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DETERMINATION OF DISTURBANCE STATES WITH A SPECIAL FOCUS ON THE HUMAN FACTOR

It is essential to explain the concept of disturbance states. A disturbance state is a state of the system when it cannot perform its functions due to the effect of well-determined technical or human disturbances. Human performance has a significant impact on the reliability of complex electric systems, including military applied complex electric systems. Among the main reasons of disturbance states human factor is always present. The concept of human error should be correctly defined and used with utmost care. In this paper a typical example that may cause a disturbance state is considered as a consequence of the human factor.

Introduction

In the following we outline the essence of the theory of disturbance state [1]. This method of examination can aid the shaping of one's attitude towards quality which is necessary for building and maintaining complex – heavy power current, light current – electric systems, including military applied complex electric systems, probably containing controlling subsystems.

The success of the operation of a complex electric system, as a service system, is determined by how the user requirements are met. This general description is basically the implicit definition of the quality following the concepts of ISO 9000 and TQM standards. In this sense the quality cannot be an exact, directly usable quantity for the system designer and operator. To overcome this problem the concept of key parameters is introduced [1]. Using key parameters the quality of complex electrical systems can be described and the related tasks can be solved.

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Definition: The key properties are measurable or calculable data which play a significant role in determining the quality of the system. The key properties are characterized by their measures. The designers have control over the parameters that are connected to these key properties.

Knowing the key properties one can account for the exact service parameters (the measures of the key properties). Depending on the system the key properties can be different. They always depend on the purpose and characteristic features of the system.

The concept of disturbance states

A *disturbance state* is a state of the system when it cannot perform its functions due to the effect of well-determined technical or human disturbances. Many times the objective is to analyze the absence of failure during the examination of the given system.

In these cases, if the key parameters are known, the theory of disturbance can be effectively used. The aim of the method is to divide the measurements into two groups.

The first group contains examinations using confidence models applied for calculations of parameters and fault-possibilities coming from the structure of the system.

In this group the analysis is based on reliability theory models (mainly Boole-models and Markov models). The second group contains disturbances which were caused by external and internal disturbance sources (human error or technical malfunction). During disturbance state tests, technical and other (e.g. human) sources of disturbance having an effect on reliability are tested, even if they have nothing to do with service characteristics. The use of fault tree analysis [2], [3] is very efficient for these tests. By means of fault tree analysis all kinds and sources of disturbances causing system failure can be represented.

Tests connected with causes of disturbance states can be performed according to different guidelines. In any case, it is essential to test in order the following sources of disturbance (Fig.1).

a) *Power-current sources of disturbance.* During these tests, the effects of power-current appliances or equipment, as sources of disturbance possibly endangering reliability, are analyzed. For example, such appliances and equipment follow.

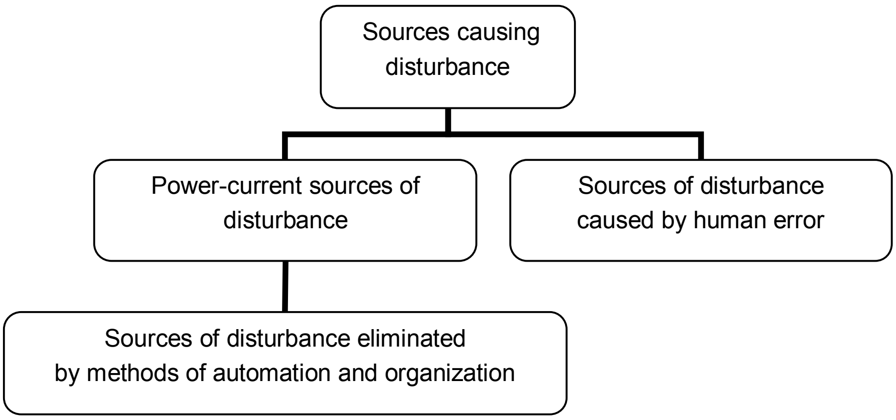

Fig. 1

Thyristor drives, correcting installations producing harmonics. Electrical drives with different working states causing voltage drop. Variable power factor thyristor drives. If high frequency disturbances develop in the system, it is essential to determine the NST factor [4] as a starting-point of analysis. Expected values of mains voltage short-time changes caused by noise, spikes, transients can well be traced by means of the above mentioned NST factor.

b) Sources of disturbance eliminated by methods of automation andorganization. If inter-subsystem electric and organizational connections of complex automation systems are correctly selected, many failures (sources of disturbance) can be eliminated. For example, there is a technological system in which several high-power squirrel-cage motors work. If these motors are switched on at the same time, they can cause short-time voltage drops ending up in disturbance states in the system of electric supply. If some motors are triggered after some delay, in accordance with technological rules, disturbance states can be avoided.

c) Sources of disturbance caused by human error

The role of the human factor in disturbance states

When composing design-documentation of complex automation systems, it is very important to find out what kind of disturbances can be caused by human error. Human performance has a significant impact on the reliability of complex electric systems. Among the main reasons of disturbance states human factor is always present. According to different papers, 45-80% of errors are due to the human factor. This fact implies that human reliability analysis (HRA) should make a principal role when analysing disturbance states.

On the other hand, the views that „human commits errors”, „humans are the weak part of the system” or „human actions have to be replaced by automation” are too simplistic. Man is able to cope with unforeseen situations, to analyse and to create solutions. Without human actions more distutbance states would lead to accidents. Safe behaviour does not mean the absence of errors but the positive human contributions to safety, even in the form of prevention. Therefore, the concept of human error should be correctly defined and used with utmost care [5].

Human error is a general concept, which includes every situations when the planned sequence of mental or physical actions fails to achieve its planned and desired aim, and this failure is not due to any kind of stochastic circumstances [6].

According to ASME 2000, human error is failure of a human action due to internal human failure mechanisms. This concept is to loosely describe any sub-optimal human performance. Two main groups of human errors are error of commission (wrong human action) and error of omission (missing human action). Human error as the consequence of the difference between planned and realized action or performance, may be categorized as slip, lapse and mistake. A separate group of errors is violation, when the action is not allowed, prohibited or not apropriate. Latent error may also play an important role, although this type of errors is usually difficult to identify because of its distance even in time and in space from the evolved event [7]. Human failure is the failure of a defined human action in an HRA model. There may be many reasons for failure compared to human error. Human failure may affect components- that is called fault, and processes, when disturbance occur. A failure that is assessed to result in unacceptable consequences such as unavailability or wrong function leading to personal or property damage is called critical failure.Another possible alignment of human errors that usually takes place in PSA (Probabilistic Safety Assessment) models, depends on the chronology of human error and the evolved danger Three types of errors may be distinguished by this chronology:

1. Error of human performance type A is an error that is committed during a human action before the initial event, mainly in connection with the availiability of the system (for example in connection with the actions of maintenance).
2. Error of human performance type B is an error which causes a direct initial event.
3. Error of human performance type C is an error that is committed during the human actions made for averting breakdowns or accidents. Errors of human performance type C have the greatest effect on the results of PSA. In this case the following groups may be differentiated: the lack of a needed action, an action made by mistake and the error of an action made for compensating the lack of a needed action [8].

Thus, a disturbance state may occur as the consequence of an error of commission as well as an error of omission. Within these two groups slips, mistakes and lapses may be alike, and also violatin and latent errors.Any type of the above mentioned errors causes a disturbance state when it is concerned with processes.

Disturbances may also result in unacceptable consequences when critical failure is due to a disturbance state. According to the other groups of errors it follows that the error of human performance type A, B and C may cause disturbances alike. Clearly, there is a need for encapsulating the multitude of factors that may cause any type of the above mentioned human errors.

Presumably, a universal list of these factors would be infinite, so it is suggested that categories of variables should be identified so that they could be adapted and applied differently according to the context. One possible way of identifying these categories is the following:

Two main groups of the factors that lead to human errors may be distinguished as internal and external factors. The next basic categories of internal factors may be physical, emotional,cognitive and social effects that also include more categories like personality, intelligence, motivation and ability. External factors could be diveded into organizational and environmental factors [9], [10].

In each of the categories separate analysis should be held to determine the extent a specific error is due to the certain factors. Methods of automation can be applied for the elimination of a part of disturbances. Nevertheless, there are disturbances whose appearance can be prevented by instructions and arbitration (calling for attention, imposition of sanctions, etc.).

An example of human factor causing a disturbance state

Finally, let us consider a typical example that may cause a disturbance state as a consequence of the human factor: the errors due to time-table.One of the basic principles of operational processes is the assumption that workers are highly predictable and standardized in their behaviour regarding their time-table. They always start work on time, operate at a constant rate throughout the day, take breaks at planned times, rotate properly, etc. Such regular behaviour of workers rarely occurs in practice. According to a test made in theUK [11] the analysis of the data suggested that up to one third of the potential time for production is lost due to stoppages, extended breaks and disruptions to the flow of the line. The loss of time definitely causes the recession of production, but it may also cause disturbance states.

Conclusions

The paper focused on some questions of designing complex automation systems. It exposed a widely-usable, systematic designing method with a philosophy, which can lead to an adequate assurance of reliability through introducing the concept of disturbance state and the human factor.

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