Prepared for ACRS—Informational Report
Link Technologies, Inc., June 4, 2003

SAFETY CULTURE:

OVERVIEW OF FOREIGN PRACTICES

INTRODUCTION

The concept of safety culture is a topic currently generating significant interest among safety communities throughout the world, and the nuclear industry is certainly no exception. In recent years a world-wide trend has been developing to introduce competition in electricity markets (commonly referred to as economic deregulation). While not all countries or their various jurisdictions have fully introduced market competition, the trend is gathering momentum and virtually all nuclear operating companies are feeling competitive pressures to reduce operating costs and to increase electricity production. The nuclear operators' responses to competition may produce either safety benefits or safety challenges. For instance, there have been recent examples of more efficient work processes; better outage planning and better overall management of day-to-day operations at some plants. There are other examples of substantial staff reductions, greater use of less skilled contractors and increased use of on-line maintenance. Thus, the issue is raised as to whether a nuclear facility has a sufficient safety culture to adapt to these circumstances. This and the accident at Chernobyl have lead to significant international attention to safety culture at nuclear facilities.

There are two major international organizations that are focusing on defining safety culture, detecting declines in safety culture, and identifying responses by regulators to any such declines. They are the International Atomic Energy Agency and the Organization for Economic Co-operation and Development. Their recent efforts are summarized below.

International Atomic Energy Agency (IAEA)

IAEA is the primary international organization in the nuclear field. It is headquartered in Vienna, Austria, and has over 110 member states. Its objectives are to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world and to ensure so far as it is able that its assistance is not used in such a way as to further any military purpose. NRC technical and policy specialists participate in a variety of IAEA programs and activities. IAEA's major program areas include nuclear technology, nuclear safety standards and reviews, technical assistance, and international safeguards.

IAEA has reported that the Chernobyl disaster of 1986 can be largely attributed to the lack of a nuclear safety culture. Subsequently, the IAEA has highlighted safety culture as a fundamental management principle in the operation of nuclear power plants. Since the Chernobyl disaster, the IAEA has undertaken several studies to develop a commonly accepted definition of safety culture and a means of confirming its effectiveness in particular cases. As a result of these studies, the IAEA defines safety culture as:

> 'Safety Culture is that assembly of characteristics and attitudes in organizations and

individuals which establishes that, as an overriding priority, nuclear plant safety issues receive attention warranted by their significance.'

Safety culture relates to the behavior of individuals within an organization who perform safety related tasks. This behavior is influenced by two general components, a structural component and an attitudinal component. The structural component refers to both the legislative framework in which the organization must function, as set by the government, and the organizational framework in which individuals within the organization must function, as set by the organization's management. The attitudinal component refers to the attitudes of staff at all levels in the organization in response to the structural framework. The influence of this attitudinal component is the reason why sound procedures and good practices are not adequate if merely practiced mechanically. Safety culture requires that all duties important to safety be carried out correctly, with alertness, due thought and full knowledge, sound judgment, and a proper sense of accountability.

According to the above definition, safety culture is related to personal attitudes and thought habits and to organizational style. These factors are generally intangible making assessment of safety culture in specific situations difficult. Nevertheless, these intangible factors do lead to tangible manifestations which may be used to indicate the effectiveness of safety culture. The IAEA's International Nuclear Safety Advisory Group (INSAG) initiated the development of a means of using these tangible manifestations to assess safety culture by identifying a set of safety culture indicators. These safety culture indicators have been further developed and expanded by the IAEA in its recently published ASCOT (Assessment of Safety Culture in Organizations Team) guidelines which provide practical guidance for organizational self-assessment of safety culture.

Promoting Safety Culture to IAEA Members

To address safety culture internationally, IAEA established the Assessment of Safety Culture in Organizations Team (ASCOT) Service in 1993 (Revised in 1996) to provide expert support and advice prior to and following self-assessments; independent safety reviews; and seminars covering "safety culture" concepts, methods for assessing safety culture, operational safety topics, and best world practices.

Since the ASCOT service began, they have conducted several reviews (e.g., the Sizewell B NPP in the United Kingdom, the Borssele NPP in the Netherlands, and the Koeberg NPP in South Africa), and seminars world-wide. ASCOT has noted that France, South Africa, Spain and the United Kingdom, among others, are already systematically assessing, promoting and enhancing safety culture; and that there appears to be a fairly high level of safety culture in most organizations, although there is room for improvement in all.

The ASCOT guidelines consist of a safety culture questionnaire with a series of key safety culture indicators, and supplemental questions to obtain the job details of each participant. Each question consists of a set of check boxes in which the participant could use to indicate their response, as well as a space for comments. Some of the check boxes are a simple YES/NO

response, while others provide a four or five point scale on which a response may be rated.

In the ASCOT guidelines, several safety culture indicators are highlighted, as follows:

- Government and its organizations
  - Government's commitment to safety
  - Regulatory agencies' commitment to safety
  - Operating organization's commitment to safety

- Corporate level
  - Safety policy at the corporate level
  - Safety practices at the corporate level

- Plant level
  - Highlighting safety
  - Definition of responsibilities
  - Selection of managers
  - Relation between plant management and regulators
  - Review of safety performance
  - Training
  - Local practices
  - Field supervision by management
  - Work-load
  - Management attitude and commitment
  - Individual attitude and perception

- Research organizations
  - Research input to safety analysis

- Design organizations
  - Codes for safety aspects of design
  - Design review process

The safety culture indicators outlined above are assessed by a list of questions, found in the ASCOT Guidelines. The method is intended to be used not as a checklist, but as a guideline for organizational self-assessments, and should be embedded in other methods (e.g., plant tours, documentation reviews). The ASCOT Guidelines also offer detailed information and time schedules for planning an ASCOT review. To date, the ASCOT methodology is used world-wide for its flexibility in application.

An IAEA Bulletin (Reference 6) notes that there is substantial diversity among organizations in their understanding of "safety culture" and how to act to influence it in a positive way. This variation is represented in different developmental stages. Three stages seem to emerge, each of which displays a different awareness and receptiveness to the effect of human behavioral and

attitudinal matters on safety. The stages are:

- Stage I. The organization sees safety as an external requirement and not as an aspect of conduct that will help the organization to succeed.
- Stage II. The organization has a management which perceives safety performance as important even in the absence of regulatory pressure.
- Stage III. An organization at Stage III has adopted the idea of continuous improvement and applied the concept to safety performance. There is a strong emphasis on communications, training, management style, and improving efficiency and effectiveness. Everyone in the organization can contribute.

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on December 14, 1960, and which came into force on September 30, 1961, the Organization 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 subsequently became Members through accession: Japan, Finland, Australia, New Zealand, Mexico, the Czech Republic, Hungary, Poland, and the Republic of Korea. The Commission of the European Communities takes part in the work of the OECD

The OECD **Nuclear Energy Agency** (NEA) was established on February 1, 1958 under the name of European Nuclear Energy Agency. It received its present designation on April 20, 1972, when Japan became its first non-European full Member. NEA membership today consists of all OECD Member countries, except New Zealand and Poland.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source. This is achieved by:

- encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionizing radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;
- assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;
- developing exchanges of scientific and technical information particularly through participation in common services;
- setting up international research and development programs; and
- other joint undertakings.

In these and related tasks, NEA works in close collaboration with IAEA, with which it has concluded a Co-operation Agreement, as well as with other international organizations in the nuclear field.

The Committee on Nuclear Regulatory Activities (CNRA) of the OECD/NEA is an international body made up of senior representatives from nuclear regulatory bodies. In 1998, following the publication of the CNRA report on Future Regulatory Challenges, the Committee established a Task Group to advance the discussion on how a regulatory organization recognizes and addresses safety performance problems that may stem from safety culture weaknesses.

The first in a series of reports on safety culture was *The Role of the Nuclear Regulator in Promoting and Evaluating Safety Culture*, published in June 1999. The aim of this document is to focus on the dual role of the regulatory body in both (a) promoting safety culture, through its own example and through encouragement given to operators, and (b) evaluating the safety culture of licensees through performance or process based inspections and other methods. On the latter, the regulator should recognize that it is not really possible to quantitatively measure safety culture. Rather, the regulator can evaluate the outward operational manifestations of safety culture as well as the quality of work processes, and not the safety culture itself. It is assumed that, when a weak safety culture exists for a period of time, signs of declining safety performance will appear. If the root causes are not found and corrected, actual safety problems will eventually appear. Therefore, the regulator will have to look for signs of declining performance and subsequently evaluate whether there are signs of a weak safety culture, which may be the root cause of the declining performance. The report lists many examples of early signs of declining performance in the following areas:

- management
- operations
- maintenance
- engineering design and safety analysis

- plant documentation
- radiological controls
- outage activities
- event analysis and
- regulatory relations.

The report also lists examples of signs of potentially weak safety culture in:

- management capabilities and attitudes
- ineffective or lack of safety programs
- inadequate self-assessments or follow through
- lack of accountability
- poor regulatory relations or attitudes
- isolation of key people and
- attitudes that are lacking.

The second report in the series (*Regulatory Response Strategies for Safety Culture Problems*) explores possible regulatory response strategies for dealing with declining safety performance when the outward manifestations of that performance suggest that there may be fundamental safety culture problems. It also discusses the resumption of normal surveillance after enhanced regulatory attention and intervention. Even good operating plants may show some of the early signs of problems from time to time, but the fundamental strengths of their organizations will soon find, analyze and correct the problems. Other safety performance problems may be corrected easily by modest early regulatory attention. But these fortunate situations do not pose a safety challenge to the regulator, and for that reason the focus of this report is on those difficult situations where regulatory intervention is ultimately needed. The strategies entail a graded approach depending on the severity and duration on the safety culture problem.

Promoting Safety Culture to NEA Members

The NEA promotes that safety culture "must permeate all levels of an operating organization. At the top of the corporation, management commitment to safety has a profound influence on the safety culture of the entire organization, and senior management must establish a set of values emphasizing safety and quality, making it clear that workers should not have a conflict in their daily tasks between safety and electrical production goals. The employees will keenly watch whether the senior management's actions match their words in this regard." The implementation of safety culture is seen as part of the overall process of ensuring nuclear safety, and is treated as such.

In its report, *Committee on the Safety of Nuclear Installations: Identification and Assessment of Organizational Factors Related to the Safety of NPPs: State-of-the-Art Report (SOAR),* NEA describes a series of organizational factors which affect the safety culture of a NPP. According to NEA, an organizational factor may be either a process or the result of a process. For example, in the "Human Resources Management" factor, the process requires that personnel are selected according to certain requirements, and that roles and responsibilities are assigned, and are

periodically evaluated. Those processes can result in choosing the right people for the right position, therefore reducing operational risk.

Likewise, there are some factors which can be seen both as process and result. For example "Communication" is a process where personnel receive appropriate information to perform their job effectively and safely. It is also the result of managerial processes, including the development and implementation of strategies or policies for the dissemination of information within the organization.

NEA's report covers the following organizational factors, which affect and contribute to an organization's safety culture:

- External Influences,
- Goals and Strategies,
- Management Functions and Overview,
- Resource Allocation,
- Human Resources Management,
- Training,
- Coordination of Work,
- Organizational Knowledge,
- Proceduralization,
- Organizational Culture,
- Organizational Learning, and
- Communication.

Each factor also has "aspects" which determine its affect on an organization's safety culture. For example, the "external influences" on an organization's safety culture include the current political and economic climates, the legal system, cultural aspects (including social and economic status of the workforce), regulatory authorities, external organizations (e.g., labor unions), public and employee opinion and perception, and media coverage. How an organization addresses these aspects determines its coping strategies, contributing to its safety culture. Although external influences can be identified, observed and reacted to, they cannot be directly controlled or changed by the organizations; and yet these aspects clearly influence how an organization meets its safety goals.

The organizational factor "Goals and Strategies" addresses how an organization sets priorities, promotes safety, allocates its resources (e.g., financial, commercial and human), and establishes long-range goals. Its aspects include how management policy and strategic planning support the organization's mission; its business planning processes; how an organization defines, prioritizes and communicates its goals and objectives; how an organization develops and implements its strategic plans, and defines its structure, accountability and authority; and an organization's mechanisms for long-term evaluation and control, problem identification and resolution.

The organizational factor "Management Functions and Overview" is significant in its own right,

and in that it overlaps with several other organizational factors. "Management Functions and Overview" ensures that all the critical middle and lower management functions are accomplished. In particular, it addresses how upper management organizes, plans, controls and monitors its processes and activities, in support of its safety goals and strategies. Its aspects include how upper management identifies, develops and supports lower management to enable them to carry out their job responsibilities; empowers lower management to act with authority; addresses promotion and reinforcement of safe work practices; defines and establishes safety goals and standards; establishes a process for reliable and effective decision-making; establishes an information management process to identify, acquire, analyze, trend, manage and disseminate safety and performance information and data in a timely manner; identifies and resolves safety problems and issues; detects and manages internal conflicts (i.e., between safety and economical benefits); manages technical and organizational changes; plans and schedules work processes (e.g., workload management); establishes effective communication with outside interest groups and regulators; monitors resource allocation; establishes and monitors safe work practices and processes (e.g., walk-throughs, housekeeping practices).

The "Resource Allocation" factor links with "Human Resources Management," "Training," and "Coordination of Work." It ensures that resources are distributed in direct support of safety, by addressing allocation, distribution and monitoring strategies and goals for financial, human, time and technical resources. Its aspects include identifying, acquiring and developing technical resources; finding balance among economic pressures, safety requirements and timetables; prioritizing safety and economic goals; creating an organizational structure to address decision-making processes for resource allocation; controlling and monitoring human and technical resource management processes; managing logistics; assigning organizational support; evaluating human factors and appropriate personnel when developing work designs; and providing a means or system for business planning and operational function support.

The "Human Resources Management" factor specifies what roles and responsibilities an organization must address to select, assign, develop and evaluate all personnel (e.g., full-time, part-time and contractual) to establish and maintain a safe work place. This factor is linked with "Training" and "Coordination of Work." Its aspects include employee recruitment and selection based on experience, education and training, among other pre-determined qualifications; attention to the psychological and physiological conditions of its employees; assignment of roles, responsibility and levels of accountability to position descriptions and standards; rules for shift organization, working hours, overtime policies, staffing policies; adaptation to technological changes; use and evaluation of contractors; management of job rotation and promotion procedures, developing a formal appraisal process (e.g., motivation, performance and competence) and a reward and recognition system; career development procedures; trending and tracking of staff turn-over; job security issues; succession planning (to anticipate and fill vacancies); and monitoring employee morale and job perception in regard to a safety culture.

The "Training" factor identifies functions, tasks, knowledge, skills and abilities required for employees to perform their jobs in a safe and efficient manner. The "Human Resources Management" factor helps to determine training needs, in part from long-term planning processes

addressed in the factor, "Goals and Strategies." Training content is dependent on requirements defined in the "Coordination of Work" and "Proceduralization" factors. The "Organizational Learning" factor also contributes to the operational experience that needs to be addressed in training programs. The "Training" factor includes the following aspects: developing a process to ensure continuous improvement in knowledge, skills and abilities to meet job requirements, and organizational goals and strategies; establishing and evaluating types of (e.g., initial, refresher, remedial) and strategies for (e.g., class room, on-the-job, distance learning, self-paced, on-line, simulator) training; implementing training methods and developing associated materials; providing training that meets individual or specific needs; implementing monitoring and quality assurance processes; evaluating training programs continually; allocating appropriate resources for training; providing periodic training opportunities for career development and new technologies; and providing professional educational support.

The "Coordination of Work" factor addresses process planning, scheduling, integrating and allocating resources for work activities, and helps define how tasks are completed and relate to each other (i.e., "Organizational Knowledge" factor). Its aspects include organizing interrelated work activities; identifying roles, responsibilities and delegation of tasks; determining shift work, turn-over and team composition; addressing organizational communication and coordination; prioritizing, planning and scheduling work activities; planning and managing workload distribution, personnel and workflow; determining task logistics, assistance and support; providing records of work activities (i.e., traceability); and coordinating contractors with licensee employees.

The "Organizational Knowledge" factor addresses the employees' understanding of an organization's processes, procedures and practices, and hierarchy. Its aspects include understanding the organizational structure, interfaces between units/departments, communication channels and interrelationships between sub-systems; awareness of an employee's own roles, responsibilities, and place within the organizational hierarchy; knowledge of work practices, shared memory of past work experiences; and management of organizational knowledge and communications.

The "Proceduralization" factor addresses the identification, development, verification, validation and implementation of rules, procedures and methods, based on work activity standards, and functional and task analyses. This factor is linked to the "Coordination of Work," "Communication" and "Training" factors. Its aspects include standardizing and formalizing recurrent and critical work activities; providing clear information of potential risks during work activities; presenting procedures based on human factors, ergonomic principles and lessons learned; providing end user (i.e., operators) participation in procedural development, design and modification; providing administrative aids, control, and quality assurance (and quality management systems); and providing balance among procedures, work activities, and personnel skills and experience.

The "Organizational Culture" factor refers to shared assumptions, values, attitudes, norms and perceptions of management and employees. Its aspects include that personnel perceive and

employ a safety culture, safe working practices, and shared basic assumptions about how to behave during normal and emergency situations; individuals possess safety awareness; there exists organizational support for employee socialization, reward and recognition systems reinforcing safe work practices, open communication with regulators, and organizational awareness of safe (and unsafe) work behaviors; supervisors and peer employees act as role models; there exists workplace competency and open communication between levels and among employees.

The "Organizational Learning" factor addresses the organizational process of identifying problems and sharing lessons learned and best practices to improve future safety performance. This factor relates to the "Management Functions and Overview," "Human Resources Management," "Coordination of Work," "Organizational Knowledge" and "Training" factors. Its aspects include providing feedback concerning operational experience to interested parties; demonstrating proactive, rather than reactive, behavior; transforming discreet information into explicit organizational knowledge; questioning prevailing attitudes toward safety; promoting the common understanding of processes and responsibilities; learning from safety issues; identifying, owning and resolving problems; performing self-assessments; demonstrating a capacity and willingness to learn; and providing opportunities for continuous improvement.
is through the organization and all its members.

The "Communication" factor addresses the information exchange process. Its aspects include encouraging information flow among the organization, regulators, and contractors; dissemination of information among different layers of the organization, itself (i.e., top to bottom, and across departments); appropriate and timely use of several methods of information sharing; awareness and application of shared information; formalization of communication and document management processes; use of tools and concepts to code and submit data and information; and providing managerial supervision of the communication process.

In Volume II of its report, NEA presented examples of methods used for assessing organizational factors in its member countries that submitted information on their programs. Below are a few examples.

Regulatory Body Assessment of the Safety Culture

- **Finland:** The Finnish Radiation and Nuclear Safety Authority (STUK) sets safety requirements and verifies compliance with them, and has also developed a comprehensive set of safety guides, referred to as YVL-guides. Since regulation of nuclear power plants covers the entire life cycle of each facility--from cradle to grave--operators have full and undivided responsibility for the safety of nuclear power plants. In accordance with its defined inspection programs, STUK verifies that both operations and related support activities are in compliance with their safety requirements. STUK also emphasizes the use of voluntary programs to ensure safe working practices, in place of regulatory requirements. STUK's YVL-guides cover the main areas of nuclear power plant operation, with both instructions and recommendations (e.g., general safety principles, quality assurance, reporting, documentation, personnel qualification and training, outages, plant modifications, inspections and safety assessments, nuclear fuel management,

utilization of operational experience, safety classification, accident analyses, PSA, fire and radiation protection, and emergency preparedness), and are updated periodically to reflect new information. Once every year, each Finnish nuclear power reactor is refueled, and the entire plant is overhauled. STUK reviews the respective plans and assesses the many efforts of technical upgrading. These results are inspected before the plant is restarted.

- **Germany:** In Germany, 19 units (BWRs and PWRs) on 14 sites are operated by different licensees. The German regulations cover technical aspects, human factors, training and organizational issues. Although no particular organizational structure is prescribed, all German utilities implement a similar type of structure. Regulated sectors of NPP organizations include operator qualification and training; organization, performance and documentation of maintenance tasks and radiation protection methods; and operating experience reporting, analysis and feedback. Principles of safety culture have always played a major role in the German nuclear industry, including a high priority toward safe work practices, clear definition of responsibilities and tasks, and blame-free response to human error. German regulators frequently inspect NPPs and take human and organizational factors into account during these inspections. Feedback is given to operators, so that they may make further investigations and improvements. In 1996, German licensees implemented the Human Factor System (HF-System) to analyze operating events and occurrences to determine if human factors caused or contributed to errors. One person on-site is in charge of all HF issues, and is required to have a good working knowledge of the plant and how to perform root cause analysis, ergonomic analysis, psychological factors related to work, interviews and observation techniques, and documentation and reporting.

- **Spain:** Spain's regulatory body, the Consejo de Seguridad Nuclear (CSN) requires that both the organization and management of NPPs have direct responsibility for their licensee, the regulatory body must not replace the licensee's responsibility, and both regulators and licensees must understand the organizational and management factors influencing the safety of their NPPs. At NPPs, responsibility for safety is assigned to line management, although some groups (e.g., Plant Safety Committee, Owner Safety Committee) ensure that priority is given to safety matters. Operators are beginning to implement safety culture and management evaluation programs, such as the Model of the European Foundation for Quality Management (EFQM). CSN monitors the efficiency of management and organizational activities through several methods, including its inspections (i.e., ESFUC program). The ESFUC program established periodic evaluation of plant operation and organizational management within five functional areas, including operation, radiation protection, maintenance-surveillance, technical support and emergencies. Consideration is given to the following criteria: management commitment to improving quality and safety, operator's capacity for self-evaluation, considerations for safety implications in resolving technical issues, effectiveness of corrective actions, operating events related to inspected issues and activities, the human resources within the organization, training and qualification programs, and deviations in safety standards or conditions and non-compliance with programs.

- **United Kingdom:** The UK's Health and Safety Executive has developed a general systems approach, described in its document, "Successful Health and Safety Management". The Nuclear Safety Directorate (NSD), a branch within the Health and Safety Executive, is responsible for ensuring that nuclear power-related activities are conducted safely. NSD makes day-to-day decisions regarding licensees through the routine regulatory site activities of its inspectors, and when the corporate management systems are examined. NSD has produced a document relating specifically to nuclear safety, entitled, "Managing for Safety at Nuclear Installations." This document is used by inspectors to audit NPP organizations. Inspections are based on documentation reviews, interviews and walk-throughs; and are also designed to help utilities build their organizational systems. Every function (e.g., Training, Communication) can be assessed as a dynamic management process.

Overview of Organizational and Safety Culture Assessment Practices by Foreign Utilities and Industry

Canada

- ***Management Oversight and Risk Tree***

  The MORT analysis which was developed for mainly addressing conventional safety was adopted to scrutinize nuclear safety related events and is used among Canadian utilities. It is a fault-tree approach addressing important management functions supporting certain tasks. It is designed to analyze events but can also be used in a proactive way. It is regarded to be applicable to the assessment of Management Functions and Overview. The most useful aspect of it is its help as a check-list. In the United Kingdom another modification called SHORT-MORT is in use.

- ***Human Performance Enhancement System***

  Another tool called Human Performance Enhancement System (HPES) is applied in most Canadian utilities (the same goes for the majority of utilities in the United States). The method is used for event analysis. Although it never has been done so yet, it seems to be worth trying it as a proactive regulator tool.

- ***Root Cause Analysis***

  Another approach was presented in a distributed paper based on the analysis of around hundred very minor events within a period of one year. The root causes of these minor events were classified according to the following five families:

  - overview and decision making
  - communication
  - organizational clarity
  - human resources management
  - culture.

All the families contain a dozen of key indications which should be chosen to describe the event.

The statistical analysis of these root causes provides a picture of the more frequent factors which appear in events and disturbances. This method is deemed to be proactive as analysis of very minor events may indicate major deficiencies in organization which could serve as root causes of more significant events.

This data collection and the analysis are performed by a small crew of four persons in the Gentilly-2 plant.

Czech Republic

Organizational factors are taken into account at the NPP Dukovany (4x440 MW, WWER type) in the framework of activities such as :

- systematic follow up on the safe performance within the framework of operating experience feedback (OEF) program including application of ASSET and HPES methods and root cause analysis, evaluation of the impact of human and organizational factors on occurrence of operating events, implementation of corrective actions
- periodic auditing of documentation and activities
- training of operating and maintenance personnel and management
- forming the correct relations between the NPP and contractors maintenance personnel during operation and shut down
- self-assessment within the framework of regular ASSET and OSART missions
- improvement of the NPP organizational structure based on comprehensive expert analysis within the framework of PHARE projects (on improvement of OEF, QA etc.)
- PSA (mainly human actions and performance during accidents, incidents or activities during shut down)
- application of HRA, ATHEANA for assessment of data from operation and full scope simulator
- research: reliability-based maintenance, Accident Sequence Precursors, risk-based indicators,
- Experience Feedback (EF) improvement, QA enhancement.
- co-operation with the regulatory body in its monitoring the safe performance by means of regular inspections as well as of reactive and proactive assessment of the licensee; regular reports on plant conditions and events.

It is expected that a special center will be formed in Czech Republic, which will systematically cover all aspects of the NPP safe performance including the impact of organizational factors.

France

The Nuclear Inspection Department of the French utility Electricity of France (EDF) has the mission to make a global evaluation of the nuclear safety. For that purpose, this department has developed an audit method which takes into account organizational factors. This approach was tested and is systematically used since 1995 on all nuclear power plants. Each plant is reviewed by EDF staff from the Nuclear Inspection Division every second year.

- ***Global Evaluation of Organizational Factors***

In order to evaluate the effectiveness of the organizational structures (i.e. sharing tasks and responsibilities, explicit (on paper) and implicit (real) organization, observed behavior of individuals and groups executing their tasks) the following aspects are reviewed:

- Organization of safety management: policy, organization, implementation.
- Operation organization: Management, training, overview and control, operation practices, program for future improvements, documentation.
- Maintenance organization: management, training, program for future improvements, quality of intervention preparation, co-ordination, intervention practices.
- Cross-cutting aspects: engineering aspects, auditing and reviewing of activities, operational feed back analysis, modifications.
- Radioprotection aspects: management training, measure analysis, quality of preparation, radioactive source management, logistic control.

The following questions illustrate the type of investigation of EDF inspectors:

About site management: Is the site management only interested in developing work rules and procedures, or is it also interested in developing work values that are common to both the staff and the management? Does management consider both individual and group inputs for each different task? Are task requirements defined with the participation of the employees involved in the task in order to develop a referential that is common to both management and the employees?

About procedures: Are procedures, standards, and rules taking into account the characteristics of the employees, their skills, personalities, and individual and group goals? Are documents that support work (procedures, instructions, etc.) improved, complete, and do they contain sufficient details according to the needs of the users? Is operating experience feedback developed to ensure that developers and users of various rules and instructions are in agreement with the intent of these rules?

About resources allocation: Does the assignment of personnel to various tasks consider the individual employees' particularities (level of experience) and not only their "administrative" certifications?

The techniques used during these audits are documentation analysis, close observation of the field activities and interviews in order to complete the task observations. These interviews provide information about the causes of identified discrepancies.

After such an evaluation, the evaluated site has to define an appropriate way for improvements and has to take precise engagements for the deadlines of the proposed improvements.

Spain

The Spanish utilities (UNESA), in collaboration with the Spanish Nuclear Regulatory Body (CSN), and CIEMAT have started a five-years R&D project, entitled "Development of methods for evaluating and modeling the impact of organizational factors on nuclear power plants safety".

Korean Peninsula Energy Development Organization (KEDO)

In October 1994, the U.S. and the Democratic People's Republic of Korea (DPRK, or North Korea) signed an agreement under which the DPRK agreed to freeze and dismantle its nuclear program. In return, the U.S. agreed to finance and construct two light-water reactors (LWR), provide an alternative source of energy (i.e., 500,000 metric tons of heavy fuel oil) each year for heating and electricity production until the first of those reactors was completed, conduct its activities to meet or exceed international standards of nuclear safety and environmental protection, and provide for the implementation of any other measures deemed necessary to accomplish these goals.

To support these goals, the Korean Peninsula Energy Development Corporation (KEDO) was established on March 15, 1995, when Japan, the Republic of Korea (ROK), and the U.S. implemented key provisions of the agreement. To date, KEDO's members include New Zealand, Australia, Canada, Indonesia, Chile, Argentina, Poland, Czech Republic, Uzbekistan, and the European Atomic Energy Community (EAEC). In addition to its member states, KEDO has received material and financial support from nineteen other non-member, contributing states.

KEDO's nuclear safety policy states that all LWR project activities shall be conducted in a manner that ensures nuclear safety is given the highest priority, and that safety will not be compromised for any reason. This policy is carried out through the Nuclear Safety Confirmation System (NSCS), which was designed to authenticate the safety and reliability of the reactors, while administering all nuclear safety aspects of the LWR project.

In light of the recent discovery that North Korea is pursuing a program to produce highly-enriched uranium for nuclear weapons, the Executive Board of the KEDO has publicly condemned North Korea's pursuit of a nuclear weapons program, as a violation of its responsibilities under the KEDO Agreed Framework, the Nonproliferation Treaty, the IAEA Safeguards Agreement, and the Joint South-North Declaration on Denuclearization of the Korean Peninsula. KEDO demands that North Korea eliminate its nuclear weapons program. To date, heavy fuel oil deliveries have been suspended. Future shipments will depend on North Korea's response to disassemble its highly-enriched uranium program. Other KEDO activities in North Korea are also currently under review.

Promoting Safety Culture to KEDO Members

To accomplish its goals, KEDO has developed a nuclear safety policy, based on five principles:

- Safety culture,
- Safety principles,
- Safety assessment and verification,
- Safety regulation, and
- Safety confirmation.

As part of its safety culture, KEDO focuses on safety; uses a disciplined approach to all safety-related activities; makes informed decisions by using an appropriate and realistic approach to safety, which acknowledges risk; act on the basis of sound technical bases; uses rigorous self-assessment techniques; requires strict accountability; demonstrates clear assignments of

responsibilities; provides strong engineering support; and insists on safety and quality by senior management. KEDO has been implementing policy to maintain and enhance its safety culture.

KEDO is committed to adopting fundamental safety principles and using internationally-recognized safety guidelines. For example, KEDO requires its organizational elements to follow basic safety principles set forth by the IAEA, which focus on, for example, quality assurance, siting, design, radiation protection, construction, operations, commissioning and emergency preparedness. As part of its safety assessment and verification principle, KEDO has committed to implementing a safety assessment and verification process, as part of its LWR project. This principle provides that all assessments and verifications will be made in a timely manner throughout the project.

Taking an idea originally expressed in the IAEA's "Convention on Nuclear Safety," KEDO has adopted the positions that the prime responsibility for the safety of NPPs rests with the organization holding the operating license, and that the State having jurisdiction over an NPP must establish and maintain both a legislative and regulatory framework to govern safety. As stated in KEDO's "Supply Agreement," the DPRK has a regulatory infrastructure, with an independent regulatory body using international standards, which performs independent nuclear safety regulatory activities as part of KEDO's safety program.

To fulfill its safety confirmation principle, KEDO established the Nuclear Safety Confirmation System (NSCS). There are three components to the NSCS: policy development, safety reviews, and oversight. NSCS assures that the highest standards of nuclear safety are achieved and maintained through its policy development. This component covers KEDOs Nuclear Safety Policy; its internal procedures, its interfaces among KEDO's safety and project operations divisions, and the Nuclear Safety Advisory Group; and its conduct of the organization's quality assurance (QA) program. KEDO's QA program consists of periodic audits of its contractor, Korea Electric Power Corporation (KEPCO) and the Korea Power Engineering Company, Inc. (At the time of publication of its 2001 Annual Report, no non-conformances had been found.); indoctrination training; management assessments; internal quality audits; and maintenance of the KEDO QA Procedure Manual.

As stipulated in its Supply Agreement, KEDO is responsible for the nuclear safety of the LWR project until plant turnover: in the meantime, KEDP reviews design criteria and basic design of the LWR, as well as evaluating safety analysis reports (SARs) and other documents prepared by its contractor. The Nuclear Safety Advisory Group (NSAG) and the IAEA play oversight roles in the NSCS. NSAG is composed of nine senior nuclear experts from KEDO member countries: the experts review and evaluate KEDO's safe work practices. The IAEA works in cooperation with KEDO, as needed.

As an organization, KEDO recognizes the value of using safe work practices in its nuclear safety program, to protect its employees and contractors in the construction of its LWR project, and to achieve world-wide recognition as having accepted and employed international safety requirements.

Forum for Nuclear Cooperation in Asia (FNCA)

In March 1990, the first International Conference for Nuclear Cooperation in Asia (ICNCA) was held in Tokyo. Its aim was to reach consensus in developing nuclear technology and nuclear energy in Asia. The meeting was sponsored by the Atomic Energy Commission of Japan. Since the first meeting, ICNCA has met in Tokyo annually. Presently, its members include Australia, China, Indonesia, Japan, Korea, Malaysia, the Philippines, Thailand, and Vietnam; and representatives from the IAEA have also participated.

In March 1999, at the Tenth Annual International Conference for Nuclear Cooperation in Asia, ICNCA members voted to rename its organization to the Forum for Nuclear Cooperation in Asia (FNCA), established the Coordinator system to enhance the cooperation activities. Administered by a secretariat based in Tokyo, FNCA uses coordinators and project leaders (from member countries) for each of its seven ongoing projects:

- Utilization of Research Reactors,
- Application of Radiation and Radioisotopes for Agriculture,
- Applications of Radiation and Radioisotopes for Medical Use,
- Public Acceptance of Nuclear Energy,
- Radioactive Waste Management,
- Nuclear Safety Culture, and
- Human Resources Development.

Promoting Safety Culture to FNCA Members

The Nuclear Safety Culture Project was established as a forum for information exchange among member countries concerning regional and international developments in safety culture, to promote the use of safety culture principles in each country (for non-power reactor facilities), to evaluate methods for implementing safety culture, to report on performance indicators annually (as a measure of safety culture), and to apply nuclear safety convention principles to research reactors.

To measure indicators of activity in safety culture, participants at the third Nuclear Safety Culture Workshop decided to regularly report on what it considered to be six standard nuclear safety culture PIs. The PIs included the following:

- Communication between management and employees to discuss and enhance the organizational safety culture,
- Human factor systems analysis (of incidents) to improve safety culture,
- Training activities related to improving safety culture,
- Communication with stakeholders (e.g., regulators, contractors and reactor users) to discuss improvements to safety culture,
- Conducting surveys and other studies (e.g., behavioral studies) to determine employee attitudes regarding safe work practices, and
- Resource allocation analysis to promote safety culture activities.

In addition to cooperating with its member countries, FNCA cooperates with such organizations as IAEA (as well as other regional organizations), and uses IAEA's international standards as a basis of comparison for nuclear safety.

Other Practices

Switzerland

According to **Organization of Nuclear Power Plants, Guideline for Swiss Nuclear Installations, HSK-R-17/e, Swiss Federal Nuclear Safety Inspectorate, June 2002,** a good organization supports safety-driven activities and promotes the safety culture. Every nuclear power plant shall have a safety culture policy that describes how its safety culture shall be promoted and evaluated. The safety culture policy shall set out the way in which the power plant management interprets and promotes the safety culture, and define criteria and characteristics for evaluating its effectiveness. It shall describe measures to be taken with the view of complying with, and promote, a questioning and analytical basis attitude, a thorough approach and efficient communication among all power plant personnel. The safety culture policy shall also describe how the safety culture will be assessed and adapted at periodic intervals. Safety culture policy shall be outlined in an established document. The Director is responsible for promoting safety culture.

Japan

Following the nuclear criticality accident at JCO Co., considerable attention was given by the industry to the issue of nuclear safety culture. According to Japan Nuclear Fuel Limited, the accident demonstrated that nuclear safety is not guaranteed without functioning both of facility safety and person's awareness of safety culture. From this viewpoint, JCO Co. criticality accident showed the lack of spread of safety culture because of indicating loose management at operation scene and lack of education to employees.

The Federation of Electric Power Companies in Japan, argued for the establishment of a Nuclear Safety Network (NS-net). All companies in Japan should enhance the safety culture across the industry. The electric power companies want to share their safety culture and know-how on safety enhancement with the entire nuclear industry. Elements of proposed programs aiming at enhancing nuclear safety culture include (a) Holding seminars on nuclear safety intended to promote and enhance a safety culture among members and (b) Supporting member organizations in educating and training executives, managers and workers of member organizations on nuclear safety and work ethics.

Selected Information Sources

1. International Atomic Energy Agency (1986) Summary Report on The Post-Accident Review Meeting on The Chernobyl Accident Safety Series No. 75-INSAG-1.
2. International Atomic Energy Agency (1986) Basic Safety Principles for Nuclear Power Plants Safety Series No. 75-INSAG-3.
3. International Atomic Energy Agency (1991) Safety Culture Safety Series No. 75-INSAG-4.
4. International Atomic Energy Agency (1996) ASCOT Guidelines (Revised 1996 Edition) IAEA-TECDOC-860.
5. International Conference on Safety Culture in Nuclear Installations, December 2-6, 2002, Rio de Janeiro, Brazil. http://www.iaea.org/worldatom/Meetings/2002/cn97prog.pdf
6. Ian Barraclough and Annick Carnino, *Safety Culture: Keys for Sustaining Progress*, IAEA Bulletin, 40/2/1998. http://www.iaea.org/worldatom/Periodicals/Bulletin/Bull402/safetyculture.pdf
7. Nuclear Regulatory Challenges Arising From Competition in Electricity Markets, OECD/NEA 2948, February 12, 2001. http://www.nea.fr/html/nsd/reports/nea2948-comp.pdf
8. The Role of the Nuclear Regulator in Promoting and Evaluating Safety Culture, OECD/NEA 1547, Paris, June 1999. http://www.nea.fr/html/pub/webpubs/#safety
9. Regulatory Response Strategies for Safety Culture Problems, OECD/NEA 2248, Paris, 2000. http://www.nea.fr/html/nsd/reports/nea2248-response.pdf
10. Identification and Assessment of Organisational Factors Related to the Safety of NPPs: State-of-the-Art Report, NEA/CSNI/R(99)21/VOL1, September 1999. http://www.nea.fr/html/nsd/docs/1999/csni-r99-21-vol1.pdf
11. Identification and Assessment of Organisational Factors Related to the Safety of NPPs: Contributions from Participants and Member Countries, NEA/CSNI/R(99)21/VOL2, September 1999. http://www.nea.fr/html/nsd/docs/1999/csni-r99-21-vol2.pdf
12. Selected Papers on Nuclear Safety Culture. http://nuclearsafetyculture.freeyellow.com/page7.html
13. "Compliance with the General Regulations for the Safety of Nuclear Power Plants (Decision 395/1991)," STUK, **http://www.stuk.fi/english/convention/compliance_ol.html#2.2**
14. Forum for Nuclear Cooperation in Asia (FNCA), http://www.ansto.gov.au/fnca/articles.html
15. Korean Peninsula Energy Development Organization (KEDO), http://www.kedo.org/
16. Organization of Nuclear Power Plants, Guideline for Swiss Nuclear Installations, HSK-R-17/e, Swiss Federal Nuclear Safety Inspectorate, June 2002.
17. Nuclear Safety Bureau (NSB), "A Survey to Assess Regulatory Influence on Safety Culture at the HIFAR Reactor," United Kingdom, January 1997, http://www.arpansa.gov.au/pubs/nsb_trpt/surhifar.pdf