Nuclear Regulation ISBN 92-64-02089-6

Nuclear Regulatory Challenges Related to Human Performance

NEA No. 5334

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

FOREWORD

The Committee on Nuclear Regulatory Activities (CNRA) of the OECD Nuclear Energy Agency (NEA) is an international body made up of senior representatives from nuclear regulatory bodies. The Committee guides the NEA programme concerning the regulation, licensing and inspection of nuclear installations with respect to safety. It acts as a forum for the exchange of information and experience, and for the review of developments which could affect regulatory requirements.

In 2001, the CNRA Bureau decided to organise a discussion on the importance of human performance with regard to nuclear safety. Aid was requested from three working groups of the NEA Committee on the Safety of Nuclear Installations (CSNI). Those groups were: the Special Expert Group on Human and Organisational Factors (SEGHOF), the Working Group on Operating Experience (WGOE) and the Working Group on Risk Assessment (WGRisk). The individual members of those groups and the NEA Secretariat prepared material to introduce the topic to the CNRA. The discussion itself took place during the CNRA meeting held in Paris in June 2003. On the same occasion, the CNRA decided that it would be beneficial to document the introductory presentations and the summary of the CNRA discussion in the form of a publication.

Dr. Albert Frischknecht (HSK) presented the input of the three CSNI working groups to the CNRA and provided the corresponding contribution to this report. Mr Herbert Deutschmann (HSK) and Dr. Vinh Dang (PSI) also contributed to the present publication. Dr. Pekka Pyy, Mr. Barry Kaufer and Mrs. Elisabeth Mauny from the NEA provided secretarial assistance and summarised the CNRA discussion.

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INTRODUCTION

This publication is based on a discussion organised by the OECD Nuclear Energy Agency (NEA) Committee on Nuclear Regulatory Activities (CNRA) in June 2003. The aim of the discussion was to confirm the idea of the importance of human performance, and the factors influencing it, to nuclear safety by sharing knowledge from recent research and CNRA members' experience. Information was provided by three groups within the NEA Committee on Safety of Nuclear Installations. These groups were the Working Group on Operating Experience (WGOE), the Working Group on Risk (WGRisk) and the Special Expert Group on Human and Organisational factors (SEGHOF).

The introductory presentation was based on three questions as follows:

1. Is human performance as important to safety of nuclear installations as many references seem to indicate?

2. Has the importance of human performance increased during the past 5 to 10 years?

3. What recommendations can be made on how to manage human performance challenges?

After the discussion, the members of the CNRA noted that it would be beneficial to both regulators and nuclear operators to prepare a booklet summarising the preparatory work and the conclusions of the discussion. Consequently, the intention of this publication is not to provide a complete picture of human performance and its contributing factors but rather to draw attention to some most challenging aspects of it.

In the publication, first response to each of the CNRA questions is presented in the light of experience derived from studies on human performance and factors, operating experience and risk analysis. Suggestions have been included which may help in assessing and improving human and organisational performance. Finally, a summary and conclusions from the CNRA discussions are presented. It is believed that this short publication is useful to readers in both regulatory bodies and utilities.

Human performance depends directly and indirectly on task characteristics and the working environment of individual. The factors that influence human performance are known as “human and organisational factors”. No commonly acknowledged definition of human and organisational factors exists nowadays. Sometimes, terms like operability, usability, maintainability have to be used instead in order to make it sure that all stakeholders correctly understand the subject of discussion. Consequently, many countries have established working definitions for the concept “human factors” in order to have a common basis for discussions and to complete the text in IAEA Safety Fundamentals (Safety Series No. 110) and other related documents. These definitions generally present human factors as task, individual and organisational characteristics influencing human performance.

IS HUMAN PERFORMANCE IMPORTANT TO SAFETY OF NUCLEAR INSTALLATIONS?

Recent operating experience shows that human performance plays an essential role in the safe operation of nuclear installations. Human performance is important in every phase of the plant lifecycle: design, commissioning, operation, maintenance, surveillance, modification, decommissioning/dismantling.

Failures in human actions, in the organisation or in the management of nuclear installations contribute to 48% of events reported in the IAEA/NEA Incident Reporting System (IRS). Only a few IRS events are due to pure technical causes or to new phenomena causing non-expected plant behaviour. About 63% of the events that were reported to the IRS, and included significant human contribution, occurred during power operation and 37% during shutdown. Also, international analyses of common cause failures show a very significant contribution from human actions.

To complete the picture with the gravity dimension, a quick review was carried out of events reported through INES (International Nuclear Events Scale) over the last 10 years. It confirms that a large majority of events with INES level 2 and higher can be attributed to human performance related causes.

In Probabilistic Safety Assessments (PSAs), the quality of human performance has an important impact on the core damage frequency (CDF). Accident scenarios that include human actions represent 15-80% of the CDF. The contribution mainly depends on the plant design, scope of the PSA and the extent to which human actions have been analysed and modelled. PSA results have been systematically studied from this perspective only seldom. One survey of the human actions and of their treatment in a range of PSAs is, however, to be found in [NEA/CSNI/R(98)1].

Despite the differences in PSAs, the results show that human actions on the whole are important to maintain a high level of safety. Improvements in the quality of human performance would have a significant decreasing impact on the level of risk as measured by the PSAs. The converse also applies. Finally, the PSA accident scenarios show that the plants are tolerant both to single human and hardware failures, and that there need to be common mode factors involved in scenarios leading to a high risk.

The contributions included in PSA mainly reflect two types of human performance: 1) maintenance and testing, and 2) personnel responses to initiating events, i.e. to events that could lead to an accident without a balancing action. Human and organisational factors support or degrade performing human actions and thus contribute to their success or failure probabilities.

Both operating experience and PSAs show that NPPs are socio-technical systems, also known as MTO (man-technology-organisation) systems. They represent a combination of the hardware of the plant and the humans that operate the installation in an organised manner. Technical problems have been treated with a very high professionalism since the very beginning of the Nuclear Era. However, for a long time human and organisational questions were mostly approached from technical point of view only.

This development has, in few cases, led to deficiencies in the design of human-system-interfaces (HSIs: alarm systems, process information systems, operator support systems, procedures, handling equipment etc.) as well as in weaknesses in work organisation, communication, teamwork, etc. Many of these shortcomings remained latent because the personnel generally are well-trained and supported by good procedures. Initiating events and special plant conditions, however, have in some cases unveiled gaps in overall MTO system design.

Furthermore, an analysis of a number of recent events with significant human contribution shows that, in most cases, the plant personnel has demonstrated their capability to cope with difficult situations in a very professional manner. However, this information is not evidently collected systematically, e.g. by identifying and recording good practices. This may mean missing a significant improvement potential.

HAS THE IMPORTANCE OF HUMAN PERFORMANCE INCREASED DURING THE PAST 5 TO 10 YEARS?

Based on the reported events in IRS, the human causal contribution has increased slightly over the past 20 years, from approximately 45% in the 1980s to approximately 55% in more recent years. It can be further stated that the Chernobyl accident and some other earlier events contributed to focusing attention to safety culture and safety management. These events also triggered the use of in-depth reviews to improve management capability at installations and efficiency of the legal and regulatory oversight processes.

The main causes for recent events with human performance problems have been deficiencies in the safety awareness, management and organisational weaknesses and unclear legal and regulatory requirements. A common feature is that senior corporate management failed to appreciate the symptoms of weaknesses or their significance, and it also failed to take effective corrective action at an early stage. Many of the events have received considerable attention in the public and nuclear community, and they have led to considerable long shutdown periods which have been used for improving safety.

The salience of human and safety management aspects in recent events reported to IRS might lead to a conclusion that the importance of human performance as causal category would have increased in absolute terms. This is not the case. Human performance has been a very important factor from the very beginning of nuclear power generation. However, the perception of the importance of human performance has increased significantly during the past 10-20 years. Another fact is the significant number of improvements in nuclear technology throughout the years. Consequently, the relative contribution of technical causes to safety related events has decreased. This together with the increased perception may explain the fact that more details of human and organisational factors are reported in the recent IRS reports.

Another reason for the increased attention may be the new challenges the nuclear industry is faced with, e.g. deregulation, use of contractors and changes in institutional ownership; ageing workforce and its turnover; perception of the nuclear by civil society; and finally emerging technologies and generally increased information demands of work itself. Such factors may challenge many cornerstones of nuclear safety work and simply cannot be left outside consideration nowadays.

PSAs confirm that human performance and human factors have been from the beginning important to safety, and that neither increasing nor decreasing importance trend is to be seen. When PSAs have identified human factor deficiencies in risk-significant scenarios, modifications to the plant hardware or improvements of the human-machine interface, procedures, and training have often taken place. In absolute terms, these measures have reduced both the overall CDF and the frequency of accident scenarios with human contributions. The relative contribution of such scenarios, when compared to scenarios due to the equipment failures, may in some cases have increased.

Significant efforts have been made during the past 5-10 years to improve and extend the treatment of human performance in PSAs by means of human reliability analysis (HRA). These efforts are aimed at improving methods for the estimation of probabilities, as well as at identifying and accounting for a more comprehensive range of failure modes in human actions. An example of activities to extend the scope of PSAs is the inclusions of “errors of commission” i.e. wrong and spurious human actions. Attention is also being paid to accident management, outages and the organisational and human factors issues that have been highlighted in recent events.

WHAT RECOMMENDATIONS CAN BE MADE ON HOW TO BETTER MANAGE HUMAN PERFORMANCE CHALLENGES?

The lessons derived from in-depth event analyses and from studies of operating experience lead to a number of suggestions. Firstly, operational experience feedback should be a standard component of any safety relevant process for operators and regulators. Secondly, enhanced event investigation including human and management point of views is needed in order to identify all contributors to the event and barriers broken. In the longer term, analysis of NPP databases is necessary in order to identify latent common cause failures of which many are caused by human acts. Those three actions should be taken by nuclear utilities and regulatory organisations. Finally, improvements in practices and tools used for dissemination, retrieval and analysis of operating experience information should be fostered. National technical support organisations, NEA, IAEA and WANO can play an important role in that process.

The PSA methodology provides an essential tool to analyze and to manage the safety of a NPP. While it has proven useful in its current state, the treatment of human performance in PSA has some known shortcomings. Firstly, systematic approaches for identification, modelling and quantification a more comprehensive range of human failure scenarios in PSAs should be further developed. Many of these scenarios involve human decision making, an area in which the available HRA quantification methods and databases currently are weak.

Secondly, continued efforts to collect and exchange human performance information for PSA and HRA data are needed to improve the empirical and plant specific operating experience basis. A systematic evaluation of events in simulator facilities and use of plant maintenance databases could increase the amount of available quantitative information about human performance in real environments. Finally, one should notice that qualitative information about human performance and factors affecting it is at least as useful as quantitative data and always required to accompany numerical estimates.

Conceptually, a term often manifested in PSAs and event analyses is human error. The view that "humans commit errors", "humans are the weak part of the system" or "human actions have to be replaced by automation" is too simplistic. Man is able to cope with unforeseen situations, to analyse and to create solutions for terminating or mitigating adverse event sequences. Without human actions many incidents would have led to accidents. Safe behaviour is not only the absence of errors but also positive human contributions to safety in the form of prevention, detection and mitigation. Therefore, it is recommended that the concept of human error should be used with utmost care.

Related to this, aiding the employees for being able to perform well and providing them with the necessary support (e.g. knowledge, information, tools) will most certainly contribute significantly to improved safety of a nuclear installation. Consequently, collection, dissemination and application of good practices to detect latent failures, means for recovery, etc. should be fostered among the utilities and regulatory bodies.

A proactive tool that helps utilities to address most of the issues mentioned in this publication systematically is a robust safety management system. International organisations, many individual countries and different nuclear utilities have recognised the importance of safety management and have already taken initiatives to give guidance for implementing explicit safety management as a part existing management systems.

Finally, it is necessary to apply the same professionalism to human and organisational issues as to the technical systems. Only a comprehensive cross-cutting approach to MTO systems as a whole leads to considering all parts of them adequately. This implies to all organisations that play a role in nuclear safety (vendors, operators and regulators) and to all phases of the life cycle of a nuclear installation. Experts in psychological and social sciences having experience with nuclear power also need to be consulted in order to make the used competence genuinely interdisciplinary.

SUMMARY AND CONCLUSIONS OF THE CNRA DISCUSSION

A number of important points were raised during the open CNRA discussion that followed the presentation. This section comprises of a summary of the discussion.

There was a general agreement that while many technical problems have been resolved in the past, human and organisational problems largely remain unresolved. Consequently, it is important to provide the proper working conditions to improve performance where required. For example, human performance in and after modifications is one important area requiring attention.

There has been an increased focus on human factors and performance during the past decades. Despite this fact, there is a need to better incorporate the human performance viewpoint into plant design. Also, the most important level is not the individual, but the organisation and the environment that he is operating within. After trained individuals have achieved a certain qualified performance, not much improvement can be reached on the task level only. Therefore, more work must be carried out to evaluate organisations and their support to workers in order to identify problems before they lead into events. Treating the employees that have the responsibility for safe NPP operation with care cannot be emphasised too much.

There have been many events with their roots in human and organisation, and such events will continue to take place. Consequently, more complete and detailed reporting of contributing factors is necessary. This should take place through international systems for exchange of operating experience, like the IRS. Reporting human and organisational performance problems should take place independently of their direct safety impact, since such problems have a high common cause potential for the whole plant. Also, commendable practices need to be exchanged as a part of event analysis, since human actions have a great potential in improving safety. Fostering such exchange of experience is a major challenge.

Special focus should be put on safety management issues by proactively analysing organisational performance to prevent incidents. Proactive safety management needs to be integrated into the overall management systems dealing with plant operational safety. Clear regulatory criteria are necessary in order to establish a balanced approach both to plant safety management and to human and organisational performance. These criteria should be imposed across plants equally. Developing and implementing such criteria is a challenge, since it should include adequate flexibility and, at the same time, maintain the ultimate accountability of the licensees for operational safety.

Training of inspectors, by especially providing tools and guidance to detect problems in declining human and organisational performance, is a vital part of regulatory oversight. While training is very important, it is also valuable to have experts in human and organisational performance issues involved due to the cross-cutting nature of the area. Expertise in human and organisational issues takes many forms and taking into account its interdisciplinary dimension is necessary in order to improve the safety of nuclear power plants.

The complex nature of human performance with the involved organisational issues and safety management dimension make the good collaboration both between NEA Committees and with international organisations like IAEA and WANO vital. Co-operation between these organisations in developing programmes has been successful over the years. In future, even more effort may be required in order to find means to understand and give guidance to deal with human and organisational performance to a sufficient extent.

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OECD PUBLICATIONS, 2 rue André-Pascal, 75775 PARIS CEDEX 16
Printed in France.