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PRESENT CONCEPT OF INTEGRAL SAFETY OF NUCLEAR FACILITIES

The work deals with nuclear facilities integral safety. On the basis of principles of strategic safety management in dynamically variable world it gives historical development of work with risks in engineering disciplines and present model of management and trade-off with risks used in nuclear facilities. It leans on rules of International Atomic Energy Agency and it characterizes present process model of nuclear facility safety management, its processes and programme for nuclear facility safety upgrading in a context of integral safety directed to existence, security and development of humans.

Key words: *nuclear facility; risk; safety; safety management model; safety culture; programme for safety upgrade*

Introduction

The main goal of all human effort is ensuring the human life, i.e. all human needs, interests, and wishes. Human needs, interests and wishes are fulfilled by intangible and material goods that have a utility value. Unfortunately, in the world is not just a human society, but also other systems, which are not subject to the human society. Therefore, conflicts originate: man vs. the environment; technology vs. the environment; man vs. technology; man vs. man, etc. Because human kind is based on its education, as well as in the present case, must realize that, in a given situation must be based on knowledge, which accumulated science and historical experience of life, which shows that there is a limit for the activities of the people, which cannot be exceeded, in order to prevent the destruction of mankind. The starting point is to accept the need for the co-existence of several systems and search conditions and ways of controlling it. The sustainable development strategy is comparable with other systems of values, which do not have the final form (e.g. the system of human rights and freedoms). It leads to ensure the highest attainable quality of life for the present generation and to create conditions for quality of life of future generations, even knowing that the ideas of the quality of life of future generations can be compared to our different.

The man knew during his development, for your life and development needs the nature and a number of other assets. He understood that the most valuable asset is its existence, security and development potential, and that the safe world is disturbed by harmful phenomena (disasters). From the evaluation of credible data, knowledge and experience, e.g. [1], it follows that the human knowledge and abilities are:

– small to avert disasters, which are the manifestation of the evolution of the planetary system of the Earth;

– adequate to mitigate the impact of disasters, which are the manifestation of the evolution of the planetary system of the Earth;

– sufficient to prevent disasters that are associated with the activities of humans and with the development of human society.

To use the knowledge and skills the humans consciously create a comprehensive system tool, which is called the ***safety management*** and also specific targeted tools to deal with emergency and critical situations, which are emergency management and crisis management; in the professional literature can be found, as well as other tools such as disaster management [2].

For qualified management of entities, according to the present knowledge and experience is considered a strategic safety management of entities in the dynamically varying world, which means the skilled management of disasters [2], which is based on the approach of "All Hazard Approach" that was introduced by FEMA in 1996 [3] and it is used by EU and OCHA [1, 2].

The aim of human effort is to construct the technical works that fulfil the prescribed function after specified time period and do not threaten human health and the environment, i.e. are safe. In order to ensure the safety of the technical works they are created since the beginning of the cultural evolution of the human species the legislation, technical standards and norms. There are

processed procedures of good practice in cases in which there is not enough data for the standard or norm. At each stage of the development, the legal rules (directives, regulations) of a different legal force reflect the level of knowledge and experience of the company. Norms and standards for the current period reflect the knowledge level at the time of the present. Since in different countries there are different legal systems and practices, norms and standards, the International Atomic Energy Agency (IAEA), since its inception in 1954, is devoted to the issue of safety of nuclear installations, which shows great attention to the development of safety standards; see the standards in [17].

1. The development of management and trade-off with the risks

The basis of human effort in creating a safe space is to handle the (tame) risks. The term "*risk*" has its origin in the Middle Ages and our present knowledge about trade-off with the risks has been systematically collected since the 1930s. The acquired knowledge and experiences have been gradually applied in risk management and designated measures and activities have been introduced gradually into the practice by engineering disciplines [5, 6]. In the present work with the risk, the risk is seen as the potential that a given action or activity (including the option of doing nothing) originates loss (the undesirable outcome). In today's practice, it uses the five concepts of risk management and risk engineering, i.e.: a classic risk-management and risk engineering; the classic risk management and risk engineering involving the human factor; management and engineering focused on security (security management and security engineering); management and engineering focused on safety, i.e. such control and trade-off with risks, that ensure both, the secure system and its safe surroundings; and management and engineering focused on the safety of system of systems (SoS) [5, 6]. It is obvious that the more advanced the concept of the use, the higher are the demands on the knowledge, the tools, time, finances, qualifications of personnel, etc.

2. Management of the safety of nuclear installations

The safety is a set of anthropogenic measures and activities, which lead to ensure security and development. Since the world is dynamically changing, so the management of the safety of nuclear installations is focused on priorities. In the first place, it means the application to access All Hazard Approach [3], determining the hazards posed by individual disasters, and according to the assessment of the size of the threat from real disasters and vulnerabilities of a site and of nuclear installations against real disaster the separation of disasters into the following groups:

– the disasters, which cannot have impacts on nuclear facility;

– disasters that have only an acceptable impacts on nuclear facility, for which we use the designation “relevant disaster”;

– disasters that have on a nuclear facility only impacts that are manageable at performance of the prepared prevention and mitigation measures, for which we use the designation “specific disaster”;

– disasters that have an unacceptable impacts on the nuclear facility and, therefore, it is necessary to carry out essential preventive measures in the field of technical, organizational, legal and educational and it is necessary to have the possibility to activate all of the resources and the means to cope with their impact and jump-start further development, for which we use the designation “critical disaster”. The disasters have the potential to cause extreme emergency situations and for their defeat it is necessary to use the tools for crisis management.

Problem areas in safety management according to [1, 12] are:

1. What disasters can occur in a given site and in nuclear facility and what impacts have they on nuclear facility and how their impacts are spread?
2. Where disasters can occur and how their impacts are spread in a given nuclear facility?
3. Under what conditions can disasters occur in nuclear facility and what conditions can cause escalation of their impacts?
4. How often can disasters occur in a given nuclear facility?
5. From what disaster sizes have disasters in a given nuclear facility unacceptable impacts, that caused losses, harm and damages on protected assets?
6. What maximum sizes of disasters are expected in a given nuclear facility?
7. What property and assets damages can be caused by maximum possible disaster determined on specified credibility level in a given nuclear facility and what are its impacts on humans, environment, property and other protected assets of a given nuclear facility?
8. What is possible to do in a given nuclear facility against unacceptable disaster impacts on section of security (land-use) planning, design, construction and operation of civil and technological objects and infrastructures, and may be in other domains as are monitoring, inspection, education etc. with the aim to avert the occurrence of disasters if possible or at least to prevent or to mitigate unacceptable impacts by preventive measures, preparedness, fit response to disaster and by renovation, at which there must be

respected losses prevention and targets of sustainable development?

9. What are necessary measures against real disasters in a given nuclear facility in the technical, organisational, financial, social, legal, education and training domains?

10. What unacceptable and residual risks (i.e. undesirable impacts with probability occurrence superior to a limit stipulated) with regard to possible disasters in a given nuclear facility will stay, when there are fulfilled rational measures that owner and operator can ensure in the technical, organisational, financial, social, legal, education and training domains?

11. How does perform the response to disaster, what are priorities, critical spots etc.?

12. How does perform the renovation of nuclear facility and its property and assets after disaster with aim rationally to use resources, forces and means for the prohibition of further losses, the upgrade of resistance against possible disasters and for the start of further territory development with all items (environment, property and assets, infrastructure, services etc.) on which nuclear facility is dependent?

13. What is suitable the form of management and of nuclear facility and its assets renovation and property performance after disaster in organisation and how is it possible to realise it?

14. How does create the financial/monetary reserve for rational renovation of nuclear facility and of its assets and property after disaster?

Secured nuclear facility is a system that is protected against all disasters, the sources of which are inside and outside the system, including the human factor.

Safe nuclear facility is a system that is protected against all disasters, the sources of which are inside and outside the system and it does not affect their surroundings in its normal, abnormal and critical conditions.

On the basis of analyses of the existing safety management systems, which are described in the professional literature, for which the data are summarized in the works [1, 4 - 6, 13], and in particular the knowledge collected by the OECD [9, 10, 14, 15] the author compiled by the method of analogy to existing safety management models the general process safety management system of real entity and she verified it on the data collected in the archive [16], and by the method of analogy she has transferred to nuclear facility (Fig. 1).

In Figure 1 the black block indicates basic decisions to ensure a safe entity – specification of the essential processes of a nuclear facility, that predispose a safe nuclear facility, i.e. its existence, safe operation and development. Then there follow the sequential steps aimed at the security and development of the entity. As the entity and it's environ dynamically develops it considers with corrections and changes. In case of the need for corrective measures there are indicated the basic feedbacks, by which it is corrected the set of measures and activities; the dotted line – feedback 1, dash-dot line – feedback 2 dashed line-feedback 3, full line – feedback 4. At least it is necessary to keep track of ten processes, the list of which is given in annex 1.

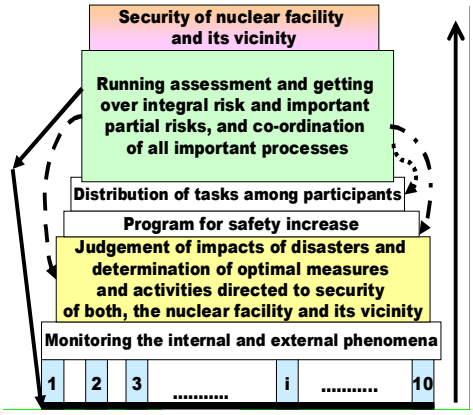

Fig. 1. Process safety management model of a nuclear facility. Black block specifications the essential processes of the entity; the dotted line – feedback 1, dash-dot line – feedback 2 dashed line-feedback 3, full line – feedback 4

From Figure 1 it is evident the vital role of monitoring the internal and external processes and phenomena (Note: the phenomenon is a look that is the result of the process of [5]), which is followed by an assessment of the impacts of processes on a nuclear facility and by determination of optimal measures and actions to ensure safe nuclear facilities. In the event that the limits and conditions are not complied with, it is necessary to make changes, as indicated on the feedbacks in Figure 1. Because the changes require resources, forces and means, on the basis of ensuring the cost-effectiveness, there is realized in the first the feedback 1, and only when not desirable, it realizes the feedback 2; after the feedback 3, and when, even after it is not a desirable outcome, so feedback 4. In the case of the occurrence of extreme phenomena with disastrous impacts, it is immediately implemented the feedback 4.

The safety management system (SMS) of a nuclear installation is based on the concept of prevention of disasters, or at least their serious effects [1, 9, and 10], which includes the obligation to establish and maintain a management system in which they are taken into account the following issues:

– roles and responsibilities of persons participating in important hazards management on all organising levels and in ensuring the training;

– plans for systematic identification of important hazards and risks connected with them that are connected with normal, abnormal and critical conditions, and for assessment of their occurrence probability and severity;

– plans and procedures for ensuring the safety of all components and functions, namely including the object and facilities maintenance;

– plans for implementation of changes in territory, objects and facilities;

– plans for identification of foreseeable emergency situations by systematic analysis including preparation, tests and judgement of emergency plans for response to such emergency situations;

– plans for continuous evaluation of harmony with targets given in safety concept and in the SMS, and mechanisms for examination and performance of corrective activities in case of failure with aim to reach determined targets;

– plans for periodic systematic assessment of safety concept, effectiveness and convenience of the SMS and of criterions for judgement of safety level by top workers group.

The safety of nuclear facility is a matter for all stakeholders, i.e. the executives, employees, even persons accidentally present. In this context, talking about ***the so-called golden rules of all participating*** [1, 9, 13].

Safety culture means that the man in all his roles (executive, employee, citizen or victim of the disaster) observes the principles of safety, i.e. he behaves so that alone prevented the realization of the potential risks and when it becomes a participant in the realization of the risks, to contribute to an effective response, stabilization of the protected assets (interests) and their recovery and to kick off their further development. An effective safety culture is an essential element of safety. It reflects the concept of safety and is based on the values, opinions and discussions of key management personnel of the organization, and their communication with all stakeholders. It is a clear commitment to actively participate in addressing issues of safety and advocates that all participants did so safely and to comply with the relevant legislation, standards and norms. Rules of safety culture must be incorporated into all activities in a nuclear facility. Their basis is not the concentration on the punishment of the offenders / originators of errors, but the lessons learned from the mistakes and the introduction of such remedial measures, in order to not repeat mistakes or at least significantly reduced the frequency of their occurrence.

Conclusion

Analysis of the current situation shows that we can systematically handle a range of undesirable processes, i.e. defects and failures that we can detect in advance. Sometimes, however, there is a mutual interlocking a series of seemingly unrelated factors, and as a result of non-linearity in the system there are originated very atypical accidents. Analysis of accidents: breaking plateau Alpha in 1988 in the North Sea; the warehouse of aviation kerosene crashes in Buncefield 11. 12.2005; maritime, railway and unexplained air crash in recent years; the accident at the Fuku-shima is 11. 3.2011 (note – it did not respected calculated scenarios of accidents), showed that the number of experts is affected by the operational requirements of the blindness and after fulfilment of the norms and standards to see the remaining risks, or the risks associated with different bindings and couplings with the surroundings. For example, a simple comparison of intervals used in probabilistic assessments shows that: the interval $(\mu-\sigma, \mu+\sigma)$ covers 68.5% of cases; the interval $(\mu -2\sigma, \mu+ 2\sigma)$ covers the 85.4% of cases; and the interval $(\mu -3\sigma, \mu+3\sigma)$ covers 99.8% of cases [4].

Therefore, we permit that complex systems to which surely include nuclear facilities, are for various reasons from time to time in an unstable state and they are formed an organizational accidents, cascade of failures without apparent cause, i.e. we recognize the random and epistemic (knowledge) uncertainties in their behaviour. For the protection reasons we are looking for a solution of response for cases that cannot be revealed by the probabilistic approaches and we build for them, alternative sources of water and energy, specific response systems and specific training of rescuers.

To achieve the desired level of safety it is necessary well manage and properly decide. Good management and good decision making is possible only when we have good data, and we can take advantage of the tools that we have available. The data: must be correct, i.e. it is known their size and accuracy; must have explanatory power for the problem, i.e. they must be validated. The data files must be representative, i.e.: complete; contain the correct data; have a sufficient number of data; the data must be spread homogeneously throughout the reference period and must be validated. In the application of models must be properly considered random and epistemic uncertainties in the data.

It should be noted that in the real world we work at ensuring the safety of nuclear facilities non-trivial problems, i.e.: there is more protected assets, the objectives of which are conflicting; assets varies in time and space; and the space with assets, i.e. the human system, is in dynamic development.

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СОВРЕМЕННЫЕ КОНЦЕПЦИИ ИНТЕГРАЛЬНОЙ БЕЗОПАСНОСТИ ЯДЕРНЫХ ОБЪЕКТОВ

Д. Прохазкова

Данная статья рассматривает понятие интегральной безопасности ядерных объектов. Базируясь на принципах стратегического управления безопасностью в динамически изменяющемся мире, в статье рассматривается исторический процесс развития работ связанных с рисками проектирования, а также современная модель управления и балансирования рисков присущих ядерным объектам. Опираясь на правила сформированные Международным агентством по атомной энергетике, в статье охарактеризована современная модель управления безопасностью ядерных объектов, ее процессы и программы модернизации безопасности ядерных объектов в контексте интегральной безопасности, направленной на существование, защиту и развитие человечества.

Ключевые слова: ядерные объекты; риск; безопасность; модель управления безопасностью; культура безопасности; программа модернизации безопасности

СУЧАСНІ КОНЦЕПЦІЇ ІНТЕГРАЛЬНОЇ БЕЗПЕКИ ЯДЕРНИХ ОБ'ЄКТІВ

Д. Прохазкова

Дана стаття розглядає поняття забезпечення інтегральної безпеки ядерних об'єктів. Базуючись на принципах стратегічного керування безпекою у динамічно змінному світі, у статті розглядається історичний процес розвитку праць пов'язаних із ризиками проектування, а також сучасна модель керування та збалансування ризиків, що властиві ядерним об'єктам. Спираючись на правила, що сформовані Міжнародним агентством з питань атомної безпеки, у статті охарактеризовано сучасну модель керування безпекою ядерних об'єктів, її процеси та програми модернізації безпеки ядерних об'єктів у контексті інтегральної безпеки, що напрямлена на існування, захист та розвиток людства.

Ключові слова: ядерні об'єкти; ризик; безпека; модель керування безпекою; культура безпеки; програма модернізації безпеки.

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