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Qualitative and quantitative methods for human factor analysis and assessment in NPP. Investigations and results

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Summary

We consider here two basic groups of methods for analysis and assessment of the human factor in the NPP area and give some results from performed analyses as well. The human factor is the human interaction with the design equipment, with the working environment and takes into account the human capabilities and limits.
In the frame of the qualitative methods for analysis of the human factor are considered concepts and structural methods for classifying of the information, connected with the human factor. Emphasize is given to the HPES method for human factor analysis in NPP.
Methods for quantitative assessment of the human reliability are considered. These methods allow assigning of probabilities to the elements of the already structured information about human performance. This part includes overview of classical methods for human reliability assessment (HRA, THERP), and methods taking into account specific information about human capabilities and limits and about the man-machine interface (CHR, HEART, ATHEANA).
Quantitative and qualitative results concerning human factor influence in the initiating events occurrences in Kozloduy NPP are presented.

1. Introduction

The basic approaches for human factor modelling in the NPP area are modelling of human errors in system failures and human behaviour modelling.
In the classical Human Reliability Analysis (HRA) the human errors are incorporated in the event and fault trees more or less assessed similar to the equipment failures. The human error probability (HEP) is corrected with factors as PSF (Performance Shaping Factors), factors, corresponding to EFC (Error Forcing Conditions) or EPC (Error Producing Conditions) with the goal to obtain more specific to the human nature human failure probabilities. The human behaviour modelling usually is presented from different networks, which represent the human decision and action from one state to another. Such nets could be rule based systems, data driven networks, risk informed networks etc.

2. Human factor methods for structuring of qualitative information

2.2 Behavioural structuring

2.2.1. Classes of human behaviour

- knowledge- based (cognitive)
- rule-based (written or non- written)
- skill- based (especially performance of memorized immediate emergency actions)

2.2.2. Human performance limitations.

- time limitations (10-15 sec);
- content limitations (5-9 units)

2.2.3. Human Error Types:

- Errors of commission (EC);
- Errors of omission (EO).

2.2.3. Task Analysis.

- The event is divided in subtasks;
- There are identified all barriers that are or could be involves in the subtask;
- An step-by step guidelines for the task performance is performed;
- The task is analyzed by team familiar with the task;
- All possible personal actions are recorded;
- The possible contributors to the event and the relevant human factors are identified.

2.3 Ergodynamic structuring methods

These methods classify the information about the system whole man-machine- environment.

2.3.1 Human performance evaluation system (HPES) [4].

Especially developed for the purposes of the NPP is the HPES, which goal is to improve overall plant operations by improving human reliability through the correction of conditions that cause human performance problems. HPES helps to identify potential problem situations. The HPES system gives wide number of human causal factors, performance factors for human errors standardising and techniques for root cause analysis and human root cause identification. The HPES system gives also the possibility for PSF and EFC identification.

2.3.2. Man- technology- organization concept- the MTO concept. [4].

The MTO concept is a modified version of HPES methodology, adopted by Swedish nuclear industry.

3. Human factor quantification. Human reliability methods

3.1 Human reliability analysis-HRA [5]

The point here is the assessment of Human reliability from the point of view of NPP safety. The HRA is based on the task analysis, which gives the possibility to incorporate the human errors in the fault and event trees. The HRA considers mainly the risk for errors of omission [9]. Swain defines the human reliability as the "probability that a person

1. Correctly performs some system –required activity in a required time period (if time is a limiting factor)
2. Performs no extraneous (i.e. non- required) activity that does or could degrade the system."

3.2 THERP- technique for human error rate prediction [5]

The basic tools used in THERP are task analysis and the HRA event tree. THERP considers errors of commission (EC) and errors of omission (EO), identifies PSF and level of dependence between dependent failures.

3.3 The HCR (Human Cognitive Reliability)

HCR is one from the models, which use time as input parameter:

The HCR takes into account factors, depending from the classes of human behaviour: knowledge- based; rule-based; skill- based and the performance shaping factors (PSF).

3.4 HEART – human error assessment and reduction technique

HEART [11] identifies 9 generic categories of tasks beginning with tasks which are completely familiar to the operator to tasks which are completely unfamiliar to the operator. HEART is similar to THERP, requires the selection of nominal HEP, which must be modified

to reflect the impact of any PSF and EPC. Only ergonomic factors (Human Factors) with significant effects are taken into account.

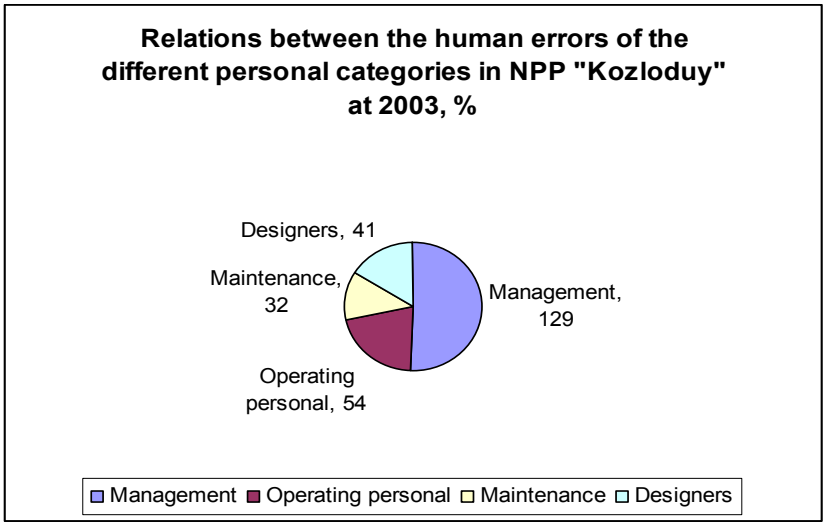
3.5 A technique for human error analysis (ATHEANA)

The review of operating events throughout the ATHEANA project [10] indicates that people commit serious mistakes by both a complicating physical condition and a complicating human condition (negative performance shaping factor). Generally these mistakes have been errors of commission (EOC). The question for HRA with respect to the most risk significant scenarios requires a subtle change of thinking: that is, to quantify the likelihood of the error forcing condition, rather than predicting random human error in the face of nominal or best estimate conditions. The project [7, 10] includes developing search schemes for both human factor events (HFE) and error forcing conditions (EFC).

The ATHEANA application is: a structured search for risk significant HFE/ EFC. The approach searches for combined plant conditions and performance shaping factors that could make an unsafe act more likely.

4. Human factor experience in Kozloduy NPP

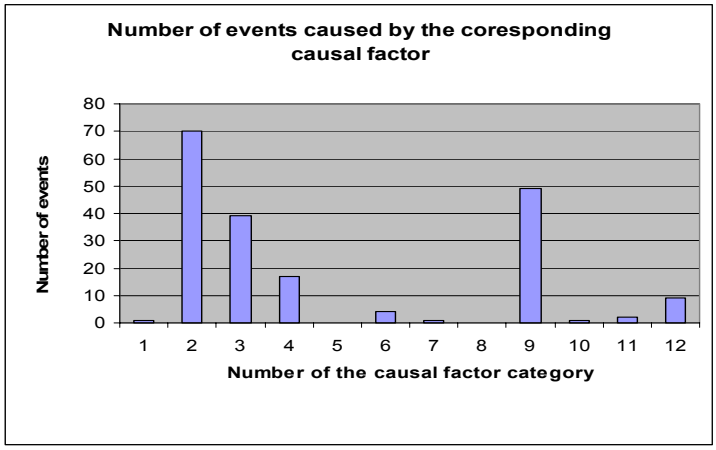
Here we give some relations between different human factor causes for human induced events in Kozloduy NPP for the time period from year 2000- end of year 2003. The approach used here is the HPES methodology, its techniques, 12 categories of causal factors and list of behavioral factors. The lists with the contributing factors of the causal factors categories and the behavioral factors give the basis for PSF categorization and calculation.



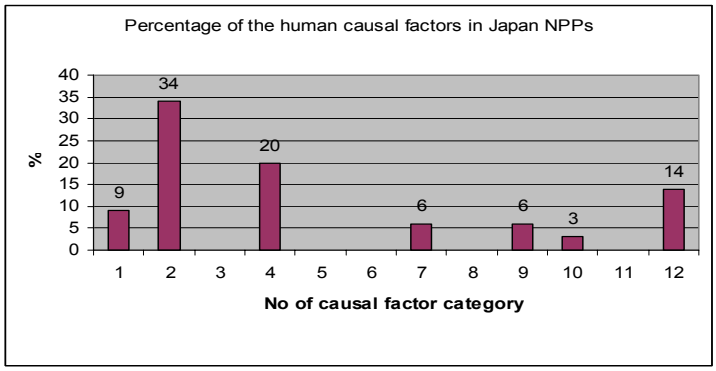
The names of the 12 human causal factor categories are given in the table bellow.

No of human causal factor category	Name of the human causal factor category
1	Verbal communication
2	Written procedures and documents
3	Man- machine interface
4	Environmental working conditions
5	Work shifts
6	Working practice
7	Work planning and organization

8	Supervising methods
9	Training/ qualification
10	Change management
11	Resources management
12	Supervising methods



For comparison we give a diagram with the contribution of the same causal factors for the events occurrences in Japanese NPP.



After comparing of the most important contributors for human errors in event occurrences, we can conclude that both in KNPP and Japanese NPP, the most important causal factors are:

- Group 2: Written procedures and documents.
- Groups 3-4: Man- machine interface; Environmental working conditions.
- Groups 7-9: Working practice; Training/ qualification.
- Groups 12: Supervising methods.

5. Conclusions

In the current report we give an explanation about the most frequently used approaches for human factor assessment- the human reliability assessment (HRA). This technique and its improvements as THERP, CHR, HEART, ATHEANA etc. incorporate the values for the human reliability in the event trees after applying the task analysis. The trend is correction of the nominal values for the human reliability with factors, taking into account the ergonomic parameters called performance shaping factors, the time, the dependence between different human failures. For screening and quantifying of performance shaping factors (PSF) we can recommend applying of HPES, MTO and other performance evaluation systems. Relative

importance in some PSF concerning human errors in Kozloduy NPP events occurrences is given. Such factors with relative important human performance influence in Kozloduy NPP are in the domain of Written procedures and documents; Man-machine interface; Environmental working conditions; Working practice; Training/qualification; Supervising methods.

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