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Program of Training A Critical Nuclear Power Plant Personnel to Ensure A Specific Response

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Based on the State Office for Nuclear Safety Action Plan, it is processed the response plan of South Bohemian Region, in which the Temelin nuclear power plant is located, to the worst station blackout. The response in question is provided by a set of highly interconnected technical and organizational works. From this reason, for ensuring the safe response process, the capability of action of nuclear power plant and the region is important. This means ensuring the organizational, technical and professional readiness of resources, forces and means of both, the nuclear power plant and the region. The present training of critical nuclear power plant personnel is aimed at response to design accidents. Responding to the worst-case scenario of station blackout means to manage response to beyond design accident that has not yet been trained. In the present paper, we deal with the content of the training of critical personnel in response to the worst-case blackout scenario. We present its program, a tool for checking the knowledge and skills of personnel, and also we show how training program and its control are integrated into the training system used in nuclear power plant.

Keywords: Nuclear Power Plant, WWER, safety; worst station blackout, response, readiness, critical personnel training program, checklist.

1. Introduction

Based on the solution of next stage of the National Action Plan in the area of response of the Nuclear Power Plant Temelin and the region to the worst a long-term power blackout (denoted as *SBO*) using the Feed and Bleed (F&B) method, we must ensure the readiness for the response. We have technical solution of the SBO, sources of risks that may disrupt the response to the SBO and the risk management plan at response. To ensure readiness of the Nuclear Power Plant Temelin and the region to realize this response safely, it is further necessary to ensure a set of highly interconnected technical and organizational works, which ensure correct co-ordination of works according to schedule and real conditions. Therefore, this readiness (operational capability) means ensuring the organizational, technical and professional readiness of sources, forces and assets of the Nuclear Power Plant Temelin and the region.

The conditions for action capability include: a high-quality personnel team, adequate equipment and good management of the response process. The quality of the personnel team is conditioned by both, the knowledge and skills of a sufficient number of team members and by training cooperation in the implementation of the response work schedule. Good management of the response process depends on compliance with the timeline of the linked work and on the readiness of the necessary equipment and resources. Proven tools for ensuring the readiness are the readiness of: personnel; outfit of material and technical means; objects including the security, services, etc.; and surroundings, i.e. in the case under consideration, the preparedness of the South Bohemian Region.

With regard to present knowledge and experiences, the organizational, technical and professional capacity of the sources, forces and means of the Nuclear Power Plant Temelin and region

to carry out the tasks of response to the worst SBO can be only ensured by: regular training of the members of the response team in terms of knowledge and skills; regular practice of critical tasks; conducting the tactical exercises in terms of organization and technology; regular inspections and tests of the condition of technical devices; and regular verification of the notification plan for critical personnel. Present training of critical personnel of the Nuclear Power Plant Temelin and the region is aimed to response of design accidents. Response to the SBO worst-case scenario means managing an beyond design accident has not been trained yet. In paper (Jirousek, Prochazkova 2021) we proposed a scenario of response to the worst SBO, which consists of a number of interconnected tasks, is highly demanding to coordinate and has many risks. Therefore, in paper (Jirousek, Prochazkova 2022) we have developed a plan to manage the risks that can be expected in response.

In the present paper, we deal with the content of training the critical personnel of the response to the worst SBO in order to ensure their new competencies that the implementation of this response requires. We divide the response process into sub-sections that fall under the responsibility of individual response managers. Based on the analysis of the requirements for individual tasks and organizational instructions to ensure coordination, we determine the content of knowledge and skills that critical response staff and individual managers must have for their quality execution. The basic volume of knowledge consists of: a nuclear power plant is an object of critical infrastructure; the obligations of the nuclear power plant operator; a crisis preparedness plan; procedures for solving tasks in individual subsections; availability of technical and communication means; the duties, responsibilities and rights of critical personnel in each section; ways of resolving the possible conflicts; documentation of activities. To regularly check the knowledge of critical personnel, we compile a set of checklists.

Since the response to the worst SBO is specific, we include in the crisis preparedness plan of the entities involved in the response to the worst SBO and in the risk management plan a requirement for regular training and regular verification of the knowledge and skills of critical personnel for the response to the worst SBO. We are also introducing requirements for verifying the cooperation of sub-sections in responding to the worst SBO, because since 2002 only the cooperation of the Integrated Response Systems, the Nuclear Power Plant Temelin and the South Bohemian Region in responding to a design accident has been regularly tested (CEZ ETE 2022).

2. Conditions for Action

Condition for action / readiness for action denotes a level of preparedness for action that is elicited as part of an response (HZS 2023). Based on current knowledge and experience (Eby, Adams, Russell, Gaby 2000, HZS 2023, Suri, Sheppes, Gross 2015), the conditions for action include: a quality and well-trained professional team; high-quality technical equipment; and good management of the response process.

The quality of the expert team is conditioned both by the knowledge and skills of a sufficient number of team members and by training cooperation in the implementation of the response work schedule. Good management of the response process depends on compliance with the timeline of the linked works and on the readiness of the necessary equipment and resources. Proven tools for ensuring the readiness for action are according to (HZS 2023, IAEA 2007, 2011 a,b, Prochazkova et al. 2019): readiness of persons, equipment with material and technical means, objects including the security, services, etc.; and the preparedness of the surroundings, i.e. in the case under , i.e. in the case under consideration, the preparedness of the South Bohemian Region to fulfil the tasks required by the response. In monitored case, according to (IAEA 2007, 2011 a,b, Prochazkova et al. 2019) organizational, technical and professional capacity of Temelin nuclear power plant forces and assets and the region to carry out the tasks of responding to the worst station blackout shall ensure: regular training of the members of the response team in terms of knowledge and skills; regular practice of critical tasks; conducting the tactical exercises in terms of organization and technology; regular inspections of the condition of technical devices; and regular inspections of the notification plan for critical personnel.

3. Role of Training the Personnel

Education is the process of acquiring the knowledge in the form of knowledge and certain abilities and skills, associated with the effort to integrate into a given culture and society and to

actively contribute to their development. It takes place at all stages of the human life cycle. The EU Council meeting in Lisbon on 23-24 March 2000 put education policy at the forefront of the European Union's interests and objectives, and these intentions were confirmed at the next Stockholm Council in 2001. The main objective of the European Union's subsequent economic and education policies was "to create the most competitive and dynamic knowledge- and education-based economy in the world, capable of sustaining economic growth by expanding and improving jobs and with greater social cohesion".

Developed countries are struggling with the exhaustibility of resources, and therefore, they are already aware that education is one of the few resources, the volume of which can be permanently renewed and further increased (Amstrong 2009, Becker 1993, Fuente, Ciccone 2002, OECD 2002, Vychova, Mertl 2009). The potential and competitiveness of each company is not only in the production capacities of machines and technological equipment, but above all in personnel and in know-how, i.e. in intangible assets. For development, the business needs talented personnel who are able to generate certain values. In order to meet the expected requirements, each individual must have certain knowledge, skills and motivation. This means that certain conditions must be created for him/her. The basic conditions are health protection, access to education, because the innovations that are necessary in terms of development require the acquisition of new knowledge and the adoption of new skills.

Adult education began in the 19th century and around 1976 it already had a comprehensive framework and was understood as the education and training of workers in organizations, the aim of which is to improve, deepen and extend the achieved degree of work capacity (OECD 2002). Today, the specific form of education systems is adapted to the specifics and needs of the enterprise and the legislation of the respective country. Business education is a planned process of modifying attitudes, knowledge and skills by learning aimed at achieving effective performance in a certain activity or range of activities. Its goal in terms of work is to develop the capabilities of the individual and meet the current and future needs of the organization regarding the workforce (Clifford, Thorpe 2007, EU 2020,OECD 2003, Philips 2011).

The IAEA (2022a) began to pay great attention to education shortly after 2000, because of the large turnover of critical personnel in nuclear facilities. The main objective was to implement an integrated approach to the management of nuclear facilities aimed at safe and reliable operation, which is based on knowledge management. Emphasis has been placed on: replacing obsolete approaches with new ones that are the result of research and operational experience and are safer; and to promote a culture of safety. Emphasis began to be placed on business education, especially on education and training the critical personnel at all levels of management. It was stressed that education and training plan must be addressed the long-term needs of the nuclear facility (IAEA 2022b). It means on activities related to safety and safety culture. The training plan must be reviewed regularly in the light of operational experience.

Training the nuclear facilities personnel must be systematic and reflect the needs of specific jobs, both knowledge and skills. It must include operation and emergency planning. It must go from good practice and lesson learned (IAEA 2022c). According to (IAEA 2008, 2021, 2022d) training must provide the required competencies for the job, and competence means a combination of knowledge, skills and attitudes and training for cooperation. Nuclear regulatory body of the country must regularly check the critical personnel training quality (IAEA 2021). Nuclear education is supported and also organized by OECD/NEA, EURATOM and WANO.

4. Data and Method Used

The current training of the Temelín Nuclear Power Plant staff respects all the requirements of the IAEA (2007,2011a,b,2022a,b,c,d), the OECD (2002,2003) and the EU (2020). The training program (CEZ ETE 2023) is divided according to job needs and has a modular character. In the area of emergency response, it is focused on the response to design accidents. In this area there is regular training on simulators.

Responding to the SBO worst-case scenario means managing a beyond design accident that has not yet been came. Quantitative analysis of such response is in (CEZ ETE 2022). On its basis we compile training program for response. We do the program in the form of a module, which has the same structure as the existing training modules (CEZ ETE 2023). When compiling it, we use

the method recommended in (IAEA 2021): an analysis of response needs based on a developed response scenario, considering the response risks identified at work (Jirousek, Prochazkova 2022); the development of a response training program for the worst station blackout in nuclear power plant Temelin with special attention to the critical points of the response process; creation of materials for training; and checklists to evaluate the effectiveness of training.

Because in this response, the procedures of crisis management in our country need to be used, we include in the education program the important pieces of knowledge on crisis management in the Czech Republic. Because Temelin nuclear power plant belongs to Czech and Europe critical infrastructure, which is important fact for safe development of the State and its inhabitants, we also include basic information on critical infrastructure.

5. Needs for Response to the Worst SBO

The integral safety is not limited to unilateral solutions to problems such as repression, but it deals with situations affecting a certain level of safety through the so-called safety chain (Figure 1), which consists of the following parts: proactivity (elimination of structural causes of uncertainties that undermine safety, i.e. threaten security and sustainable development); prevention (elimination of direct causes, if possible, of an uncertain situation violating the existing safety); correction (to prepare to deal with a situation in which safety is disrupted); response (to bring off safety disruption and stabilize the situation); and renovation (to ensure conditions for the restoration and growth of safety).

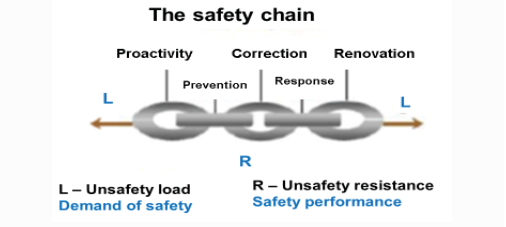

Fig. 1. Activities for ensuring the safety.

In (Jirousek, Prochazkova 2021) we proposed a scenario of response to the worst SBO, which consists of a number of interconnected tasks and is highly demanding to coordinate. The response process consists of sections that fall under the responsibility of the three organizational units participating in the response: NPP - Temelin Nuclear Power Plant; EH – Hydro power plant Hnevkovice; and PV – River basin of Moldau (Povodí Vltavy, s.p. - an organizational unit that manages the Hnevkovice and Korensko dams), Figure 2.

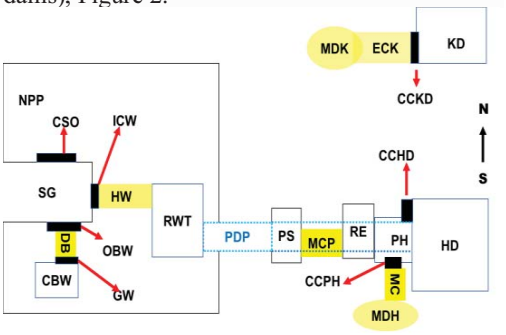

Fig. 2. Situational scheme to support the response to the worst SBO – N-S view. ***Stable objects**:* NPP - Temelin Nuclear Power Plant; PG – steam generator in NPP; ICW – input of raw cooling water to steam generator; CSO – steam by-pass valve (cower steam outlet); OBW – outlet of blow-of water from steam generator; GW – Nozzle for hose on Essential Service water System (); CBW - collector of blow-off water; RWT - water tank of raw water in NPP; PDP - underground double pipeline of raw water between the raw water pumping station from the Hnevkovice dam to the raw water tank in the NPP; HD – Hnevkovice dam on Moldau River; PH – Hnevkovice Hydro Power Plant; RE – Electricity Substation Produced at Hnevkovice Hydro Power Plant; CCPH – part of switchgear room of Hnevkovice Power Plant; CCHD – Control center (switchgear room) of Hnevkovice dam; KD – Korensko dam on Moldau River; CCKD – Control center (switchgear room) of Korensko dam; PS - pumping station of raw water from the Hnevkovice dam for the needs of NPP; ***Mobile objects*** – means for response: MDK – mobile diesel generator (50kW) for water level regulation at the Korensko dam; ECK – mobile electric cable to Control center of Korensko dam; MDH mobile diesel generator (50 kW) for the Hnevkovice Hydro Power Plant; MC - mobile electric cable to part of switchgear room of Control center of Hnevkovice power plant; MCP – mobile electric cable and clamps between the electricity substation produced in the Hnevkovice Hydro Power Plant and CP pumping station; HW – mobile engine pump and hose for connecting the raw water tank in the NPP and the steam generator; DPS - discharge of blow-off from the SG -steam generator.

All organization units have management structure in harmony with ISO 9000 in last version. Individual sections are managed by special managers. The main response levels to the worst

SBO structure is: Governor of the South Bohemian region; professional support from the State office for Nuclear Safety; Integrated rescue system commander (fire fighter response commandant) for the coordination of activities of: Temelín Nuclear Power Plant; Hydro power plant Hnevkovice; River basin of Moldau; and mobile objects which are necessary for this response; and Directors of Temelín Nuclear Power Plant and Hydro Power Plant. All tasks summarized in (CVUT 2023) are demanding to correctly implement technical and organizational measures at the right time. Individual tasks for medium response scenario are shown in the timeline in Table 1.

Table 1. Overview of actions in time scale. D – SBO duration in hours; DV – domain of validity of measures; SBR - South Bohemian Region; PH – Hnevkovice Hydro Power Plant; RBM - River basin of Moldau River; KD – Korensko dam; EOP – Emergency operation procedures.

D	DV	Organizational measures		Technical measures
0	NPP	Operating instruction for total loss off-site power		Design solution – Reactor tripped and I&C systems try automatically and unsuccessfully to start diesel-generators as an alternate current power supply.
1	NPP	EOPs start		Design solution - Direct current power supplies are in operation. It goes to increase of pressure in all of SG open safety-relief valves on SGs, and to decrease of coolant level in SGs
2	NPP	NPP director proclaims in force EOPs for the worst SBO. Crisis staff NPP Temelin chairman starts preparation for response to the worst SBO.		Design solution - Direct current power supplies are in operation. It goes to decrease of pressure in all of SG owing to opening the steam by-pass valves. It starts to operate Feed Water Tank and coolant from it gravitationally flooding the SGs.
……				
9	NPP	EOPs for the worst SBO continue. Fire brigade starts operation.		Because Feed Water Tank is empty. Tanks with demineralized water in Unit starts operate. This cooling water is flooding the SGs.
……				
24	SBR	Governor proclaims condition of danger.		Region response to the worst SBO starts.
		NPP	EOP for the worst SBO continue.	Technical measures continue.
		PH	Director gives in force the EOPs for the worst SBO.	Outflow of water from HD is reduced
……				
107	SBR	Condition of danger continues.		Response to the worst SBO continues.
		NPP	EOPs for the worst SBO continue.	It starts the use of raw water from RWT for SGs cooling. Feed & Bleed method starts
		PH	EOPs for the worst SBO continue.	Technical measures continue.
		RBM	EOPs for the worst SBO start.	Technical measures continue.
……..				
216	SBR	Condition of danger continues.		Response of Region to the worst SBO continues.
		NPP	EOPs for the worst SBO continue.	Technical measures continue. Blow-down water from SG to CBW continues.

Table 1 (Continued)

		HD	EOPs for the worst SBO continue.PH director decrees to interconnect RE and PS.	Technical measures continue. It is interconnected RE and PS.
		RBM	Emergency response procedures for the worst SBO continue.	Technical measures continue.
…….				
500	SBR	Condition of danger continues.		Response to the worst SBO continues.
		NPP	EOPs for the worst SBO continue.	Technical measures continue. PS ensures supply of water from HD to RWT by help PDP.
		HD	EOPs for the worst SBO continue.	Technical measures continue.
		RBM	EOPs for the worst SBO continue.	Technical measures continue.
……				
683	SBR	Condition of danger continues.		Response to the worst SBO continues.
		NPP	EOPs for the worst SBO continue.	Technical measures continue. PS ensures supply of water from HD to RWT by help PDP.
		HD	EOPs for the worst SBO continue.	Technical measures continue.
		RBM	EOPs for the worst SBO continue.	Technical measures continue. Further reduction of outflow of water from KD.

F&B is conditioned by both, the convection heat transfer from reactor core in water, and the boil on the secondary side of the steam generator, and therefore, the temperature primary circuit it cannot be lower than 110 °C (CEZ ETE 2022); cooling the primary circuit to a temperature below 110 °C requires the safety bus power to be re-established.

Based on safety documentation (CEZ 2022), the cooling process described in Table 1 reaches sufficient conditions for safety, because the temperature of the primary circuit of 110° ensures a sufficiently high margin to prevent damage to the fuel cladding, which is the first safety barrier.

Table 1 shows that most of the technical measures need to be carried out at the Temelin Nuclear Power Plant, and therefore, we focus on the education of its critical personnel.

Based on the analysis of the complexity of operational tasks and organizational instructions to ensure coordination (CEZ ETE 2022), we determined the content of knowledge and skills that critical response workers and individual critical managers must have for their quality execution. On this base (CVUT 2023), we created education program, which contains general knowledge and very specialized pieces of knowledge and skills.

6. Education Program

Since responding to the worst SBO is a critical task, it is a lifelong learning of response participants (IAEA 2007, 2008, 2011a,b, 2021, 2022 a,b,c,d, Prochazkova et al. 2019). The educational program is prepared in the form of a modular system, which allows critical personnel to have a suitable composition of education with a focus on the needs of the response in question and on the required expertise, as well as a possible change in profiling. The time allocation of the educational program is determined by the range of modules set for individual target groups.

We conceive the educational program as an open document which, thanks to its modular arrangement, allows complementarity and updating according to changing response needs and based on the results of research and development and new knowledge in related areas. The modular layout will enable its more effective integration into the existing education system at the Temelin Nuclear Power Plant and will increase the effectiveness of training critical personnel to respond to the worst SBO.

Based on professional knowledge summarized above, the requirements of Czech legislation and the analysis of the scenario for the response

to the worst SBO for the Temelín Nuclear Power Plant, we have included the following topics in the basic volume of knowledge: a nuclear power plant is an object of critical infrastructure (government regulation No. 432/2010 Col.); obligations of the nuclear power plant operator as an object of critical infrastructure (government regulation No. 432/2010 Col.); basics and principles of crisis management, elements of crisis management, organizational structure of management (act. No. 240/2000 Col., act. 110/1998 Col., act. No 241/2000 Col., act. No. 239/200 Col.); the plan of crisis preparedness of the Temelín Nuclear Power Plant according to the government regulation No 462/2000 Col.; principles of feed and bleed (F&B) method and experiences with it use; basic strategies for responding to the worst SBO; a description of the response to the worst SBO; critical response points during the worst SBO; demonstration of activities at critical points; a risk management plan for responding to the worst SBO; internal emergency procedures for SBO; procedures for solving tasks in individual subsections; the method of communication during the response to the worst SBO; the location and availability of technical and communication means; the skills, duties, responsibilities and rights of critical personnel in each response segment; ways of resolving conflicts; and documentation of activities. Educational material is prepared for all topics, which will be continuously updated. We also prepare also the training of critical personnel on the simulator.

For ensuring the readiness of the co-operation at the highest levels of management of the entire response (the Governor of the South Bohemian Region and his potential representatives, director of nuclear power plant Temelin and his deputies; the Chairman of SÚJB and his potential deputies Director of the Integrated Rescue System of the South Bohemian Region and his potential representatives, and the Director of the Regional Authority of the South Bohemian Region and his representatives, these activities are included in the regional training the response to the Temelin nuclear power plant accident which since 2002 has been happen every two years (CEZ ETE 2022).

Trainings the CEC executive response personnel also require practice: regular maintenance of response equipment; picking up and relocating the response equipment; specific technical operations; and the transportation and involvement of diversionary and mobile means – hoses, cables, diesel generators. For each position three persons are necessary to train. The activities execution in the NPP must be perfect and the response schedule must be met. Therefore, these trainings must be more frequent and controlled. The tests are adapted according to person position in response process; questions are in Table 2. The answers will be classified by scale 1- 5; 1 is the best. The result of each test will be evaluated according to Table 3.

Table 2. Checklist for knowledge test for individual positions; A - grade risk rate.

Question	Answer	A
What to do?		
How to do?		
Why to do?		
By which EOP?		
What risks can be expected?		
How to mitigate risks?		
Which principles of safety culture you must respect?		
Which principles of communication with other response personnel you must respect?		
How do you document your action?		
Total		

Table 3. Value scale for test evaluation.

Risk rate	Values
Extremely high – 5	More than 43
Very high – 4	32 - 42
High – 3	21 - 31
Medium – 2	9 - 20
Low – 1	9

If the risk rate is in category 4-5, the participants must immediately repeat training and test. If risk rate is 2-3, the participant must repeat test after three months. CEC training Temelin Nuclear Power plant and Hnevkovice Hydro Power Plant belong to the Czech Energy Company (CEC). They will train together once a year.

7. Conclusion

With regard to present knowledge and lessons learned, we show the program of education of critical personnel to the worst station blackout for

the Temelín nuclear power plant. Since the response to the worst SBO is too specific, it requires the crisis preparedness of the entities involved in the response to the worst SBO and the risk management plan (Jirousek, Prochazkova 2022), we insert a requirement for regular training and regular testing of critical personnel knowledge for response to the worst SBO into the atomic law (act. No. 263/2016 Coll.). We are also introducing an obligation to test regularly (each year) the cooperation of sub-sections in responding to the worst SBO, because since 2002 only the cooperation of NPP and the region in response to design accident has been regularly tested.

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