CONSIDERATIONS REGARDING RISK MANAGEMENT OF NUCLEAR POWER PLANT AS A CRITICAL INFRASTRUCTURE

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În industria energetică actuală, managerii centralelor nucleare (CN) trebuie să ia în considerare multe valențe ale riscului în plus față de cea legată de siguranța nucleară. CN sunt considerate infrastructuri critice în cele mai multe țări, iar acestea fac eforturi considerabile pentru identificarea şi implementarea măsurilor ce se impun pentru eliminarea sau reducerea impactului riscului implicat în exploatarea lor. Această lucrare prezintă paşii din procesul de management al riscului: identificarea riscurilor (listarea, măsurarea şi clasificarea); identificarea tehnicilor/strategiilor pentru managerierea riscului (diminuarea, acceptarea şi transferul riscului); implementarea strategiilor de managementul riscului; şi monitorizarea efectelor acțunilor implementate.

In today's global energy environment, nuclear power plants' (NPP) managers need to consider many dimensions of risk in addition to nuclear safety-related risk. NPP are considered critical infrastructures by most countries, and they spent a lot of efforts for identifying and implementing the appropriate measures to eliminate or reduce the risk impact involved in their operations. This paper presents the steps of the risk management process: identifying risks (list, measure, and rank); identifying techniques/strategies to manage the risk (reduction, retention, and transfer the risk); implementing risk management strategies; and monitoring the effects of implemented actions.

Keywords: nuclear power plants, critical infrastructures, risk management, nuclear safety

1. Introduction

Critical infrastructures are physical or virtual systems and assets so vital to the nation that their incapacitation or destruction would have a debilitating impact on national and economic security, public health, and safety. These systems and assets—such as the electric power grid, chemical plants, nuclear facilities, water treatment facilities, dams, transportation systems (Fig.1) — are essential to the operations of the economy and the government [1]. Recent terrorist attacks and

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threats have underscored the need to protect our nation's critical infrastructures. If vulnerabilities in these infrastructures are exploited, our nation's critical infrastructures could be disrupted or disabled, possibly causing loss of life, physical damage, and economic losses.

In today's global energy environment, nuclear power plant (NPP) managers need to consider many dimensions of risk in addition to nuclear safety-related risk. Nuclear power plants are considered critical infrastructures by most countries. As a consequence a lot of efforts are spent for identifying and implementing the appropriate measures to eliminate or reduce as much as possible the risk impact involved in their operations. In order to stay competitive in modern energy markets, NPP managers must integrate management of production, safety-related, and economic risks in an effective way.

This integrated risk management (RM) approach generates benefits that include the following [2]:

- **Clearer criteria** for decision making.
- **Making effective use of investments** already made in probabilistic safety analysis (PSA) programs by applying these analyses to other areas and contexts.
- **Cost consciousness and innovation** in achieving nuclear safety and production goals.
- **Communication improvement** — more effective internal communication among all levels of the NPP operating organization, and clearer communication between the organization and its stakeholders.
- **Focus on safety** — ensuring an integrated focus on safety, production, and economics during times of change in the energy environment.

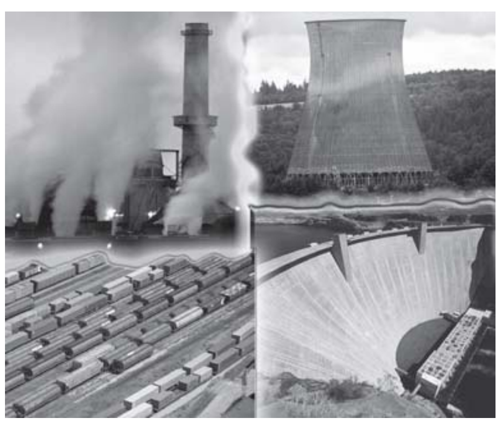

Fig. 1. Examples of Critical Infrastructures (clockwise from upper left: chemical plants, nuclear power plants, hydroelectric dams, and railroads)

2. Definition and types of risk

In general, risk encompasses two aspects: the potential for things to change, and the magnitude of the consequences if they do change. The notion of risk includes both opportunities and threats. Different disciplines — economics, engineering, safety analysis - have their own more specific definitions of risk, each reflecting a different disciplinary focus on parameters and consequences, but all encompass in some way the frequency and consequences elements of risk.

Consider the following case: a plant manager is considering replacement of the plant's instrumentation and control system as a prelude to plant life extension. The replacement has not (yet) been required by the nuclear safety regulatory body. The manager must weigh the risk of making this investment [3]. Management's advisors may have the following views:

- For the nuclear safety analyst, the relevant risk is the potential for ending up with a system that can demonstrate a frequency of radioactive release that satisfies established institutional and regulatory goals *(a focus on nuclear safety related risk*).
- For the financial analyst, the relevant risk is the potential that the cost of the investment will not be recovered over the life of the investment (*a focus on financial risk).*
- For plant operation, the relevant risk is that the installation and operation of the new system may introduce operational difficulties (or operational benefits) *(a focus on operational risk*).
- For the project manager, the relevant risk is the probability that the project will be completed on schedule and within budget along with the associated cost impacts (a *focus on budget and schedule risks*).

All of these views encompass aspects of risk that are important to the organization. Organizations are exposed to many sources of risk, which might be characterized into four broad categories:

1. safety related;
2. production/operations;
3. commercial/financial; and
4. strategic.

3. Risk management process within the critical infrastructures

The NPP operating organization is viewed in this paper as comprising three major sectors (safety, production/operations, and financial/commercial) embedded within the strategic environment (Fig. 2) [4]. These sectors intersect one another, so that decisions in one arena have impact and are impacted by decisions in a different sector. In addition, there are stakeholders outside of the NPP who have impact on these three sectors as well as on the strategic environment.

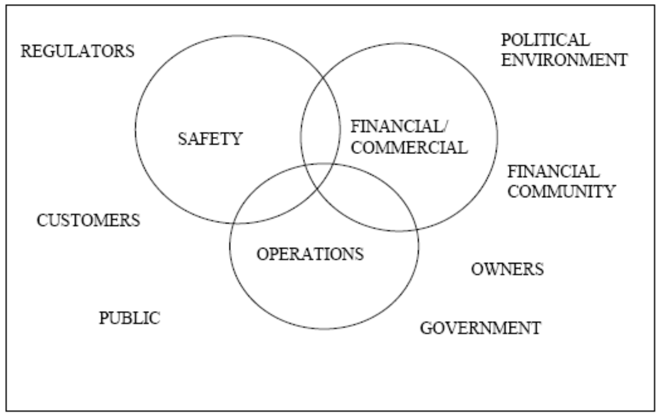

Fig.2 Risk management environment model for a nuclear power plant operator
Source: Risk management: A tool for improving nuclear power plant performance, IAEA, 2001

3.1 STEP 1. Identification, measurement and assessment of risk

In the management of a nuclear power plant, risk can come from many sources —production processes, training processes, social responsibility (including communication with the public), outside influences (natural disasters and economic factors), and financial processes, to name a few. Many different sources of information can be used to identify sources of risk, such as industry (or company) specific or generic risk exposure checklists, flowcharts of critical processes, examination of contracts, physical inspection, analysis of financial statements, and employee, contractor, or regulator interviews. A wide-reaching integrated information system needs to be used to provide continuous updates about operations, acquisition of assets, and changing relationships with outside entities and stakeholders.

After identifying sources of risk, one needs to characterize the risk. Deterministic and probabilistic safety analyses (PSA) have been used extensively in nuclear power plants around the world for assessment of nuclear safety risk. PSA methodology integrates information about plant design, operating practices, operating histories, component reliabilities, human behavior, thermal hydraulic plant response, accident phenomena, and taken to it conclusion potential environmental and health effects.

In practice PSA aims to achieve completeness in defining possible mishaps, deficiencies and plant vulnerabilities, producing a balanced picture of safety significant issues across a broad spectrum.

PSA is one of the most efficient and effective tools to assist in the decision making process for the safety and risk management of nuclear power plants. As such, it can have one or more of the following objectives:

- to assess the level of safety of the plant and to identify the most effective areas for improvement ,
- to assess the level of safety and compare it with explicit or implicit standards,
- to assess the level of safety to assist plant operation.

Some qualitative questions can help the NPP manager examine the essential characteristics of the risk from a conceptual point of view:

- Does the risk produce opportunities and threats, or only one? If both, do we need to measure both?
- Is the cause of risk likely to be a continuously occurring or is it episodic or rare in time and space?
- Is the risk such that a risk management decision/action will be reversible in the future or is it likely that for this source of risk, the choices are basically irreversible?
- What are the potential effects of the risk on the performance of the NPP owner or operator?
- Is the source of risk such that it is mission critical, 'make-or-break', or is it a source of risk that will modify results in less severe ways?

3.2 STEP 2. Determination of appropriate risk management techniques

Risks identified and characterized are next evaluated with respect to the best combination of techniques for management. Three generic categories of risk management techniques include *reduction of risk, retention of risk, and transfer of risk.* In practice one or more of these techniques is likely to be used in managing risks associated with a particular issue. It is also important to examine whether the use of a particular solution takes into account the interaction among different areas of risk. For example, in the implementation of a design change to improve nuclear safety, the manager needs to examine if the change would have unacceptable industrial safety consequences.

Reduction of risk involves at least two dimensions: first, to reduce the likelihood (or frequency) that an event occurs and second to reduce the consequences of an event, if it does occur. Techniques to reduce frequency of occurrence include, for example, engineering measures, education of employees, and enforcement of standards. Reduction of severity can include measures to keep events from progressing into more severe episodes, as well as measures to reduce the economic impact of severe disruptions. These risk reduction measures may be pre-event, simultaneous-with-event, and/or post-event actions. The second dimension of understanding reduction/control tools is to characterize them according to whether they focus attention on the behavior of the individuals involved, on the functioning of the physical assets (machinery, control systems, etc.), or the environment within which the event would occur.

Examples of reduction of risk: *remote diagnostics*, *smart instruments*, *component inspection and repair database*, *configuration management software*, *staging and laydown logistics planning for outages*, *enterprise management systems*.

Organizational factors play also a role in almost all accidents and are a critical part of understanding and preventing them. A concept that addresses the organizational aspects of safety is High Reliability Organizations (HROs). HROs are those that operate “under very trying conditions all the time and yet manage to have fewer than their fair share of accidents” [5]. These organizations do this by consistently noticing the unexpected, reporting it in an honest way, responding quickly and appropriately, learning from the things they did, and improving the process for the next time a challenge arises [6]. To anticipate, respond to, and learn from mistakes, HROs rely on their culture of expertise, focus, and delegation.

In their book Managing the Unexpected, Karl Weick and Kathleen Sutcliffe suggest there are five common concepts that help organizations manage the threat of failure, absorb damage and surprises, and thereby become an HRO. The first three concepts fall under the category of “Anticipate the Unexpected”: (1) focusing on, and having a preoccupying dedication to, preventing failure and accidents; (2) being skeptical of simple answers; (3) being sensitive to how things really work. The final two are listed under “Contain the Unexpected”: (4) developing behaviors that enable individuals and their organizations to be resilient; and (5) relying on those with the most expertise and experience.

Retention of risk is, perhaps, the most difficult concept to understand for managers in the NPP industry. Because of the almost one-minded concept of risk as meaning nuclear safety risk, and the perception that nuclear safety-related risk must be managed to negligible levels, it is harder for managers on the nuclear side of these organizations to consider the idea of deliberately accepting measurable levels of other types of risk, than perhaps in any other industry. Think of the situation of someone starting a business. All risk ‘resides’ in the owner’s pockets. As the business evolves, the owner identifies sources of risk that can be reduced or transferred to others, but a degree of risk inevitably remains. Some factors that cause this risk may be understood by the owner and accepted as being reasonable tradeoffs for the possibilities of high returns. In fact, this ‘accepted’ or retained risk is the real reason that owners are involved in the business in the first place. The retained risk produces the possibility of high returns for the investment made. Only if financial risk is present, is there any possibility of high returns.

Risk transfer means that the original party exposed to a loss is able to obtain a substitute party to bear the risk. These transfers occur by contract, through use of financial market instruments, or by terms and conditions of sale and delivery of products and services. In some cases, the degree of risk is reduced through a transfer if the risk-accepting party has portfolio effects (such as for insurance contracts where a pooling of risk takes place); in other cases, degree of risk stays the same but is transferred to another party willing to accept the variability of performance, for a given price.

Most risk transfer mechanisms are some form of contractual agreement with a counter party. In contracting, the idea is to put the risk to the party who can control the results, or prevent the problem, or manage the risk if it happens, or can best absorb the impact.

3.3. STEP 3. Implementation

Step 3 is to implement the chosen techniques or strategies.

Before implementing the chosen strategies some final checks are suggested:

- Does the strategy or solution address the identified risks?
- Is the selected solution consistent with the solutions to other risks?
- Are the key risks addressed by the selected strategy
- Can the exit strategy be exercised?
- Is flexibility maintained?

The key aspects of implementation are to assign responsibilities and accountabilities. It is helpful to establish milestones and checkpoints to allow verification that responsibilities and accountabilities are being met. Measures or indicators of success should also be established to track the success of the strategies [7].

3.4. STEP 4. Monitoring and feedback

The risk management process is iterative. In many cases, the feedback mechanisms are automatically built into the tool, while in other cases, a more formal feedback analysis, outside of the tool, is necessary.

One purpose of monitoring and feedback mechanisms is to help the utility recognize if (or when) an exit strategy needs to be invoked. Recalling the generic questions about the nature of risk, one of the issues for characterizing a source of risk is the extent to which a management tool can be backed out of; i.e., whether the risk management strategy can be reversed or if it is a permanent choice. When an exit strategy is possible, the monitoring and feedback loop will be continually reevaluating the data to determine if the risk management should continue or if the situation should be terminated.

Another aspect of the monitor and feedback process is explicit recognition of where the responsibility lies for overseeing the risk management program. Use of diagnostic information and reporting systems, coupled with regular in-house risk management meetings and periodic reviews by outside experts will help ensure that company risk management policies are followed in general, in addition to the more specific actions relating to particular plant systems. These should be in addition to the analysis and reporting requirements of regulatory authorities to which the management must answer.

4. Conclusions

As was indicated at the beginning of this paper, in today's global energy environment, NPP managers need to consider many dimensions of risk in addition to nuclear safety-related risk. In this context, the following are considered to be the most important messages in this paper:

- it is necessary for NPP managers to main a broad perspective in integrated management of safety-related, operational, commercial/financial and strategic risks;
- risk management should be integrated into the organization management systems, not be a stand along process;
- PSA is expected to play more and more roles in the management issues of the NPP;
- the theory of High Reliability Organizations is based on the belief that accidents can be prevented through good organizational design and management;
- to create a safe climate in which people can question assumptions and report problems or failures candidly.

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