ERGONOMIC RESEARCH ANALYSIS ON CENTERS FOR CONTROL AND MANAGEMENT OF ELECTRIC DISTRIBUTION SYSTEMS

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1. INTRODUCTION

The interest for researches on human factor in the centers for control and management (CCM) was initiated by the findings of investigations for causes of incidents in three nuclear power plants on Iceland.
Therefore, the first researches on human factors in the CCM conducted for EPRI, USA were related to human factors in CCM in nuclear power plants.
In 1977, they started the research project R 1354 called "The overview of human factors in dispatch control centers" consisting of three basic research tasks, namely:

- **Task one**: research of the representative dispatch control centers in order to determine present condition of the representative group of control centers, to document the factors influencing designing systems for informational compatibility between the operators and elements within the center, and to give recommendations for reduction of human error to the minimum.
- **Task two**: to determine the scope, type and form of information that should be presented to the operator for the purpose of more adequate functioning of the control and managing system according to the set up requirements.
- **Task three:** to create the method of communication based on processed information and management decisions reached according to them.

Major part of these research tasks was carried out by 1982 in 13 dispatch centers, and the results of the researches were presented in five short reports dealing with basic research tasks, namely, designing of control rooms and accompanying facilities, systems for displaying information, as well as dispatchers' stress analysis and interpersonal relationships within control centers.
Besides, the simulators designed for training of operators became commercially available in that period, so they were used in big EDS with significant software and slight hardware finishing.
In 1978, IEEE formed the work group for training of operators (W6 78-4). Between 1997 and 1982, they had also been collecting bibliographic data on courses and machines for training EDS operators produced by American companies.
Following these preliminary researches, the interest for more expert studies in various fields of control and management increased significantly.
Here, we will present the research projects conducted in Sweden, Brazil and UK, since these are the most quoted ones in the analyzed literature.

2. RESEARCH PROJECTS IN THE UNITED KINGDOM

In the UK, the issue of control and management by the closed circuit television systems was promoted by Tickner [7] using applications specially programmed for highways and prisons. Since then, these systems have developed significantly, and now they are being used for production monitoring as well as control and management of various systems.

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This system of control is introduced in all city centers as a method for reduction of criminal and increase of public safety and security. The Study [10] on such control centers revealed some widely spread mistakes caused by human factors. The Study also exposed omissions in training, equipment designing and inadequate operating environment, which altogether led to inadequacy and inefficiency of these systems.
Therefore, a document [1] aimed at improving such systems was prepared in the UK, which was fully described in the paper.
Most of the papers on such control systems have dealt only superficially with human factors, and incline to a supposition that an operator is capable of dealing with problems. However, data from the research programs no.8 and 9 provide sufficient evidence that such suppositions are wrong.
Evidence from the past researches [8] only confirms the suspicion that human abilities in using *CCTV* systems are limited.
In paper [2], the authors have provided an analysis on the project for a new design of emergency service control room.
The basic document for ergonomic designing of such control room was "the work specification" which explained issues like control room recruitment, role, importance and arrangement of equipment, ergonomic analysis of the existing control room, as well as analysis of operators' complaints about the quality of working environment.
Information given in the work specification and guidelines provided by the Control Room Committee contributed to preparation of an instructive document for design and construction, specially dedicated to architects, construction workers and engineers.
Ergonomic approach did not end at the level of an instructive document. The ergonomist also plays an important role in issuing official approval for all pre-projects of work rooms, but also in operational realization of this project, thus preventing eventual corrections after control room commissioning.

3. RESEARCH PROJECTS IN BRAZIL

In Brazil, the authors [11] conducted an ergonomic evaluation of ten control rooms for management of the plants with continual processes. Starting point of these evaluations was Draft ISO/CD 11064.
When designing control rooms, cooperation of architects, engineers of various fields and ergonomists is of great importance [12].
Differences and inadequacies found in control rooms are principally the result of disagreement of various experts about application of ergonomic principles in designing, as well as in failing to accept the idea about importance of human factor when designing control rooms.
According to paper 13, there is a strong link between communication and competence, whereas they view competence as orientated action for promotion of understanding among persons. Every kind of cooperation is preceded by knowledge acquired in a team work, and such knowledge allows not only coordination of actions, but also reciprocal understanding, without any need for explicit repetition of what one would like to say or do. Such mutual knowledge is definitely present in team work and takes over the role of competence which is rather questionable in modern control of production processes.
The authors of paper 12 within Ergon Projects, and based on seven control room projects, provide methodology for ergonomic designing of control rooms.
The Authors [6] explain the importance of professional training of operators for prevention of accidents. Being familiar with the provisions of the security law related to control rooms and the process of management, as well as having knowledge about eventual risks within the system, contributes to creating an idea about technical and operative reality of the system, which again reduces the risk of unexpected situations and unprepared reaction of an operator to such situation.
According to that, cognitive ergonomy will be of coexistent help in present and future studies of work safety when it comes to formulating conceptual bases for accident prevention.

4. RESEARCH PROJECTS IN SWEDEN

In Sweden, a pre-study was initiated in 1994, in order to develop a philosophy for control room designing which should serve as a concept for development and designing of new control rooms for managing 6 nuclear plants [3] (CRUM project "Control Room Modernization").
The essence of the project is in presentation of a long-term perspective of development of the new century control rooms, with completely computerized system for utilization of

operative stations. The project was created according to determined standards and guidelines (NUREG-0711, 1994).
According to the results of this pre-study, a detailed database will be prepared for a preliminary project. The data base will consist of the man-machine interface on work stations, big screens and conventional panels, alarm systems designing, and control room typology.
The author of the paper published a manual on human factors in control rooms, in which he presented models of control process, ways of designing, SPI and OU environmental factors, system designing and operator's abilities and limitations. He came to a conclusion that controls carried out in Sweden nowadays are mostly conventionally equipped with computer process systems serving as a complement to classical systems for displaying information.

5. ERGONOMIC DIRECTIVES FOR DESIGNING OF ELECTRIC DISTRIBUTION SYSTEMS

Realizing the importance of these issues, in 1992, the International Ergonomic Association (IEA) created a work group to deal with these issues and promote the following objectives:

- Advisory activities for governments, national expert organizations, and management structures of big systems concerning the importance of human factor studies in designing and utilization of big systems for control and management.
- Raising public awareness on international level, especially of those on influential and responsible positions, about crucial importance of ergonomy for safety of EDS, health and quality of living.
- Development of human resources in ergonomics, for adequate global improvement and utilization of the centers for control and management, in order to facilitate easier international communication on expert level.

One of the activities planned to back these goals was development of general directives for inclusion of human factors in designing and operation of big EES. These directives should be applied on various types of EES worldwide.

Forty pages of published Directives consist of the following parts:

- Introduction, in which they define principal objectives of the document and reasons for the studies and reliance on human factors in designing and operation of big EDS.
- Ergonomic principles, dealing with issues related to human resources, tasks, equipment, software and compatibility of operators and computers, work environment, training equipment and specifications and instructions for work.
- Application of ergonomic principles, consisting of recommendations for ergonomic pre-designing of EDS, ergonomic pre-designing of small EDS and modification, reconstruction and new construction of the existing EDS.
- Ergonomic tools, including various ergonomic recommendations and criteria, as well as various methods, techniques and equipment for measuring of ergonomic parameters of relevance for development and functioning of EDS.
- Macro ergonomic parameters which include human factors in the fields of organization, economy, national culture, etc.

Copies of the Draft Directive were sent to 43 representative EES world wide (20 in the USA, and 23 in other countries including Australia, Brazil, Canada, China, France, Germany, Japan, Norway, Russia, South Africa, Sweden and England).

With adequate modifications, these Directives can be adjusted according to national requirements in the interested countries and issued as a regulatory document for application of ergonomics in designing, development and operation improvement in any EES.

CONCLUSION

Creation of standards for ergonomic designing of centers for control and management started in 1987, forming of a small work group. In time, the work group developed so, on a working set held in Tokyo in 1994, there were 19 experts from 6 countries. Creation of this work group was triggered by evident problems detected wile performing an analysis of activities within centers of control and management. These activities include: great concentration of modern equipment, twenty-four-hour work, considerable variations in work load, performance of critical activities under psychological pressure,

inadequate lightning, overcrowded space and bad arrangement of equipment, inadequate designing and construction solutions of equipment and the environment, etc. The work of this group resulted in Draft of the International Standards on “Control Room Ergonomy” ISO 11064.
In the beginning, the work on creation of these standards was aimed at topography of work stations, however, in the course of work they realized that this was a fairly limited approach with respect to their purpose, so, this discrepancy was the subject of many work group meetings.
In the present form, this Standard is related to all static centers of control and management. Even though mobile centers of control and management are not included because of special conditions under which they operate, it is expected that major part of these guidelines can apply to them as well.

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