (NEA/CNRA/R(2001)3).
2. Summary Record of the Twelfth meeting of the Committee on Nuclear Regulatory Activities (CNRA), NEA/SEN/NRA (2001)1.
3. Summary Record of the Twenty Eighth Meeting of the Committee on the Safety of Nuclear Installations (CSNI), NEA/SEN/SIN (2001)1.
4. Proceedings Safety Performance Indicators, Madrid, Spain, October 17-19, 2000.

Appendix 1

Programme Overview

Specialist Meeting on Safety Performance Indicators
Madrid, Spain, October 17-19 2000

Tuesday 17 October 2000	
8:00 – 9:00	Registration
9:00 – 9:30	
9:30 – 10:00	**OPENING (10)** • *A. Martín (CSN),* • *A. Carmino (IAEA),* • *K. Shimomura (NEA),* • *F. Ynduráin (CIEMAT)*
10:00 – 10:15	
10:15 – 10:30	*Break*
10:30 – 11:00	
11:00 – 11:30	**UTILITY INDICATORS (11)** Chair: *S. Floyd (NEI, USA) / Jürgen Schlegel (WANO)* • U.S. Industry Perspectives on Role of Indicators in the Regulatory Process **–** *S. Floyd (NEI, USA)* • Performance Indicators in the USNRC's Revised Reactor Oversight Process **–** *D. Hickman (NRC, USA)* • Can Safety be Measured? **–** *L. Dumont (EDF, France)* • International Pls and the UK Nuclear Energy Generators **–***C. Atkinson (B. Energy, UK)*
11:30 – 12:00	*Coffee break*
12:00 – 13:30	**RISK INDICATORS (12)** Chair: *M. Khatib-Rahbar (ERI, USA) / U. Schmocker (HSK)* • An Approach to Development of a Risk-based Safety Performance Monitoring System for Nuclear Power Plants **–** *M. Khatib-Rahbar (ERI, USA)* • Use of WANO Pl and living PSA in Okiluoto NPP **–** *R. Himanen (TVO, Finland)* • Pls: Relationship to Safety and Regulatory and Inspection Programs? **–** *U. Schmocker (HSK)* • Risk Indicators at Cofrentes NPP **–** *J. Suárez (IBERINCO, Spain)*
13:30 – 15:00	***Lunch***
15:00 – 16:30	**INTERNATIONAL PERFORMANCE INDICATOR SETS (13)** Chair: *L. Lederman (IAEA) / L. Carlsson (NEA)* • Indicators to Monitor NPP Operational Safety Performance **–** *L. Lederman (IAEA)* • Results of PWGIP Baltimore Meeting Related with Pls **–** *J.J. Van Binnebeck (AVN, Belgium)* • WANO Pls **–** *H. Hamlin, Y. Shimada (WANO)*

Wednesday 18 October 2000	
8:00 – 9:00	Registration
9:00 – 10:15	**REGULATOR INDICATORS (Part 1 - 21)** Chair: *A. Gea (CSN)* • Pls at Bavarian NPP – *E. Seidel (Germany)* • Development and Use of Safety Indicators at STUK – *P. Tiippana (STUK-Finland)* • Experience in the Use of Pls in Korea **–** *Sae-Yul Lee (KINS, Korea)*
10:15 – 10:30	*Break*
10:30 – 11: 30	**REGULATOR INDICATORS (Part 2 - 22)** Chair: *J.J. V. Binnebeck (AVN, Belgium))* • New Pls System in Spain **–** *M. Maroño (CIEMAT, Spain)* • Development of Safety Pl of Regulatory Interest (SAFER) in Pakistan **–** *Khatoon (Pakistan)* • The Development of Safety Indicators for NPP at the French Safety Authority **–** *M. Raymond (DSIN, France)*
11:30 – 12:00	*Coffee break*
12:00 – 13:30	**REGULATOR INDICATORS (Part 3 - 23)** Chair: *P. Tiippana (STUK-Finland)* • Development of Safety Pl in Japan **–** *J. Tanaka (NUPEC, Japan)* • Development of Safety Pl System at Ukrainian Regulator **–** *O.V. Pecherytsya (SSTC, Ukraine)* • Safety Indicators in the Nuclear Regulatory Process **–** *T. Hill (CSN, South Africa))* • Regulatory Body Experience with the Safety Indicator Use **–** *R. Rehacek (Czech Republic)*
13:30 – 15:00	***Lunch***
15:00 – 16:30	**ORGANISATION AND SAFETY CULTURE INDICATORS (24)** Chair: *J. Toth (Paks, NPP) / F. Calduch (Cofrentes NPP)* • Cofrentes NPP Indicators to Monitor Operational Safety Performance **–** *F. Calduch (Cofrentes NPP))* • Indicators of Plant Performance During Events Identified by Recuperare Method **–** *S. Bardou (IPSN,France)* • Assessment of Human Performance and Safety Culture at the Paks NPP **–** *J. Toth (Paks, NPP)* • Pl at Daya Bay NPP **–** *C. Fang (Daya Bay NPP, China)*

Thursday 19 October 2000	
8:00 – 9:00	Registration
9:00 – 11:30	**ROUND TABLE DISCUSSION ON OPPORTUNITIES FOR INTERNATIONAL CO-OPERATION ON PERFORMANCE INDICATORS (31)** Chair: *J. Johnson (NRC)* Table: *M. Raymond (DSIN), L. Carlsson (NEA), L. Lederman (IAEA), P. Baranowsky (NRC)* • Presentation of a proposal for discussion – J. Zarzuela *(CSN, Spain)*
11:30 – 12:00	*Coffee break*
12:00 – 13:30	**CLOSURE** **ROUND TABLE OF SESSION CHAIRMEN** **BRIEFING CONCLUSIONS (32)** Chair: *A. Alonso (CSN) / J. Zarzuela (CSN)* All session chairmen

Appendix 2

PERFORMANCE INDICATORS TASK FORCE

LIST OF PARTICIPANTS
MEETING 19-20 FEBRUARY 2001

Issy-les-Moulineaux

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Appendix 3

Spain running set of performance indicators

- **Automatic scrams while reactor critical**

  - Safety systems actuations
  - Significant events
  - Safety system failures
  - Forced outage rate
  - Forced outage rate for 1000 critical hours of critical commercial operation
  - Radiation exposure to workers

Future Performance Indicators of Spanish NPP

<table>
<tr><th colspan="2">PERFORMANCE INDICATOR</th><th>AREA</th></tr>
<tr><td colspan="2">Unit Capability Factor (%)</td><td rowspan="4">PERFORMANCE STABILITY</td></tr>
<tr><td colspan="2">Non scheduled shutdowns/year (excluding SCRAMS)</td></tr>
<tr><td colspan="2">SCRAMS/7000 critical hours (auto + manual)</td></tr>
<tr><td colspan="2">Non scheduled Safety System Actuation (1) /year</td></tr>
<tr><td colspan="2">Safety System Failures(2) / year</td><td rowspan="2">RELIABILITY OF MITIGATING SYSTEMS</td></tr>
<tr><td colspan="2">Safety System Unavailability / year</td></tr>
<tr><td colspan="2">RCS Activity (% TS limit)</td><td rowspan="2">BARRIERS INTEGRITY</td></tr>
<tr><td colspan="2">RCS Identified Leakage (% TS limit)</td></tr>
<tr><td colspan="2">Collective Radiation Exposure to workers (Sv-year)</td><td rowspan="4">RADIOLOGICAL IMPACT</td></tr>
<tr><td>Volume of Low and Medium Level Solid Radioactive Waste</td><td rowspan="3">Under Consideration whether to substitute these three indicators by a new one: radiological dose to critical individual of public</td></tr>
<tr><td>Activity of Gas Radioactive Release</td></tr>
<tr><td>Activity of Liquid Radioactive Release</td></tr>
</table>

1. Safety System Actuation: It is counted as long as the challenged System fulfils its function: to inject water, to supply power. Auxiliary Feedwater actuations, when properly actuated, e.g., following a scram, are excluded.

2. The Safety Systems considered vary at different reactor design:

PWR.	**BWR**
Emerg. AC Power system	Emerg. AC Power system
HPSI	HPCI/HPCS
RHR	IC/RCIC
AFW	RHR

Running set of performance indicators in Finland:

SAFETY OF NUCLEAR FACILITIES	
A1 Safety and quality culture	
A1.1 Failures and their repairs	number of failures of TS equipment
	ratio between corrective and preventive maintenance tasks (TS equipment)
	repair time of failures of TS equipment
	number of single and multiple maintenance errors (CCF)
	number of technical common cause failures (critical and potential)
A1.2 Number of TS deviations	number of non compliancies with TS
	number of exemptions of TS
A1.3 Availability of safety systems	unit specific WANO indicators
A1.4 Radiation doses	annual collective dose
	annual average of ten highest doses
A1.5 Radioactive releases	radioactive releases to the athomosphere
	radioactive releases to the water system
	Calculated dose of the most exposed person living in the vicinity of the plant
A1.6 Documentation	number of unupdated documents on the outage related to the plant modifications implemented during previous outage *(planned)*
A1.7 Investments	annual investment rate to plant modernisation
A2 Operational events	
A2.1 Number of events	number of reported operational events according to Guide YVL 1.5
A2.2 Significance of events	calculated risk significance of
	TS exemptions
	failures of TS equipment
	preventive maintenance of TS equipment
	operational events
A2.3 Causes of events	number of events caused by organisational factors
	number of events caused by technical factors
A2.4 Number of fire alarms	number of malfunctions
	number of real fire alarms
	number of fires
	number of other rescue missions
A3 Structural integrity	
A3.1 Integrity of nuclear fuel	a maximum activity of the primary circuit equivalent to I-131
	number of removed fuel bundles due to fuel leakage
A3.2 Integrity of primary circuit	WANO chemistry index
	volume of identified and unidentified leakage
A3.3 Integrity of containment	overall leakage of isolation valves compared with the highest allowed overall leakage of the isolation valves
	percentage of isolation valves at each plant unit that passed the leakage test at the first attempt
	an overall leakage of containment’s entrance and other holes in relation to the highest allowed overall leakage of these holes at each plant unit

Introductory Indicator System for SKI

DEF. IN DEPTH	BARRIERS	
1.Prevention of abnormal oper. and failures	***1.1 Robust design and constr.:***	
	1.1.1 Fuel	1.1.1 No. of fuel failures
	1.1.2 Primary press.boundary	1.1.2. Later
	1.2 High qual. in maint.and oper.	1.2.1 Rate of violations of Tech.Spec by plant pers. contr.and others. 1.2.2 Rate of maint. problems (repeated maint. or overdue maint).
Initiating Events	***1.3 Initiating events***	1.3.1 No.of scrams 1.3.2 No. of safety system initiations
2. Control of abnorm. operation and detection of	***2.1 Robust superv. systems***	2.1.1Unavail. for supervision and protect. systems 2.1.2 No. of incid.w.failing syst. at scram
Failures	***2.2 High quality in maint. and oper.***	2.2.1and 2.2.2. See 1.2.1 o 1.2.2
3.Control of accid. within the design Basis	***3.1 Effective safety systems***	3.1.1Unavail of safety systems 3.1.2 Unavail.of separat. barriers 3.1.3 No. of leaking cont isolat. valves
	3.2 High quality in maint. and oper.	3.2.1 and 3.2.2. See 1.2.1 o 1.2.2
	3.3Effective emerg. oper. proceed.	
4. Control of severe plant conditions, incl. prevent. of accident progress. and mitigating of the consequences of severe accidents	***4.1 Conseq. mitigating measures***	4.1.1 Unavail.of conseq. mitig systems 4.1.2 Unavail. of supervision systems
	4.2 High quality of oper. and maint.	4.2.1and 4.2.2. See 1.2.1 o 1.2.2
	4.3 Physical protection	Later
	4.4 Effective accid.management	Later
5. Mitigation of radiological conseq. of significant releases of radioact. materials	***5.1 Prep. measur.for eff. Info to and protect. of the population***	Later
6. Global safety		6.1.1 Unplanned loss of production

WANO Performance Indicator Programme

The WANO Performance Indicator Programme supports the exchange of operating experience information by collecting, trending and disseminating nuclear plant performance data in eight key areas. The data is quarterly gathered for a set of quantitative indicators of plant performance in the areas of plant safety and reliability, plant efficiency and personal safety.

These indicators are intended principally for use as a management tool by nuclear operating organisations to monitor their own performance and progress, to set their own challenging goals for improvement and to gain additional perspective on performance relative to that of other plants.

The internationally agreed programme is continuously reviewed and further developed to allow individual plants to compare their performance more easily with industry average values. For many years the level of reporting data has grown to nearly 100% of the operating nuclear power plants reporting at least seven indicators.

Overall results are annually issued for public information. Confidential unit results are quarterly updated and continuously available for all WANO members.

The WANO Performance Indicator set comprises since year 2001:

Unit Capability Factor
The unit capability factor is the percentage of maximum energy generation that a plant is capable of supplying to the electrical grid, limited only by factors within control of plant management.

Unplanned Capability Loss Factor
The unplanned capability loss factor is the percentage of maximum energy generation that a plant is *not* capable of supplying to the electrical grid because of unplanned energy losses, such as unplanned shutdowns or outage extensions, limited only by factors within control of plant management.

Unplanned Automatic Scrams per 7000 Hours Critical
The unplanned automatic scrams per 7000 hours critical indicator tracks the mean scram (automatic reactor shutdown) rate for approximately one year (7000 hours) of operation.

Collective Radiation Exposure
The collective radiation exposure indicator monitors the effectiveness of total personnel radiation exposure controls.

Industrial Safety Accident Rate
The industrial safety accident rate tracks the number of accidents that result in lost work, restricted work or fatalities per 200 000 work-hours.

Safety System Performance
The safety system performance indicator monitors the availability of three important standby safety systems at each plant.

Fuel Reliability
The fuel reliability indicator monitors progress in preventing defects in the metal cladding that surrounds fuel.

Chemistry Performance
The chemistry performance indicator provides an indication of progress in controlling chemical parameters to retard deterioration of key plant materials and components.

The latter three indicators are defined in a manner that reflects differences in plant-specific design, configurations or operational practices. As a result, data cannot simply be summarised across all reactor types for comparison purposes.

The volume of solid radioactive waste indicator and thermal performance indicator as well were cancelled as WANO performance indicators, because the WANO members felt that these indicators were internationally not very well comparable and not very well connected to the WANO mission respectively.