THE CONTRIBUTION OF HUMAN FACTORS TO RISKS FROM RADIOACTIVE MATERIAL TRANSPORT

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SUMMARY

The use of probabilistic risk assessment to assess the safety of radioactive material transport operations is well accepted. However, quantitative risk assessments of radioactive material transport operations have generally not explicitly considered human factors in estimating risks.

Given the high profile of human factors as the root cause of many serious transport incidents omission of an explicit consideration of human factors in a risk assessment could lead to assessments losing credibility. In addition, scrutiny of radioactive material transport incident databases reveals a large number of operational incidents and minor accidents that could have been avoided if more attention had been paid to human factors aspects, and provides examples of instances where improvements have been achieved.

This paper examines the areas of radioactive material transport risk assessments (both qualitative and quantitative) which could be strengthened by further examination of the impact of human errors.

It is concluded that a more complete and detailed understanding of the effects of human factors on the risks from radioactive material transport operations has been obtained. Quality assurance has a key part to play in ensuring that packages are correctly manufactured and prepared for transport. Risk assessments of radioactive material transport operations can be strengthened by concentrating on the key human factors effects.

INTRODUCTION

Quantitative risk assessments of radioactive material (RAM) transport operations have generally not explicitly considered human factors in estimating risks (Blenkin et al 1995, Humphries and Dodd 1989). It has been assumed that human errors are implicitly included in the base accident data used to support such assessments. In addition, scrutiny of RAM transport incident databases reveals a large number of operational incidents and minor accidents that could have been avoided if more attention had been paid to the human factors aspects in design of operating procedures etc. and instances where this has been achieved (e.g. industrial radiography sources, handling of Type A packages at Airports). Given the high profile of human factors as the root cause of many serious transport incidents (such as the Clapham rail incident and the Herald of Free Enterprise incident) omission of a consideration

of human factors explicitly in the hazard identification phase of an assessment and the subsequent quantification, could lead to assessments losing credibility.

The International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material (IAEA 1990) are based on the fundamental principle that safety is assured through the engineering design of the package, rather than placing undue emphasis on operational controls, to help minimise the potential impact of human factors. Controls are graded to match the hazard potential of the package. The regulations also place an emphasis on the importance of Quality Assurance to ensure that the measures are applied correctly and fully in practice. However, the only direct references to specific measures to address human factors are with regard to training and safe working practices:

- 'Compliance will ensure a high degree of safety, but managers and workers have a continuous responsibility for maintaining safe working practices'.
- 'Transport workers shall receive appropriate training (to the extent necessary considering the type of work) concerning the radiation hazards and the precautions to be observed'

Since the regulations are neither detailed nor specific with respect to human factors, they are open to wide variations in interpretation.

The IAEA Co-ordinated Research Programme (CRP) on the development of relevant data for assessing risks during transport of radioactive material has identified a need to examine whether human factors should be included more explicitly in risk assessments than has usually been attempted. The United Kingdom representatives on the IAEA CRP have been asked to lead a task investigating methods and data for quantifying the effect of human error on the risks associated with the transport of radioactive materials. It was decided that the most useful starting point for this task would be to review work already carried out in this area and to examine member states experience of human factors issues. This would enable identification of areas where guidance on identification and quantification of human factor related risks would be most important. As well as enabling more credible quantitative risk assessments to be carried out this would have the benefit of helping RAM transport operators to identify potential human factor concerns associated with their operations and hence more effectively focus risk management efforts.

HISTORICAL EXPERIENCE

Historical experience provides information regarding the impact of human factors in incidents and accidents during radioactive material transport operations. The following sources of information were reviewed:

- published incident data
- data available from nuclear operators

The sources (IAEA 1994, NRPB 1995) cover incidents that have occurred over the last 40 years, although the methods of recording the data and the level of detail recorded have become more sophisticated only in the last decade. There are therefore many minor incidents where little information is available regarding the root causes. The sources show that human factors are a significant cause of RAM transport incidents and accidents although the underlying causes are generally not examined in detail.

The key issues identified by the review of historical experience are discussed below:

- The majority of incidents caused by human factors reflect deficiencies in managerial control and procedural error. Potential errors in a number of aspects of packaging, handling and loading were highlighted resulting in a range of outcomes from increased exposure to operators to release of RAM into the wider environment. The development and application of quality assurance systems reduces the potential for human errors to result in significant consequences.

- Data in an IAEA incident report (IAEA 1994) indicates that handling in transit or whilst en route is susceptible to human error. Narrative data describes failure to adhere to procedural requirements. Also cited was carelessness in handling at airports by fork lift truck and errors in preparation. It is evident from these narratives that human error does contribute to RAM transport incidents.

- The United Kingdom incident database maintained by the National Radiological Protection Board (NRPB) (NRPB 1995) demonstrates that incorrect application of procedures and poor handling are responsible for many incidents. Rail derailments were also cited but were not responsible for damage to flasks or release of materials. The number of instances of damage caused by fork lift truck handling at airports has declined in recent years, this may be due to initiatives introduced with regard to handling procedures.

- The incidents with the largest resultant dose uptake were found in the handling of industrial radiography sources. One possible explanation of this is that there may have been an inadequate risk perception amongst personnel involved in these operations. It is acknowledged that better procedures and training have gone some way to reducing incidents in this area.

- Root cause analysis of RAM transport events performed on behalf of a nuclear operator, highlighted human factors as being a common feature in incident causality. Problem areas in relation to these findings are that transportation requirements are not always fully understood or adhered to. The underlying causes all appear to be broadly 'managerial': communications problems, procedural failures and lack of competence or knowledge of the personnel involved in operations. There is little evidence of deficiencies in workplace or equipment design or other ergonomic factors, although the information available is limited in this area.

- Package integrity, especially for Type B packages, is relied upon as a first line of defence against release of radioactive material or loss of shielding in transport accidents Incident data suggests this reliance is well placed, since during even severe accidents, Type B packages have remained intact. However, most incidents involving releases from packages are attributed to errors involving failures of managerial controls and procedural error, for example failure to adequately seal the package or incorrect labelling.

RISK MANAGEMENT

Papers available in the published literature addressing human factors in the transport of radioactive material and other hazardous materials (Banks et al 1987, Ferrara et al 1995,

Freudenberg 1991, McCall 1992, Price 1992, Price and Chu 1992, Ridder 1992, Standish 1995) were examined to identify methodologies employed to quantify risk and risk management measures that help to reduce the impact of human error.

Risk Assessment

The findings of the review support the view that human factors issues are addressed implicitly rather than explicitly. It is assumed in most risk assessments that the use of general road accident statistics to derive rates of accidents during RAM transport is adequate to reflect the risk involved in RAM transport. In many cases the special features of RAM transport are not taken into account. These features include:

- the type of vehicle driven
- vehicle and equipment maintenance and servicing over and above that of general road vehicles
- driver training over and above that of general road hauliers
- driver experience
- experience of driving whilst surrounded by escort vehicles
- fitness of driver for duty (rest periods, drug and alcohol testing)
- effect of errors in package preparation or documentation.

The lack of any formalised database addressing human factors issues in RAM transport was highlighted in the literature review. This may reflect the RAM transport industry's lack of awareness of human factors issues or the inadequacy of methods to identify and record human factors issues.

Safety cases for RAM transport operations have been developed by AEA Technology for a number of nuclear operators. The methodology used to assess risks within these safety cases was reviewed to identify the means by which human errors were modelled and the impact of human error on overall risks.

The following specific types of human error were considered:

- handling errors (dropped packages)
- handling errors (leading to contaminated wounds)
- excessive RAM being packaged
- incorrect package assembly (eg failure to seal lid)
- health physics monitoring errors
- crane/fork lift truck driver error

The following human errors were identified but not modelled explicitly:

- incorrect packaging manufacture
- goods vehicle/train driver error leading to transport accident
- unauthorised smoking leading to fire/explosion

Assessment of the significance of these errors on overall risks and the development of more detailed assessment methods where appropriate are currently being undertaken.

Risk Control

The literature review identified the implications of organisational issues for safety in RAM transport. Risk is affected by the organisational safety culture. Certain generic organisational characteristics contribute to the safety of RAM transport (Freudenberg 1991):

- commitment to risk management
- ability to communicate problems effectively to management and ability of management to initiate solutions
- clear responsibilities for safety
- good inter-organisational relationships

Although the RAM transport industry has a good safety record, the public perception of RAM transport operations is that it is an inherently dangerous practice. It would be desirable to educate the public regarding the safety of RAM transport although it is recognised that there is no simple solution to this problem

CONCLUSIONS

The incident record clearly demonstrates that human factors are a significant cause of RAM transport incidents. Many of these factors are not modelled in current risk assessments of RAM transport operations.

The types of human error commonly encountered include:

- incorrect application of procedures
- poor handling
- inappropriate or insufficient managerial controls
- errors in documentation
- organisational factors.

While package design clearly mitigates against many of these errors it cannot address them all. Managers responsible for the safety of RAM transport need to give attention to minimising the impact of human error from the earliest stages of design of the package and the whole transport system. Attention must be given to fault tolerant package design the promotion of risk perception in operators and to the quality of:

- procedures
- training
- the management systems for controlling the transport of RAM
- guidance available to designers and operators.

To help managers in these tasks the IAEA could provide specific advice on the control of human error in RAM transport to supplement the regulations.

Organisations also need to address the organisational factors that can contribute to risk. Safety audits, human factors assessments, organisational structure assessments and safety culture audits all help to identify problem areas.

Finally, there is clearly a shortage in the literature of methods and data for the reliable assessment of human factors. As part of the IAEA CRP we are currently assessing the impact of human error on calculated risks and devising methods to allow assessment where appropriate. Development of an incident database that clearly identifies the contribution of human error would improve such models enormously.

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