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# Reduction of Technological Risks through Effective Human Factor Management Based on Modern Information Tools

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**Abstract.** The relevance of effective human factor (HF) management with the aim of reducing modern technological risks is shown. Professional and psychological testing (PPT) is highlighted as one of the HF main management tools. A technology is proposed for increasing the objectivity of PPT by taking into account individual information parameters (IIP). Developed methodological and software tools for remote network registration of IIP. The software is based on the use of a database (DB) containing the original psychological tests, as well as keys for processing the test results, taking into account the IIP. The results of an experimental study of the effectiveness of testing technology are presented.

## 1. Introduction

Large technospheric accidents and recent catastrophes, primarily at the sites of the nuclear and chemical industry, as a rule, lead to the contamination of vast territories, causing great harm to land use, ecology and economics [1]. Unfortunately, the majority of man-made accidents and disasters could have been foreseen, which would allow taking timely measures to prevent them or minimize the damage caused by them [2, 3].

One of the components of the technosphere safety is the reliability of the HF. Investigations of major accidents and disasters have shown that the HF is the main cause of the emergence of many of them, as well as the cause of ineffective and untimely response. Typical examples in this regard are accidents and disasters in aviation [4-6], in railway transport [7].

Thus, the reduction of technological risks is objectively related to the need to improve the reliability of the HF, which is one of the principal components of technospheric safety. This problem is most acute in the atomic sphere [8-10].

## 2. Relevance, scientific significance of the study

In view of the above, the development of technology management of the HF with the aim of increasing its reliability is a topical scientific and practical task. Of particular relevance in this regard is the creation of technologies for analyzing, evaluating and forecasting the possibility of man-made accidents and disasters in order to take timely measures to prevent them [11-15].

The reliability of the HF is a complex concept [16-20], including such aspects as:

- the level of professional training of the management operator of a potentially hazardous object (PHO);



- the ability to act correctly in difficult, including stressful situations;
- psychological stability, mastering the skills of self-control and self-regulation;
- reaction time, speed of decision making;
- psychological climate in the work shift [21].

Currently, the main approaches to improving the reliability of the HF in the management of PHO are:

- objectification of the assessment of the professional training level at all stages of training, training on simulators, retraining and advanced training of PHO management personnel [22, 23];
- objectification of the results of pre-shift express monitoring of the PHO management staff [24];
- the implementation of continuous monitoring of the staff current state throughout the work shift [25].

Continuous monitoring allows timely identification of employees in inadequate condition. Unfortunately, in practice it is not always possible to promptly replace such employees.

Objective assessment of the level of vocational training, especially the ability to apply acquired skills in emergency situations, as well as admission to PHO management only of staff in normal working form are fundamental conditions for ensuring trouble-free operation of such PHO. For this reason, it is important to develop a methodological and practical apparatus for an objective assessment of the professional knowledge level, skills and abilities, as well as an objective express control of the state of PHO management staff.

In practice, PPT are widely used to solve the above problems, including, among other things, the construction of a behavioral (mental) model of the operator [26]. Professional tests are usually typical PHO management tasks in various, including abnormal and emergency modes of operation. They allow you to determine the level of operator training.

Traditional psychological testing involves the use of questionnaires, graphics tests, test tasks. The results of such testing are usually processed using so-called keys (specialized techniques, algorithms), which allow to determine such important personal qualities as personality type, motivation for professional growth in PHO, interests, mental abilities and characteristics.

Psychological tests can be a textual questions, statements, or tasks. For example, psychological tests may be the classical tests MMPI (personality type research), Ammon (assessment of psychological aspects of personality), Eysenck test (assessment of the level of intelligence). One of the types of psychological tests are the so-called graphic tests. Typical examples of such graphic psychological tests are: the Vartegg test (expressive-projective methods of personality research), the Luscher test (personality analysis), the Rorschach Blur test (studies of the psyche and its disorders).

### **3. Statement of the problem**

Unfortunately, in practice, paper-based technology is often used. This significantly increases the time of testing, reduces the reliability of the results obtained due to the effect of habituation to the contextual content of the tests, as well as complicates their remote network application.

Modern, in the first place, digital information technologies [24, 25] provide an opportunity to significantly expand the capabilities, reliability and informational content of classical PPT. These technologies provide the greatest efficiency when conducting final professional attestation and deciding on the admission of the operator to PHO management. The PPT is one of the universally recognized tools that allows you to make informed personnel decisions at all stages of the "life cycle" of personnel.

The aim of the study is to develop methodological and technical means of reducing technological risks due to the effective management of the HF reliability during the implementation of PPT based on digital information technologies.

#### 4. The essence of the suggested approach

The essence of the approach developed in the work lies in the integrated assessment of the PPT results, which involves the analysis of the results taking into account the IIP. The implementation of the considered approach was based on the following principles of building an automated remote network PPT system:

- automated registration of IIP, objectively characterizing the testing process;
- the possibility of functioning of testing system in a local network, as well as on the Internet;
- universality of a specialized DB containing initial psychological tests, as well as keys for processing test results, taking into account IIP obtained during the testing process.

Table 1 lists the IIP describing the testing process that was used in software development. These parameters allow to increase the objectivity of the results obtained in the process of remote network testing.

**Table 1.** Individual informative parameters.

Parameters	Designation
The number of returns and answers corrections	NC
The number of requests on the Internet or to the built-in DB	NR
Time spent working on the Internet and from the DB	TH
The execution time of each item $i$ test item	Ti
(i = 1, ..., M, where M is the total number of test items for PPT)	

The effect of these parameters on the results of professional and psychological testing varies. Table 2 gives an interpretation of the possible influence of the considered parameters on the results of psychological testing in the event of a significant excess of their average values for this category of workers (average for this test).

**Table 2.** Interpretation of the results of psychological testing.

Parameters	Interpreting possible parameter values
NC	Uncertainty, instability of the psyche
NR	The desire to distort the results of psychological testing, an attempt to hide the existing deviations in the state of mental health
TH	The ambiguity of the answer, the difficulty of choosing between the available response options, a low level of intelligence (for example, for expressive-projective tests)
Ti	Attempt to find the correct answers to similar questions based on the known algorithm (key) processing test results

Table 3 gives an interpretation of the possible influence of the parameters under consideration on the results of professional testing in the event of a significant excess of their average values (average for this professional test).

**Table 3.** Interpretation of the results of professional testing.

Parameters	Interpreting possible parameter values
NC	Uncertainty about the correct response, attempting to cheat
NR	Attempt to find the correct answers to questions based on the known algorithm (key) processing test results
TH	The desire to distort for the better the test results
Ti	The ambiguity of the answer, the difficulty of choosing between the available response options, a low level of intelligence

Of most interest are the temporal [27–29] parameters  $T_i$ ,  $i = 1, 2, 3, \dots, M$ . They make it possible to obtain additional objective information about the perception, understanding and preparation of the answer for each item of the test task.

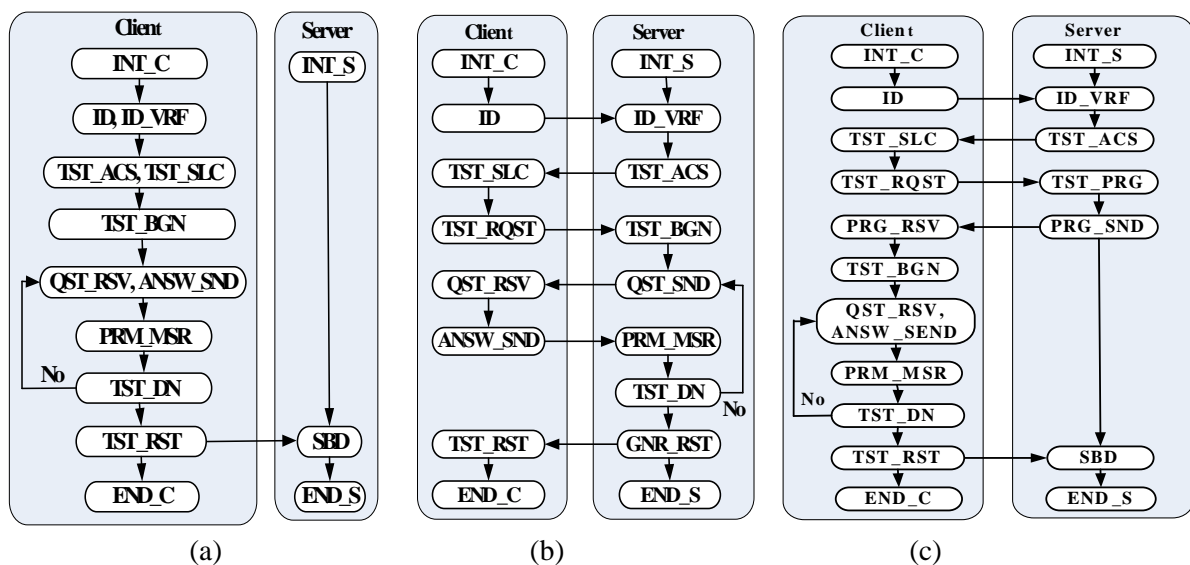
When conducting professional testing, a low value of these parameters compared to their average values for the entire work shift, or average values for this test undoubtedly indicates the level of operator training. Moreover, for professional tests containing questions on knowledge of principles, methods and approaches, such parameter values indicate the level of acquired theoretical knowledge. For professional tests based on solving applied problems, such values of parameters testify to the ability to apply the obtained theoretical knowledge in practice.

### 5. Development of unified PPT tools

To put into practice the considered approach, unified software and hardware were developed. The main difficulty in the implementation of the approach was caused by the measurement of the parameters  $T_i$ ,  $i = 1, 2, 3, \dots, M$ , which have a fairly high information content.

The following three main options for the implementation of testing in an automated mode with various options for information exchange were implemented:

- testing on a dedicated personal computer with the transfer of test results to a specialized database (SBD) (Figure 1a);
- testing on a personal computer in a local network (Figure 1b);
- testing on a remote computer in the global Internet (Figure 1c).



**Figure 1.** The implementation of information exchange.

To implement the first test version, the following procedures and functions are used: INT\_C, INT\_S — software initialization, respectively, on the client side (Client) and on the server (Server); ID, ID\_VRF - user identification and verification, respectively; TST\_ACS, TST\_SLC - opening access to tests and the choice of the test being performed; TST\_BGN - the beginning of the test; QST\_RSW, ANSW\_SND - receiving the next question and entering the answer to it; PRM\_MSR - determination of the value of the parameters  $N_C$ ,  $N_R$ ,  $T_H$ ,  $T_i$ ; TST\_DN - check the execution of the entire test; TST\_RST - getting general test results; SBD - record the results in the WAS; END\_C, END\_S - end of testing on the client side and on the server.

The considered test version allows determining the value of additional informative parameters with high accuracy. First of all, it concerns the reaction time of the test to the question posed.

This option is most convenient to use when conducting individual testing in a specially equipped computerized place. When conducting automated testing of work shift operators, it is advisable to implement the second test option. This option involves the use of additional procedures: TST\_RQST - request the next test question (task); QST\_SND - sending the next question (task) from the server; GNR\_RST - getting general results on the server.

A feature of this option is that the determination of the magnitude of the reaction time is carried out on the server side. This does not lead to a significant increase in error, since the local network does not imply access to the global Internet network, the time delays in which can reach significant values.

The third test version allows you to determine the reaction time on the client side using downloadable software.

## 6. The results of experimental studies

The laboratory approbation of the developed automated testing tools confirmed the possibility of increasing the objectivity of the professional level assessments. When conducting experimental studies, we used the method of forming integral estimates, presented in [30]. For this purpose, a comparison was made of private test results on professional subjects, with marks given by instructors (experts) based on the results of the final professional tests of varying complexity. In order to obtain particular results, two groups of test subjects were selected — experimental and control. For these groups, respectively developed and classical technologies of professional testing were applied. The classic testing technology took into account only formal test results. Analysis of the results showed that the proposed approach gives a significantly better correlation of the partial estimates with the final estimates (the Pearson correlation coefficient can reach 0.98) compared to the classical (the corresponding correlation coefficient is 0.82). At the same time, the error in measuring time parameters using the developed network technologies did not exceed 7% relative to parameters measured directly on the local computer.

## 7. Conclusion

The developed methodological and automated technical means allow to increase the objectivity of the PPT results of the PHO management personnel. From this point of view, they should be considered as an effective means of reducing man-made risks through effective HF management.

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